FUSIONS Definitional framework for food waste - full report. Project report FUSIONS

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FUSIONS Definitional Framework for Food Waste

Full Report

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Reducing food waste through social innovation

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Colophon

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Executive Summary

To develop reliable food waste estimates, which can be accurately repeated over time, it is necessary to produce data within a robust methodological framework. This must comprise a consistent definition of food waste and its components, and consistent system boundaries for the food supply chain. The absence of a framework for defining food waste to date has led to the production of datasets that are not always comparable or transparent as to which fractions are included.

A common definitional framework will support policy-makers at both EU and Member State level, and stakeholders across the food supply chain, by enabling them to accurately track the rate of food waste reduction, and the effectiveness of their waste prevention strategies.

The development of this framework for defining food waste signals a key step towards improving our understanding of the food waste challenge in Europe and its consistent use will help measure progress towards both resource efficiency and food security goals. The main conclusions are presented below.

Resource flows in the agri–food system

The starting point for the framework is the generic, simplified system of resource flows in the agri-food system together with their destinations as described in Figure 1.

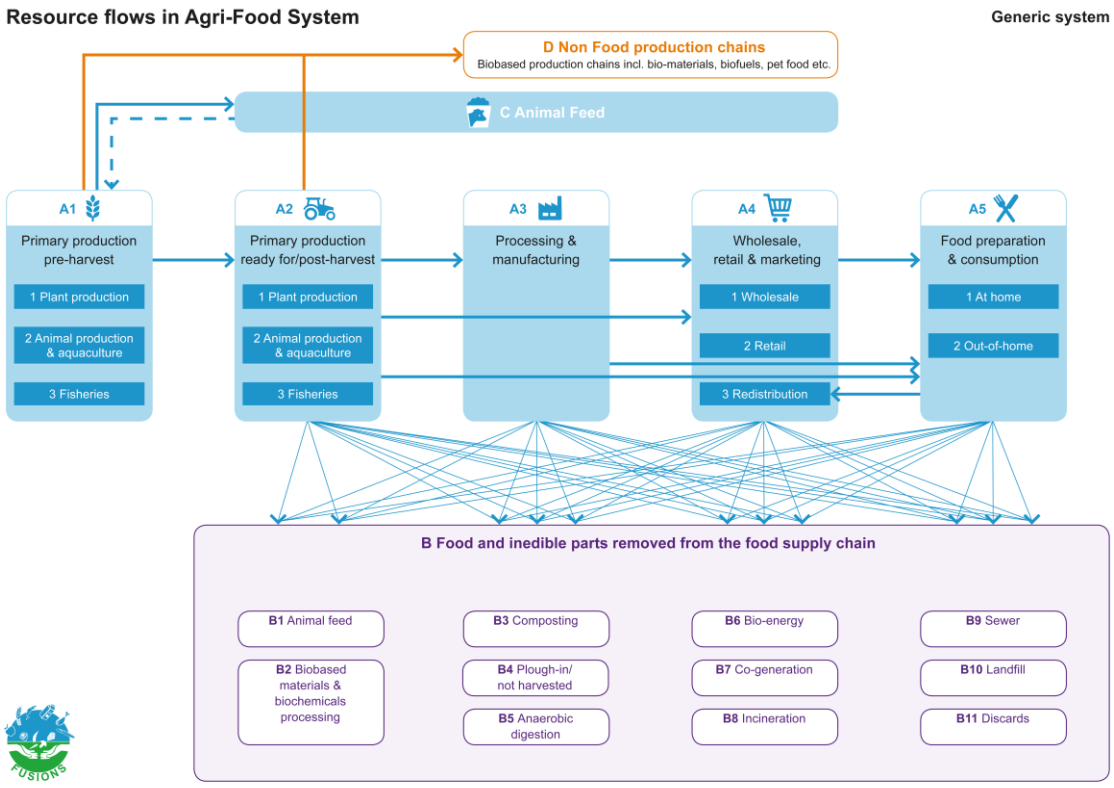


Figure 1.General resource flows in the agri-food system

Section A, in Figure 1, presents the major steps in the agri-food system from production to consumption.

The destinations (Section B) reflect different routes for re-use, recycling, recovery and disposal of all material that is not consumed[1]. The destinations reflect a hierarchy of best food use without suggesting any absolute order.

Section C, also a part of the agri-food system, covers the production of animal feed[2], which includes the production of crops for animal feed and in turn produces animals for processing.

Section D 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.

Building a technical framework for defining food waste

Using the general system of resource flows (Figure 1) FUSIONS proposes:

- clear boundaries for the "food supply chain", and
- a definition of "food waste" based on the food supply chain and destinations of resource flows.

The proposed definition for food waste is as follows:

Food waste is any food, and inedible parts of food, removed[3] 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 discarded to sea).

[1] Examples of B2 are extracting enzymes to create fibres for packaging material, bioplastics including polylactic acid (PLA) as main ingredient, rendering, etc. B5 refers to production of methane from fermentation processes, B6 refers to production of energy using resources other than methane, including bio-ethanol, for fuel, B7 refers to combined heat and power generation from incineration and B8 to incineration without energy recovery.
[2] Animal feed in Section C has its own production, processing and retail / marketing activities hence 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.
[3] 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.

The technical framework for defining food waste is presented below (Figure 2).

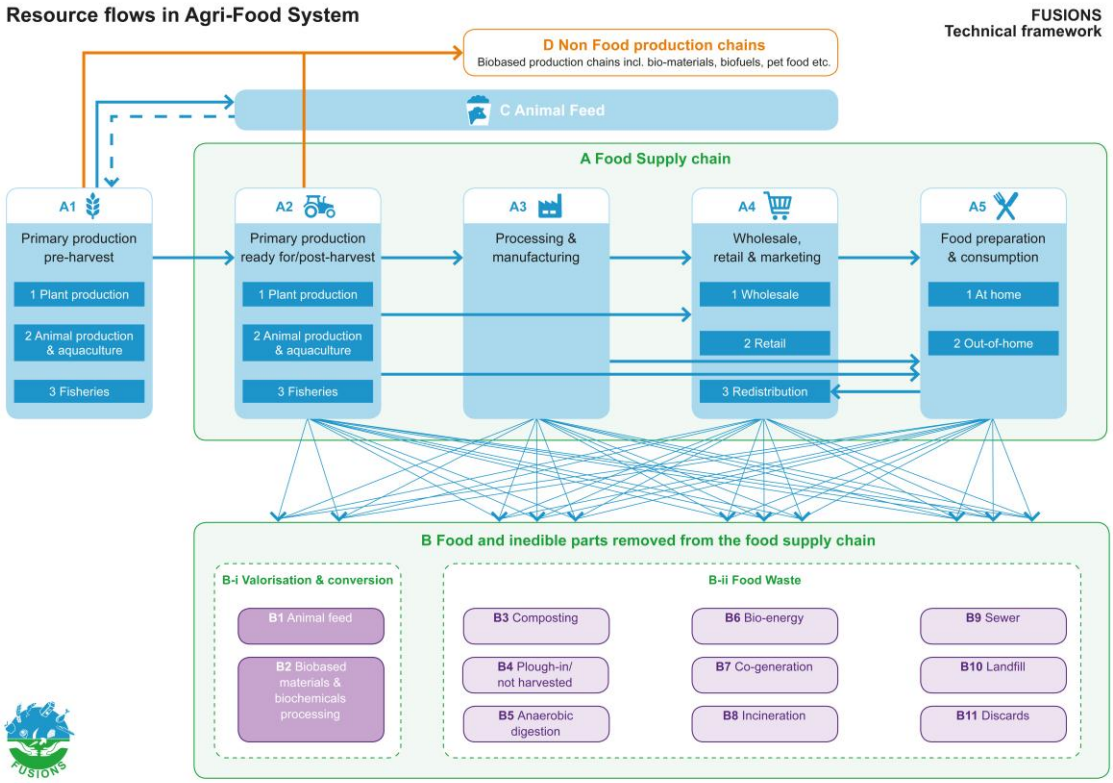


Figure 2. The FUSIONS technical framework defining the Food supply chain and Food waste

Section B-ii shows the FUSIONS proposal for 'food waste'. 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'. Any food, or inedible parts of food, sent to animal feed, bio-material processing or other industrial uses (B1-B2) are termed 'valorisation and conversion' and are distinct from 'food waste'.

Where possible the edible and inedible fractions should be separately analysed or estimated in order to allow for the development of accurate management strategies for the different resource flows[4]. However including both edible and inedible parts of food in the technical framework is a key to ensuring that the framework can be practically used by all stakeholders in the food supply chain, since it is not always feasible to separately collect edible and inedible parts of food. Furthermore, monitoring both edible and inedible fractions, together or separately, will ensure that the overall resource efficiency of the food system is taken into account when assessing its sustainability.

Redistribution, the act of donating food surplus to charity, is usually considered alongside other destinations in Section B. FUSIONS considers redistribution as a part of the food supply chain since the food is consumed, although the logistics and distribution activities are different from that originally planned. It may go on to be wasted and it is this

[4] *It is understood that a complete separation of edible and inedible parts of food is necessary for optimising the resource efficiency of the agri-food system. Taking into consideration the current level of waste analysis being undertaken, requiring such a separation is not considered a realistic approach. Therefore, within the forthcoming FUSIONS Manual, an approach for collecting waste data either combined, from which estimates of the edible and inedible fractions can then be calculated, or separately will be presented.*

resource flow that is of interest, hence it feeds into Section B in the same way as all other consumption routes.

A common understanding

The FUSIONS technical framework is based on the following definitions:

- *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"[5]. 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. It ends when the food is consumed (A5) or 'removed' (Section B) from the food supply chain.

The numbering in the 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.

Next steps

Having developed this framework, the FUSIONS Partners will undertake two key activities simultaneously. The analysis of existing datasets will be conducted to establish how existing data maps onto the new framework, to bring transparency to existing data and allow accurate comparisons to be made. Clearly there will be gaps in the datasets, so the other activity will be to develop a Food Waste Quantification Manual which will recommend suitable methodologies for quantifying food waste. It will be focused on delivering guidance for the European Commission and to Member States undertaking new work to quantify food waste so that over time, data gaps will be filled.

Conclusion

The current situation, in which many different definitions are used, leads to food waste estimates that include different fractions of resources which makes them difficult to compare and potentially difficult to monitor trends. The European Commission set FUSIONS the challenge of developing and consulting on a new definition that, over time, could help achieve harmonisation of how food waste is quantified.

The framework for defining food waste proposed by FUSIONS clearly separates and defines all resource flows in the food supply chain. A sub-set of destinations are termed 'food waste' with the goal of driving resource efficiency and improved use of all food resources.

The definitional framework goes further than many existing definitions by including fish discarded to sea and waste of any materials that are ready for harvest, but which are not harvested, as waste. It covers both food and drink waste, and hence both solid and liquid

[5] *EU Regulation No 178-2002:* http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF

disposal routes. It also, crucially, includes both food and inedible parts of food, such as banana skin and bones, in order to support the development of resource efficient and sustainable food systems, though where possible, deriving separate estimates for each of these fractions will be encouraged.

Encouraging everyone collecting food waste data to do so in line with this proposed framework would, over time, generate comparable estimates, at all stages of the food supply chain and across all EU28.

Contents

1 Introduction

The overall aim of FUSIONS is to *contribute* significantly to the harmonization of food waste monitoring; feasibility of social innovative measures for optimized food use in the food supply chain and the development of a Common Food Waste Policy for EU28. FUSIONS focus is on resource efficiency and it is promoting *food waste prevention* by optimising food use and waste prevention strategies.

The absence of a framework for defining food waste to date has led to the production of datasets that are not always comparable or transparent as to which fractions are included. The FUSIONS Project will deliver the definitional choices for food waste, suggest standard quantitative methodologies for measuring food waste, develop a food waste quantification manual and estimate EU-28 food waste levels based on the following outcomes:

- Report: "FUSIONS definitional framework for food waste" providing the main definitional choices for food and drink waste
- Report: "Standard approach on quantitative techniques to be used to estimate food waste levels", in progress, presents a selection of methods suitable for monitoring the resource flows leaving the food supply chain.
- Report: "Food waste quantification manual to monitor food waste amounts and progression" will recommend how to *practically measure* and quantify all resource flows in different steps of the food supply chain focusing on EU28. It will provide a harmonized method for representative, effective and meaningful quantification of food waste.
- Report: "Estimates of European food waste levels and analysis of food waste drivers" which will present an estimate of food waste amounts produced in EU28 by mapping existing datasets against this definitional framework . It will also provide input to the manual on what levels of quantification are feasible.

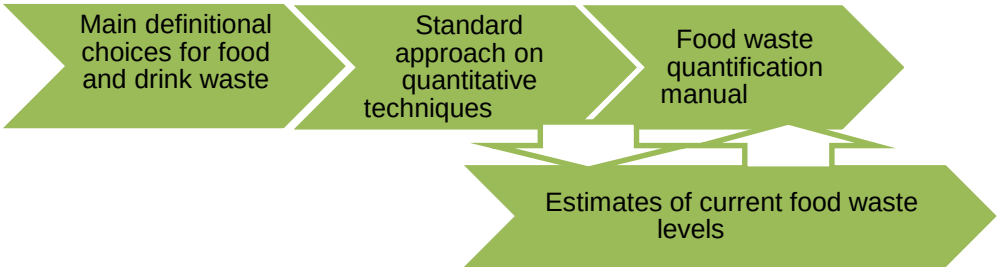


Figure 1 Related work on definition & quantification within FUSIONS

Having developed this framework, the FUSIONS Partners will undertake two key activities simultaneously. The analysis of existing datasets will be conducted to establish how existing data maps onto the new framework, to bring transparency to existing data and allow accurate comparisons to be made. Clearly there will be gaps in the datasets, so the other activity will be to develop a Food Waste Quantification Manual which will recommend suitable methodologies for quantifying food waste. It will be focused on delivering guidance to Member States undertaking new work to quantify food waste so that over time, data gaps will be filled.

This report presents the *FUSIONS theoretical framework,* by which we can separate and quantify all resource flows leaving the food supply chain. It establishes the system boundaries and definition of food waste, and provides general guidance on boundary conditions relating to food, the food supply chain and the edibility of food which will facilitate the collection of comparable data. Based on the FUSIONS theoretical framework a *technical framework* is given which presents the resource flows leaving the food supply chain which today are considered practically feasible to measure and monitor on a EU28 level. The technical framework will serve as the base for the Food waste quantification manual.

The outcomes are based on the criteria document (given in Annex A) and an extensive literature review (given in Annex B), the combined knowledge and experience of the FUSIONS Consortium. Further on it has been reviewed through a consultation processes with the FUSIONS multi-stakeholder platform.

2 Approach

Based on the resource flows in the food system, the FUSIONS framework has been built up systematically, *setting boundaries* and *providing definitions for*:

- "food"
- "food supply chain"
- "food waste" based on the destinations of resources leaving the food supply chain

The work on developing the framework has been carried out progressively by building consensus, step wise, according to the following order:

1. A literature review (see Annex B and E)
2. A criteria document to serve as a methodological reference point (see Annex A)
3. A workshop within FUSIONS to agree on a final version of the criteria document and the main definitional choices
4. A first suggestion of definitions and system boundaries
5. A project internal consultation process
6. A project external consultation process
7. Formulation of a final FUSIONS theoretical framework
8. Formulation of the technical framework for defining food waste within EU28

The Literature review was made for each step of the food supply chain in order to examine which definitions and system boundaries have previously been adopted, including environmental, economic & socio-economic aspects of food waste.

Analysis of the literature was made with regards to, for example, pros and cons of using different definitions; differences in definitions and system boundaries depending on the aim of the studies and lack of previous studies for certain steps of the supply chain.

The Criteria document (Annex A) was developed in order to create a common view within the working group on what criteria the suggested methodological framework should fulfil. It served as a reference point for all discussions leading to the suggested framework. All WP1 Partners took part in developing the criteria document.

At the internal project workshop in Lund, Sweden on March 4th, discussions were held on the issues and questions identified during the literature review. Some key questions were:

1. Which main aspects should be considered when defining food waste within FUSIONS, in order to reduce food waste and to increase resource efficiency?
2. Where should the "food supply chain" start according to FUSIONS, and why?
3. How should we define food waste in FUSIONS to promote waste prevention; efficient resource use and allow for waste monitoring?

A first suggestion for a definition and system boundaries, within FUSIONS, was compiled after the workshop. This suggestion was written by parts of the WP1 working group and was based on the previous discussions held during the workshop. The ambition was to present a clear argument for the agreements reached during, and the decisions made after, the workshop in Lund. The suggestion was sent out for consultation internally in April 2013 before the final draft for external consultation was finalised.

The external consultation process involved the first four regional platforms meeting held in May-June 2013, presentation of the definition for the External Expert Advisory Board (EEAB) in Paris June 2013, an internet survey carried out within the stakeholder platform in September 2013, presentation of the revised definition at the annual FUSIONS meeting in October 2013 and a final consultation round involving EEAB between December 2013-June 2014.

3 Resource flows in the agri-food system

The starting point for the FUSIONS theoretical framework is the generic, simplified system of resource flows in the agri-food system together with their destinations as described in Figure 2. The resource flows, including both edible and inedible parts of food, covers the flows from plant/vegetal production, animal production/aquaculture and fisheries.

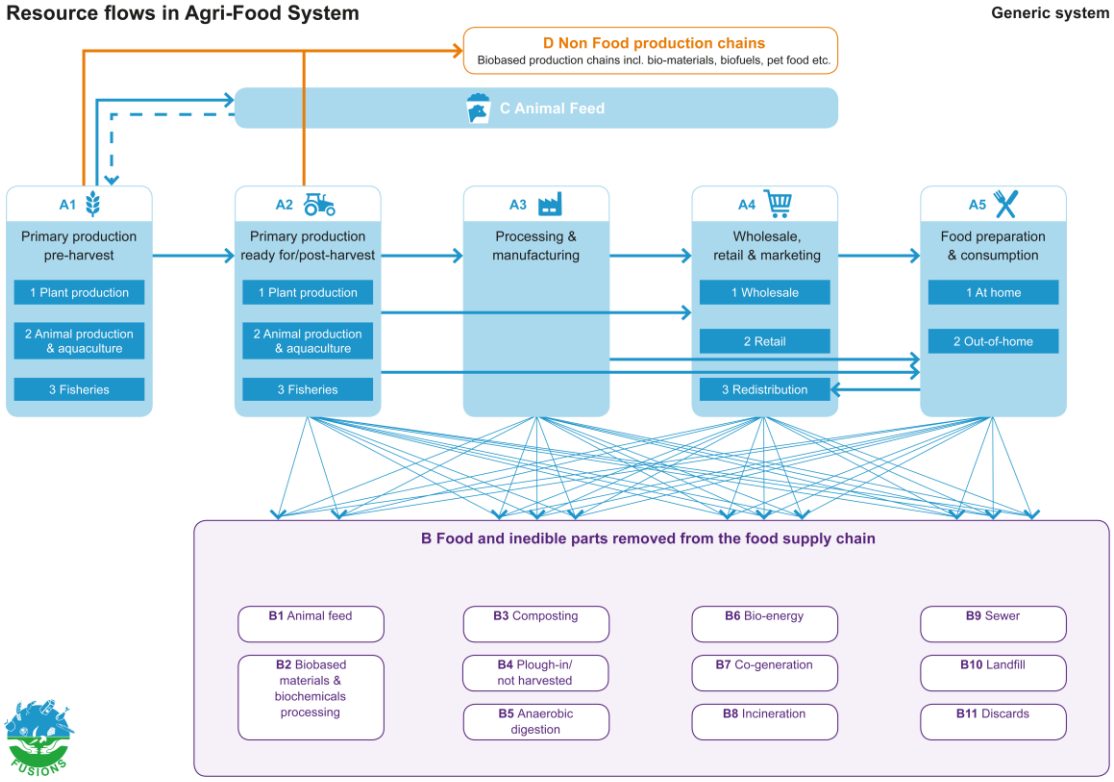


Figure 2 System of resource flows in the food supply chain, and their destinations

Section A, in Figure 2, presents the major steps in the agri-food system from production to consumption. The destinations (Section B) reflect different routes for re-use, recycling, recovery and disposal of all material that is not consumed[6]. The destinations reflect a hierarchy of best food use without suggesting any absolute order.

[6] *Examples of B2 are extracting enzymes to create fibres for packaging material, bioplastics including polylactic acid (PLA) as main ingredient, rendering, etc. B5 refers to production of methane from fermentation processes, B6 refers to production of energy using resources other than methane, including bio-ethanol, for fuel, B7 refers to combined heat and power generation from incineration and B8 to incineration without energy recovery.*

Section C, also a part of the agri-food system, covers the production of animal feed, which is both fed by the production of crops for animal feed and in turn produces animals for processing (A1). Animal feed in Section C has its own production, processing and retail / marketing activities hence 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 refers to the (further) processing of primary production resources specifically intended for non-food uses, such as crops grown for bio-fuel production. The arrows represent resources flowing from one major processing step to another.

4 The FUSIONS theoretical framework of resource flows leaving the food supply chain

The FUSIONS theoretical framework of resource flows leaving the food supply chain is provided in Figure 3 and is described in detail in the subsequent sections of this chapter. It is based on the system of resource flows being described in Figure 2, Chapter 3.

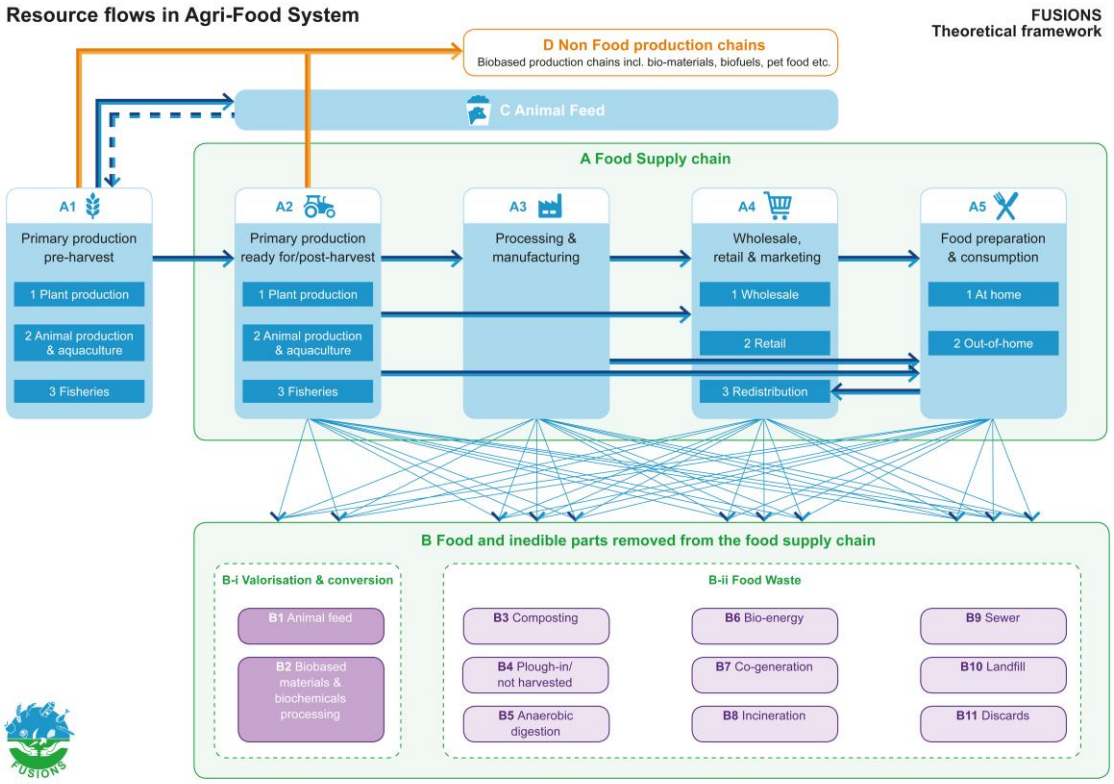


Figure 3 The FUSIONS theoretical framework

<u>Explanation:</u> The Food supply chain is described by boxes A2 to A5. Note that box A1 ends when the crop is ready for harvest or animal is ready for slaughter. "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'. 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 they are not putting food to its most productive use. Any food or inedible parts of food sent to animal feed, bio-material processing or other industrial uses (B1-B2) are termed 'valorisation and conversion' and are distinct from 'food waste'.

The FUSIONS theoretical framework is based on the criteria document (see Annex A) which states that the framework should provide a definite starting and end-point of the food supply chain. Furthermore the definition of food waste should follow the key criteria of being:

- Unambiguous
- Applicable to all types of food
- Applicable in all segments of the food supply chain
- Applicable to food supply chains at different levels; e.g. regional, national, sectorial or single companies / households
- Able to support the practical work on quantification, evaluation & monitoring and understanding different drivers of food waste
- Framed in the context of a mass

The FUSIONS theoretical framework provided in Figure 3 allows codification of any flow, edible or inedible, leaving the food supply chain. The codification represents important input to the up-coming work in FUSIONS with preparing the Quantification Manual recommending how to practically measure and quantify all resource flows in different steps of the food supply chain for improving the sustainability of the food system as a whole. To do this, all resource flows need to be described specifically. In this context the possibility to differentiate between the edible and inedible fraction are crucial since the optimal use of the fractions are different from a resource efficiency perspective.

4.1 Boundaries

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 usually considered alongside other destinations in Section B. FUSIONS considers redistribution as a part of the food supply chain since the food is consumed, 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 edible and inedible fractions should be separately analysed or estimated ensuring that the focus is on managing the resource flows (B) as resource efficient as possible.

4.2 Definitions

4.2.1 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[7] as well as the FAO/WHO Codex Alimentarus Commission on food safety (ALINORM 04/27/33A) Article 3[8]. The FUSIONS definition of "food" is given in table 1.

Table 1 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".

4.2.2 Food supply chain

The "food supply chain" produces, processes, distributes and consumes "food". The FUSIONS definition of "Food supply chain" is given in table 2.

Table 2 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

[7] EU Regulation No 178-2002: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF
[8] FAO/WHO Codex 04/27/33A: http://www.codexalimentarius.org/input/download/report/618/al0433ae.pdf#page=46

- 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) 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).

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.

4.2.3 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:

- Water incorporated into food, which is removed from the food supply chain, 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 down).

"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 (Figure 2)) but not a part of the food supply chain as defined by FUSIONS (Figure 3)
- Other industrial uses
- Bio-material processing
- Composted (at home or industrially)
- Land-spread
- Rendered; if not aimed for further processing in the food supply chain
- Anaerobically digested
- Used for biofuel production (e.g. biogas)
- Incinerated (with or without energy capture)
- Co-generation
- Made into briquettes and used in stoves

- Flushed down the sewer or to a controlled water course
- Sent to landfill
- Plough back into ground or not harvested
- Discarded at sea

"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. using fibre from vegetables 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 3, "food" and "inedible parts of food".

Table 3 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	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. FUSIONS does not introduce a third category - "potentially" edible (e.g. as used in UK[9]). Instead, a resource is either [edible] "food" or inedible. Determining what is edible and inedible will be further considered, and guidance given, as part of the Food Waste Quantification Manual.

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's 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's 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.

[9] http://www.wrap.org.uk/content/household-food-and-drink-waste-uk-2012

"Valorisation & conversion" and "food waste":
"Food and inedible parts removed from the food supply chain" can be utilized either for "valorisation and conversion" (B-i in Figure 3) or become "food waste" (B-ii in Figure 3). Depending on the destination, the fractions of "food and inedible parts removed from the food supply chain" are defined in Table 4.

Table 4 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)

5 The FUSIONS technical framework of resource flows leaving the food supply chain

The FUSIONS technical framework (Figure 4) has been developed from the theoretical framework (Figure 3) after having consulted the FUSIONS Stakeholder platform and the FUSIONS External Expert Advisory Board The only difference is that the technical framework does not separate edible and inedible fractions, but considers the total resource flow removed from the food supply chain.

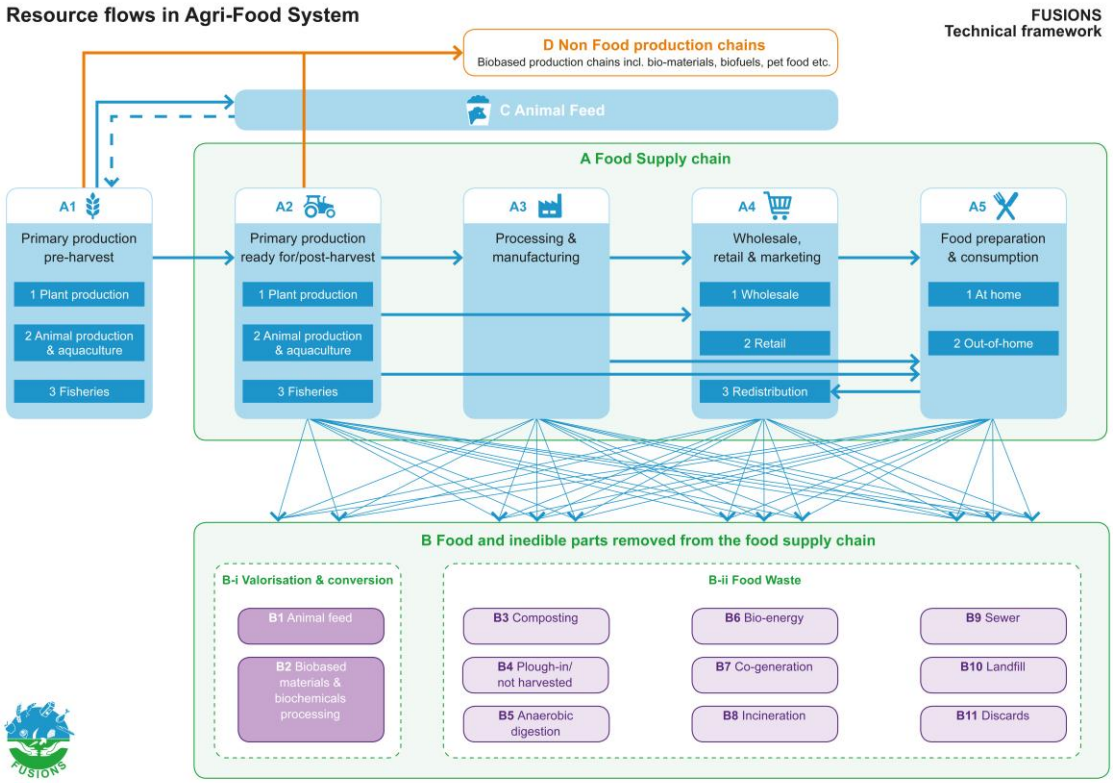


Figure 4 The FUSIONS technical framework

<u>Explanation:</u> The Food supply chain is described by boxes A1 to A5. "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 (B-ii) or disposed as food waste (B-ii). Box (B) covers the destination of all flows removed from the food supply chain.

The FUSIONS technical framework presents the basis for the up-coming work with developing the FUSIONS Quantification Manual, recommending how to *practically measure* and quantify all resource flows in different steps of the food supply chain, since the total (edible and inedible) resource flow leaving the food supply chain is what today is considered *practically* possible to measure and monitor on a EU28 level. Never the less 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).

6 Pre-harvest resource efficiency

The FUSIONS literature review (see Annex B) highlighted some in efficiencies before resources become part of the food supply chain (Table 5). Even though pre-harvest resource use is not within the scope of the FUSIONS framework the project seeks to highlight the importance of addressing these inefficiencies as part of any future work on improving the resource efficiency and sustainability of the agri-food production system in general.

Table 5 FUSIONS' definition and sub-fractions of unutilised Pre-harvest resources in the agri-food system, *not included* within the scope of the FUSIONS framework but recognized and highlighted for other or future initiatives

Pre-harvest resources	Biomass resources and raw materials in agriculture and seafood production systems with the potential to be eaten by humans but which are not part of the food supply chain	Un-utilized potentially edible resources in food production
		Un-utilized raw materials which are not yet ready to be eaten
		Inefficiencies in primary production of food

Examples of pre-harvest resources not recognized are;

- *Un-utilized potentially edible resources in food production:*
  Examples are male chickens and layer hens which are discarded due to not having a market value but which have the nutritional value to potentially be eaten by humans. These resources are not defined as food since they are not "*intended to be, or reasonably expected to be, ingested by humans*"[10]/"*intended for human consumption*"[11]. Whether or not these types of resources fall outside the definition of "food" differs between cultures of the world (most likely also within Europe), as well as across time.
- *Un-utilized raw materials which are not yet ready to be eaten:*
  Examples are livestock and crops being removed from the production system, whilst not fully grown or not ready for harvest but which have or have had the nutritional value to potentially be eaten by humans; the causes could be e.g. animal sickness, pests or weather conditions. In other words, these raw materials comprise a pre-stage for food; meaning they would have become food if they would have continued to grow and thereby become ready for slaughter/harvest.
- *Inefficiencies in food production, less food being produced compared to in an optimal production system:*
  Examples are;

  Differences between actual crop yields and potential crop yields – meaning that less crops are produced, than could have been produced, due to e.g. farmer practices; weather conditions etc.
  Differences between actual livestock yield and potential livestock yields– meaning fewer animals were produced, than could have been produced, due to e.g. animal sickness, poor living conditions, drought etc.

[10] EU Regulation No 178-2002: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF

The above mentioned examples of inefficiencies relate to existing or not yet produced resources and raw materials being a part of the economic/technical system for food production which have the potential to be eaten by humans, *but which are not defined as "food"* and which are therefore considered outside the scope of FUSIONS theoretical framework. In the case of "less food being produced in comparison with an optimal production system", the inefficiencies rather make up a gap between what could have been produced and what was actually produced, neither to be considered as "food".

The inefficiencies described above belong to the economic/technical system for food production but are still not a part of the "food supply chain" as defined by FUSIONS (Figure 4). In the future these inefficiencies need to be addressed when improving the resource efficiency of food production on a broader scale. Further on, there might be extensive business opportunities in improving different types of inefficiencies; e.g. by making food use of the resources and raw materials in the food supply chain which have the potential to be eaten by humans.

7 Discussion

The FUSIONS theoretical framework is designed to provide a new definition for, and clarify the meaning of various terms related to, 'food waste'. The FUSIONS theoretical framework covers *all* fractions removed from the food supply chain, edible parts as well as inedible parts, both being valorised and becoming food waste. The inclusion of specific fractions into the framework will remain a point of discussion, since there are cultural differences, various perspectives and interests that influence these classifications.

Also, different implementation levels of monitoring will influence the practical monitoring of food waste. For EU28, this will be further addressed in the upcoming FUSIONS' report "Food waste quantification manual to monitor food waste amounts and progression". The FUSIONS project thus intends to provide a foundation to support implementation of food waste monitoring. Below, a number of issues are considered that influence the inclusion of fractions into the monitoring framework.

By considering "food" and "inedible parts of food" as separate fractions within the theoretical framework will allow for separate measurement of these fractions, enabling targeted development of waste prevention and management strategies. Imagine the following example: Two food manufacturing companies produce the same amount (kg) of food waste; for the first factory the share of edible food waste is large and for the second factory the share of edible food waste is small. In this example, the first factory has higher resource efficiency in their production compared to the second factory. A larger fraction of the raw material is used for what it was first intended for, even though the total amount of food waste produced is the same.

FUSIONS theoretical framework is focused on reducing the mass of food and inedible parts of food removed from the food supply chain , which means that the primary measure should be by volume (tonnes) and this information can be used to calculate relevant impact indicators, such as the environmental, monetary, nutritional and social impacts. Monitoring the mass of edible and inedible parts of the food supply chain can be done in a robust way since the method is not affected by changing preconditions or context (and any changes in weight on the basis of added water content can be accurately estimated). In contrast, if the monetary value should be used as a base, this would be susceptible to changes in the economic conditions; e.g. material generated in the food supply chain that has to be paid to be taken away, may make a profit in the future and vice versa. There are calculation methods available to compensate for changes in economic conditions; these do however require input in mass as a starting point. A mass based approach allows indicators and time series of indicators to be adjusted retrospectively.

Decreases in the quality and nutritional value of food can be the *cause* of a food item, originally intended to be consumed, being removed from the food supply chain before being consumed. This must be recognized. Where the food supply chain functions poorly, this can be a key reason for food being wasted and should be considered as one of the main targets for FUSIONS. However, the causes of food being wasted should not serve as the basis for the definition. Nevertheless, understanding the root causes and pinpointing why food is wasted is a key step in improving the resource efficiency in the long term.

The FUSIONS theoretical framework separates resource flows removed from the food supply chain and inefficiencies that occur before entering the food supply chain. The main target when addressing "pre-harvest resources" is to make these resources available to the food supply chain. This is slightly different from preventing removal of resources,

both food and inedible parts of food, from the food supply chain. Furthermore, another advantage of separating "food and inedible parts of food removed from the food supply chain" from "pre-harvest resources" is that *food* is subject to specific rules according to the food law (e.g. traceability, food safety and labelling), which play a role in the generation of food waste and potentially provide solutions for its prevention. By addressing "food and inedible parts of food removed from the food supply chain" and "pre-harvest resources" separately, different solution strategies may be developed in a more efficient way. FUSIONS' primary target is the prevention of food and inedible parts of food to be removed from the "food supply chain".

Trade-offs between preventing resources from leaving the food supply chain and resource efficiency in the agri-food system may occasionally be necessary, e.g. when the prevention risks being less resource efficient than using the resources for other purposes than first intended (to consume it). Trade-offs, for example, may be necessary in the production stage due to varying quality of raw materials. Wheat, for example, produced for human consumption, may be unsuitable for flour production due to weather conditions which makes bio-energy production a better option, even though this was not the intention from the beginning. Using the wheat (=food) for bio-energy may, in this example, be considered a good option since a poor quality of flour may lead to an inferior quality of bakery products and possible food waste further down the chain. Thus, active decisions to sort out food or leave mature crops in the field may be rational and financially rewarding for the time being, but one needs to assess if this is the most resource efficient way to produce food in the long run. The definitional framework set by FUSIONS acknowledges that those harvest ready crops left in the field for resource efficiency reasons, are not considered as food waste, when they were not originally intended to be eaten or consumed.

The FUSIONS theoretical framework meets the requirements stated in the criteria document in an adequate way. The definition is framed in the context of a *mass based approach*. It is applicable to *all types of food* in *all steps and different levels of the food supply chain*. The definitions provided will also support the practical work on *quantification, evaluation & monitoring* of food waste. The definition was developed, as far as possible, to meet the requirement of being *unambiguous*. Furthermore, the framework provides a definite *starting point* of the food supply chain and a definite *end point* of the food supply chain.

Preventing and reducing food waste is only one part of increasing the resource efficiency of the food supply chain and the food system as a whole. In a wider perspective, the resource efficiency of the agri-food system needs to be considered in relation to other bio-based systems, e.g. when making decisions on what to produce and how to use the produced resources in an optimal way considering agriculture, fisheries, aquaculture and forestry. The FUSIONS approach will allow such integration.

Finally, encouraging everyone collecting food waste data to do so in line with this proposed framework would generate comparable estimates, at all stages of the food supply chain and across all EU28, and leads to a more harmonised approach.

A Annex Criteria document

A.1 Introduction

Early on, guidance was developed on what criteria the methodological framework, created through WP1, should fulfil. This need was identified in order that decisions at a detailed level (regarding e.g. which material streams should be considered as food waste or not) could be made and agreed upon by all contributors. Many questions needed answers, such as; Should we be restricted by current data availability? What are our geographical boundaries? Do we treat different steps of the food supply chain separately? What about different food products?

It was agreed that a document would be developed, which could guide our response to such questions and thereby underpin the methodological framework of FUSIONS.

A.2 Aim and goal

The aim of the criteria document is to act as a reference point for all discussions leading to the methodological framework suggested in WP1 and thereby support FUSIONS' goal to enable, encourage, engage and support key actors across Europe in delivering a 50% reduction in edible food waste and a 20% reduction in the food supply chains resource inputs by 2020 (FUSIONS' proposal 2011).

The goal of the criteria document is to create a common view within the WP1 working group on what criteria the suggested methodological framework should fulfil.

A.3 Method

A first version of the criteria document, including some initial suggestions, was sent to all WP1 task 1.1 and task 1.2 FUSIONS' partners. The document was sent to each partner one by one, in a pre-decided order, so that all partners did not edit the document at the same time. The partner receiving the document could add on new criteria and/or comment on those already suggested.

After the document had been commented on by all partners; a draft set of criteria was summarised and discussed at a WP1 workshop in Lund, Sweden on March 4th '2013. Following the meeting, a final version of the Criteria document was agreed.

A.3.1 Our key criteria

To determine the methodological basis of FUSIONS (definitions methodology and indicators; WP1), the framework should:

- Enable evaluation and monitoring of EU / EU-nations' waste prevention initiatives and policy goals on food waste prevention.

- Take into account the way data are collected today (level of detail and kind of data) using a reasonable combination of approximations.

- Give guidance on how to move forward within the suggested framework (i.e. to progress from how / what data are collected now to more comprehensive and granular data collection in the future).

- Allow evaluation of key environmental and socio-economic impacts from waste generation.

Furthermore:

- The framework should be applicable for both data gathered using national and international statistics as well as for data gathered through local / business-level studies:

    - In other words, the framework should be applicable for all relevant levels of the food supply chain; e.g. regional such as the EU; national such as specific countries; a city or a single company or production line.

    - And the framework should be applicable for all relevant sectors in the food supply chain; e.g. the agricultural sector or the household sector.

- The framework should take into account those data sets which are currently available and work to improve these

- The framework needs to be general, recognizing cultural and geographical differences and preferences

- The frame work should be developed considering on going global initiatives to optimise food use and improve food security.

- The framework should not be a unaffordable bureaucratic burden for the food supply chain actors but should rather motivate to and contribute to the ongoing internal waste reduction work

- The framework should provide consistent and reliable indicators for monitoring food waste generation for consecutive years to be able to compare food waste on a consistent basis between parts of the value chain, between different types of food and between nations as well as taking into account variation /differences in consumption, population and production.

- The methodology should be robust enough so that waste streams are visible, in other words, it should not be possible to 'move' waste beyond the scope of any definition e.g. by processing fish at sea, by processing vegetables in the field etc.

- It should provide explicit criteria, where appropriate, for what to include and not include in each part of the food supply chain, and indicate any inter-connections with non-food sectors that need to be taken into account.

- It should be clear how it relates to the Waste Framework Directive and supports the waste hierarchy.

The definitional choices of food waste:

- Unambiguous.

- Applicable to all types of food.

- Applicable in all parts of the food supply chain.

- Applicable to food supply chains at different levels; e.g. regional, national, local, sectorial or at the level of single companies / households.

- Support the practical work on quantification, evaluation & monitoring and understanding different drivers of food waste.

- Focused on recording mass of waste, from which other equivalents can be calculated (e.g. nutritional loss, embedded water used etc.)

Criteria relating to boundary issues:

- Provide a definite starting point of the food supply chain

- Provide a definite end point of the food supply chain

A.4 Discussion

The criteria document is a key document for FUSIONS because it provides the basis for all WP1 work. By actively involving all partners in the writing of the criteria and final editing of the document consensus on content and formulations was assured.

It should be emphasized that during the process there were never any major disagreements on the range of criteria set up.

B Annex Literature review

B.1 Summary

The steps of the food supply chain examined and reported on in *the literature review* were production, processing of farm staples, processing, wholesale and logistics, retail, markets, redistribution, food services and households. One of the major results from the literature review is that the same terms are used and defined differently in the studies and reports dealing with food waste. Commonly used terms are "food waste", "food loss", "avoidable food waste", "unavoidable food waste", "potentially avoidable food waste" etc. but these terms are *not* always defined in the same way. Some terms and definitions are very specific for the supply chain step for which they refer to and for the context in which they are used. Differences were also found regarding the basis of different definitions; meaning what's considered wasted when food goes to waste. Most definitions are based on a mass balance perspective, which means that the primary measure of food waste is mass. Other definitions take an economical perspective meaning that the primary measure of food waste is money. Some definitions include also nutritional aspects of food waste. One of the major questions which were highlighted in the literature review was; *what is food?* In order to define food waste, one must also define "food" and how food is defined decides *where the food supply chain starts.* Considering the environmental aspects of food waste, Life Cycle Assessments (LCAs) with ISO as the most commonly applied standard, was the most commonly used approach. Climate change, energy use, acidification, eutrophication and water use were identified as the most frequently used environmental impact indicators. Climate change was the most widely used indicator and is particularly relevant for food waste as it can capture all aspects of the food supply chain (e.g. emissions resulting from livestock as well as food transportation). The economic aspects relating to food waste found general economic issues related to food consumption (e.g. household expenditures, Consumer price index, Economic Intuition, FAO Commodity Price Indices); costs for raw materials used for production of later wasted food products; direct value/savings of wasted/prevented food (mostly edible/avoidable/partly avoidable food waste); costs for waste treatment of (food) waste respectively donation of food; costs appearing due to impact of food (waste) related issues in society (e.g. health cost due to over-eating and environmental costs due to (improper) food waste disposal). A large number of socio-economic issues were addressed in the reviewed literature. The most commonly used ways of relating socio-economic aspects to generated amounts of food waste was to consider number of persons in the household; type of household; age of persons in the household; settlement structure/house type/region; education of persons in the household; income of persons in the household respectively turn over in retail; consumption patterns; presence of animals and cultural issues. Other aspects found were food price; patterns with respect to price issues; responsibilities; employment; real or self-evaluated waste generation and provided waste system. Further on, various multi-variable socio-economic issues were used in some cases as well as national/global socio-economic issues and food waste related issues. The literature review was carried out during the fall and winter 2012 -2013.

B.2 Abbreviations

Short name	Name
BIOIS	BIO Intelligence Service
BOKU	Universität für Bodenkultur Wien
DLO	Wageningen UR - Food & Biobased Research
FAO	Food and Agriculture Organization of the United Nations
IFR	Institute of Food Research
IVL	IVL Swedish Environmental Research Institute
INRA	French National Institute for Agricultural Research
LCA	Life Cycle Assessment
MTT	MTT Agrifood Research Finland
SIK	The Swedish Institute for Food and Biotechnology
UNIBO	The University of Bologna

B.3 Introduction

The WP1 task 1.1 "Definitions and study of boundary issues" started out with an extensive literature review in order to explore the different food waste definitions and system boundaries which have been adopted so far in Europe and elsewhere.

In total, 11 literature review reports were written; one report for each step of the food supply chain as well as one for environmental and one for economic & socio-economic aspects of food waste. These reports act as the scientific background material for the definitions and system boundaries suggested within FUSIONS WP1.

The first-hand information is available in the FUSIONS internal literature review reports submitted by each review partner. This report summarizes some of the main questions highlighted for each step of the supply chain but includes the full review reports for the environmental and economic-/socio-economic aspects of food waste.

B.4 Aim and goal

The aim of this literature review is to support the work on definitional choices and boundary issues in that it served as scientific background material for the internal WP1 task1.1 and task1.2 workshop on food waste definitions and food supply chain boundary issues in Lund March 4^{th,} 2013.

The goal of the literature review reports is to present the key questions/points to inform FUSIONS decision-making, by:

- Give an overview of the number of studies reviewed in each step of the supply chain
- Give an overview of the most commonly used definitions for each step of the supply chain
- Give an overview of the system boundaries considered for food waste studies
- Highlight environmental indicators/impact categories used to describe the impact of food waste
- Highlight the socio-economic correlations used in studies on food waste generation/prevention

This section summarizes the overall results from the literature review.

B.5 Method

The literature review was carried out for separate steps of the food supply chain, and for environmental and economic & socio-economic aspects of food waste, separately. Each literature review was carried out by different FUSIONS partners, see Table 6.

To facilitate the literature review a FUSIONS data base was set up by the partners in WP1; growing to contain over 300 classified articles and reports. The reports were classified with regards to e.g. authors; year of publication; the food product(s) studied; the supply chain step(s) studied; if any environmental or socio-economic/economic aspects of food waste were highlighted and if the study provided important definitional choices and/or methodological approaches. The FUSIONS database was used to collect the references relevant for each literature review.

Table 6 The literature reviews within WP1 task 1.1 and the FUSIONS partners who carried out each literature review; (the responsible partner is underlined)

Literature review	FUSIONS partners
Production	UNIBO, INRA
Processing of farm staples	UNIBO
Processing	SIK
Wholesale and logistics	BOKU, Ostfold Research
Retail	Ostfold Research, BOKU
Markets	UNIBO, BOKU
Redistribution	BOKU, Ostfold Research
Food services	Ostfold Research, DLO
Households	WRAP, BOKU
Environmental aspects of relevance	BIOIS, SIK, Ostfold Research, BOKU
Socio-economic/economic aspects of relevance	BOKU, DLO

Different evaluation forms were used during the literature reviews, to help collect the information needed. These can be found in C.

B.6 Legal definitions referred to in the literature review

This literature review report refers to a number of legal definitions, below are the most frequently referred to legal definitions.

B.6.1 From the Waste Framework Directive

The following definitions are stated in the directive 2008/98/EC on waste (the Waste Framework Directive) [12]:

Definition of "waste":
"'*waste' means any substance or object which the holder discards or intends or is required to discard"*.

Definition of "bio-waste":
"'*bio-waste' means biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants".*

Definition of "by-product":

"1. A substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste referred to in point (1) of Article 3 but as being a by-product only if the following conditions are met:

(a) further use of the substance or object is certain;
(b) the substance or object can be used directly without any further processing other than normal industrial practice;
(c) the substance or object is produced as an integral part of a production process; and
(d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts".

B.6.2 From Regulation (EC) No 178/2002 on food law

The following definition is stated in the Regulation (EC) No 178/2002 on general principles and requirements of food law[13]:

[12] The Waste Framework Directive: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

[13] Regulation (EC) No 178/2002 on food law: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF

Definition of "food":

"For the purposes of this Regulation, 'food' (or 'foodstuff') means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans.

'Food' includes drink, chewing gum and any substance, including water, intentionally incorporated into the food during its manufacture, preparation or treatment. It includes water after the point of compliance as defined in Article 6 of Directive 98/83/EC and without prejudice to the requirements of Directives 80/778/EEC and 98/83/EC.

'Food' shall not include:
(a) feed;
(b) live animals unless they are prepared for placing on the market for human consumption;
(c) plants prior to harvesting;
(d) medicinal products within the meaning of Council Directives 65/65/EEC (1) and 92/73/EEC (2);
(e) cosmetics within the meaning of Council Directive 76/768/EEC (3);
(f) tobacco and tobacco products within the meaning of Council Directive 89/622/EEC (4);
(g) narcotic or psychotropic substances within the meaning of the United Nations Single Convention on Narcotic Drugs, 1961, and the United Nations Convention on Psychotropic Substances, 1971;
(h) residues and contaminants".

The following clarification of the food law was provided by the Directorate-General for Health and Consumers (DG SANCO) which states that "*inedible parts of a food (such as the inedible parts of a pineapple) are not intended to be, or reasonably expected to be ingested by humans and therefore they do not constitute 'food' in the meaning of Article 2 of Regulation (EC) No 178/2002. As regards the issue of meat, if the meat (unprocessed/processed) is intended to be, or reasonably expected to be ingested by humans (subject to certain conditions of use, e.g. cooking), then it also constitutes food. Inedible animal parts or animal parts that are not intended to be or reasonably expected to be ingested by humans, are not considered food. Finally, as indicated in Article 2 of Regulation (EC) No 178/2002 'food' shall not include, amongst others, live animals unless they are prepared for placing on the market for human consumption*[14]".

However, the Swedish National Food Agency recognizes some difficulties in the definition as responding to the same question and states that "*apple peels are to be considered as food since they are expected to be eaten and banana peels are also to be considered as food although the peels are not expected to be eaten*[15]".

It can be concluded that the definition of "food" is not fully clear according to the existing EU food law.

B.7 Results

B.7.1 Overview tables

Table 7 presents the number of references (from the FUSIONS database) which have been reviewed (as in read during the literature review) and which were found relevant

[14] Joanna Kniaz-Hawrot, Unit 04 – Communication, Health & Consumers Directorate-General European Commission, e-mail April 17th, 2013
[15] Svenska Livsmedelsverket (The Swedish National Food Agency), e-mail April 12th 2013

(as in actually included in the review report) for each step of the supply chain and for environmental and economic-/socio-economic aspects of food waste. Note that the review of different steps of the food supply chain may include the same references; thus the number of studies found relevant for each step of the supply chain cannot be summed up to estimate the number of studies found relevant for all supply chain steps together.

Table 7 Number of references reviewed, from the FUSIONS database

Step in supply chain	Filters used (except for supply chain step)	No. of studies reviewed	No. of studies found relevant
Production	Language: English	50	23
Processing of farm staples	Language: English	45	16
Processing	Provide important methodological approach: Yes	37	20
Wholesale and logistics	-	30	15
Retail	-	35	16
Markets	Language: English	24	0
Redistribution	-	8	2
Food services	Provide important methodological approach: Yes	22	13
Households	Language: English The paper is based on original data: yes	32	32
Environmental aspects of food waste	Provide estimates of environmental impact Scope: Europe and Global	49	42
Socio-economic and economic aspects of food waste	Provide socio-/socio-economic aspects of food waste	53	42

B.7.2 Main definitional choices

This report summarizes the overall results from the literature reviews carried out as a starting point of the work of WP1 task 1.1. The full first-hand results can be found in the complete literature review reports available as internal FUSIONS reports.

There is a difference between terminology and definitions; in that one term can be defined in several different ways. *A term* is a word which are used to refer to a certain thing (in this case a certain waste); and the *definition* describes the term. The definitions and terms found in the literature review are summarised in Annex Definitions.

One of the major results from the literature review is that the same terms are used and defined differently in the studies and reports dealing with food waste. Commonly used terms are "food waste", "food loss", "avoidable food waste", "unavoidable food waste", "potentially avoidable food waste" etc. but these terms are *not* always defined in the same way, see Annex Definitions.

Some terms and definitions are specific for the supply chain step for which they refer to and for the context in which they are used; e.g. the term "avoidable food waste" defined as "*waste from kitchen and from guests*" used in a study dealing with food waste in the food service sector (Martinsen 2012) in Table 20 in Annex Definitions from literature review or "pre-store waste" defined as "*…items rejected by the supermarket at delivery due to non-compliance with quality requirements…*" in Table 17 in Annex Definitions from literature review (Eriksson, Strid et al. 2012).

Differences were also found regarding the basis of different definitions; meaning what's considered wasted when food goes to waste. Most definitions are based on a mass base perspective which means that the primary measure of food waste is mass. Other definitions take an economical perspective meaning that the primary measure of food waste is money; e.g. "*products that are marked down by retailers and thereby do not achieve their full selling price*" (WRAP 2011) in Table 17 in Annex Definitions from literature review. Some definitions include also nutritional aspects of food waste, e.g. "*…including over-nutrition - the gap between the energy value of consumed food per capita and the energy value of food needed per capita*" (Smil 2004) in Table 13 in Annex Definitions from literature review, for more examples see Annex Definitions from literature review.

One of the major questions which were highlighted in the literature review was; *what is food?* In order to define food waste, one must also define "food". One example which brings these questions to light is the waste arising in the poultry sector. Current areas of inefficiency in the poultry sector include (for Switzerland) (no references found, but the context description in a research project):

- discarding laying hens after about 1 year of laying and treating spent hens partly as waste (1/3 of Swiss spent hens are currently disposed of);
- discarding male layer chickens at day 1 in life;

"Food" is defined by law; Article 2 of the regulation (EC) No 178/2002 of the European Parliament (EU 2002). Although theoretically these animals are edible, they are not defined as food since they are "*not intended to be, or reasonably expected to be ingested by humans*" (in Europe) due to economic and consumer acceptability reasons. It should be discussed whether these un-utilized potentially edible resources make up "food waste".

How food is defined decides *where the food supply chain starts?* Some definitions of food waste/losses include un-harvested crops (left in field); livestock pre-slaughter (dead during breeding or dead during transport to slaughter) or losses of milk due to mastitis and cow sickness. It should be discussed whether these losses at primary production should be distinguished from food losses and food waste further down in the supply chain; during processing, distribution and consumption.

A large number of studies use the term "food waste", which includes the term "waste" previously defined in the EU Waste Framework Directive (EU 2008). The directive defines waste as "*any substance or object which the holder discards or intends or is required to discard*" and bio-waste as "*biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants*". This means that the EU directive, which is an instrument to harmonize the jurisprudence the member States, does not include non-harvested products and food losses/waste at agricultural production step in the definition of waste.

Table 8 presents the papers and reports reviewed for each step of the food supply chain.

Table 8 The references reviewed for each literature review

Literature review	References reviewed
Production	*(Kantor 1997; Hospido and Sonesson 2005; Kelleher 2005; Ritz 2005; Petracci, Bianchi et al. 2006; Malena, Voslářová et al. 2007; Lundqvist, de Fraiture et al. 2008; Schneider 2008; Gooch 2010; Lyndhurst 2010; Parfitt, Barthel et al. 2010; Agreste_Les_Dossiers 2011; FAO 2011; Foresight 2011; French_Ministry_of_Ecology 2011; Hodges 2011; Mason 2011; Parfitt 2011; Reisinger 2011; BCFN 2012; Gunders 2012; Redlingshöfer 2012; Beretta, Stoessel et al. 2013)*
Processing of farm staples	*(Ritz 2005; Weidema 2008; Griffin, Sobal et al. 2009; Gooch 2010; Parfitt, Barthel et al. 2010; FAO 2011; Foresight 2011; Hodges 2011; Parfitt 2011; WRAP 2011; Buzby and Hyman 2012; Gunders 2012; Katajajuuri 2012; Kummu, de Moel et al. 2012; Redlingshöfer 2012; Silvennoinen 2012)*
Processing	*(AWARENET 2003; C-Tech_Innovation 2004; Somsen 2004; Gunnerfalk 2006; Svenberg 2007; Söderlund 2007; Morley 2008; Organics_Report 2009; Hanssen 2010; Monier 2010; WRAP 2010; Almeida 2011; FAO 2011; Hanssen 2011; Jensen 2011; Mena and Yurt 2011; WRAP 2011; WRAP 2011; Kummu, de Moel et al. 2012; Møller 2012)*
Wholesale and logistics	*(Milà i Canals, Cowell et al. 2007; Berlin, Sonesson et al. 2008; Lundqvist, de Fraiture et al. 2008; Weidema 2008; Hanssen 2010; Monier 2010; FAO 2011; Hanssen 2011; Stenmarck 2011; WRAP 2011; WRAP 2011; WRAP 2011; BCFN 2012; Kranert 2012; WRAP 2012)*
Retail	*(Hanssen 2008; Schneider 2009; Gustavsson 2010; Hanssen 2010; Buzby, Hyman et al. 2011; Hanssen 2011; Jensen 2011; Mena and Yurt 2011; Stenmarck 2011; Venkat 2011; WRAP 2011; WRAP 2011; Beretta 2012; Eriksson 2012; Eriksson, Strid et al. 2012; Silvennoinen 2012)*
Markets	*No studies were found relevant from the review of the supply chain step "markets".*
Redistribution	*(Alexander 2008; Mason 2011)*

Food services	*(Collison and Colwill 1987; Barton 2000; Li, Poon et al. 2003; Engström and Carlsson-Kanyama 2004; El-Mobaidh 2006; Pocock 2010; SRA 2010; French_Ministry_of_Ecology 2011; Jensen 2011; Mason 2011; Sonnino and McWilliam 2011; BCFN 2012; Martinsen 2012)*
Households	*(Wenlock 1980; OECD 2001; Lebersorger 2004; Wassermann 2005; FAO 2006; Obersteiner 2006; Muth 2007; Baker 2009; Bernhofer 2009; Glanz 2009; Griffin, Sobal et al. 2009; WRAP 2009; WRAP 2009; Monier 2010; Parfitt, Barthel et al. 2010; Selzer 2010; Almeida 2011; Evans 2011; FAO 2011; Foresight 2011; Lebersorger and Schneider 2011; NSW 2011; Pham 2011; WRAP 2011; WRAP 2011; BCFN 2012; Beretta 2012; Gunders 2012; Katajajuuri 2012; Kranert 2012; Sonigo 2012; Williams 2012)*
Environmental aspects of relevance	(OECD 2001; Hospido and Sonesson 2005; Alvemark 2007; Milà i Canals, Cowell et al. 2007; Mistry 2007; WRAP 2007; Berlin, Sonesson et al. 2008; Lundqvist, de Fraiture et al. 2008; Sonesson 2008; Weidema 2008; Cederberg 2009; Nellemann 2009; Wallman 2009; WRAP 2009; WRAP 2009; Franckx 2010; Gustavsson 2010; Hanssen 2010; Hanssen 2010; Lyndhurst 2010; Monier 2010; SRA 2010; WRAP 2010; Bernstad and la Cour Jansen 2011; Davis, Wallman et al. 2011; Defra 2011; French_Ministry_of_Ecology 2011; Hanssen 2011; Silvenius 2011; Silvenius, Katajajuuri et al. 2011; Williams and Wikström 2011; WRAP 2011; WRAP 2011; WRAP 2011; WRAP 2011; WRAP 2011; Beretta 2012; Bernstad and la Cour Jansen 2012; Hanssen 2012; Koivupuro 2012; Silvennoinen 2012; Soethoudt 2012; Sonigo 2012)
Socio-economic/economic aspects of relevance	(Wenlock 1980; Barton 2000; Lebersorger 2004; Somsen 2004; Wassermann 2005; FAO 2006; Obersteiner 2006; Hogg 2007; Alexander 2008; Lundqvist, de Fraiture et al. 2008; Weidema 2008; Bernhofer 2009; Darlington, Staikos et al. 2009; Glanz 2009; Huijps, De Vliegher et al. 2009; Nellemann 2009; Schneider 2009; Schneider 2009; WRAP 2009; WRAP 2009; Defra 2010; Franckx 2010; Monier 2010; Selzer 2010; WRAP 2010; Almeida 2011; Buzby, Hyman et al. 2011; Foresight 2011; Lebersorger and Schneider 2011; Pham 2011; Venkat 2011; World_Bank 2011; WRAP 2011; WRAP 2011; WRAP 2011; Doron 2012; Eriksson 2012; Koivupuro 2012; Nahman, de Lange et al. 2012; Redlingshöfer 2012; Williams 2012; WRAP 2012; WRAP 2012)

B.7.3 Production

There are quite diverse definitions used due to differences in study aims and frameworks. However, the definition given by FAO has frequently been adopted, with some formal changes (FAO 1981). The Parfitt (2010) and FAO (2011) studies have frequently been mentioned in recent papers (Parfitt, Barthel et al. 2010; FAO 2011), see Table 13 in Annex Definitions from literature review.

Literature on losses at primary production stage usually does not distinguish losses of edible and inedible parts of a food product. A reason may be that in many cases farm commodities (such as whole plants and whole animals) are not yet food products as they require processing/refining to become food products (slaughtering and cutting, milling, etc.). In other cases primary production already provides edible products (milk, fruits, vegetables, nuts etc.), see Table 13 in Annex Definitions from literature review and Table 22 in Annex System boundaries from literature review.

However, definitions used for the overall supply chain very often introduce a distinction between edible and non-edible (Kantor 1997; Lundqvist, de Fraiture et al. 2008; Monier 2010; Almeida 2011; FAO 2011; Hodges 2011; Mason 2011; Parfitt 2011), see Table 13 in Annex Definitions from literature review.

B.7.4 Processing of farm staples

Considering the analyzed segment of the supply chain - Processing of farm staples - reviewed reports do not suggest a specific definition of food waste clearly focused on this stage. Only in a very limited number of cases there was a clear reference to farm staples, mostly relating to the meat sector (Ritz 2005; Weidema 2008; WRAP 2011), see Table 14 in Annex Definitions from literature review. It is however not evident whether or not processing of meat can be considered "processing of farm staples".

These papers highlight how food waste might have a dual origin. The first is linked to losses related to meat processing. The average carcass cutting yield is about the 63% of the total with losses of edible and mostly inedible parts (bones, skin, etc..) (Weidema 2008). These losses could be decreased through a better separation of material, coupled with collaborative programs between abattoirs (WRAP 2011), see Table 23 in Annex System boundaries from literature review.

The second specific source of losses identified in the reports is related to the so called Dead-on-arrival (DOA) (Ritz 2005), see Table 23 in Annex System boundaries from literature review. In United States DOA annual average percentages for the period from 2000 to 2004 have been in the range from 0.35 to 0.37%. In national terms, this could represent an estimated annual loss of 29.7 to 31.4 million birds, based on the USDA 2003 broiler production estimate of 8.49 billion birds.

B.7.5 Processing

When quantifying food waste (especially avoidable food waste) in the manufacturing industries, problems are often found in how to separate data on avoidable food waste and by-products, which may be defined as edible/potentially edible (AWARENET 2003; Jensen 2011; WRAP 2011) or inedible (WRAP 2011).

Several reports use the wide definition of "waste" from the Waste Framework Directive (EU 2008) in which waste is referred to as "any substance or object which the holder discards or is required to discard". This broad definition makes it difficult to distinguish whether or not by-products from the food industry should be considered as waste or not. The European Commission has communicated some guidelines regarding the difference between "waste" and "by-products" drawn from the Waste Framework Directive, published in 2007 (EU 2007). This interpretative communication, on the difference between waste and by-products in a legal perspective, states that by-products from the food and drink industry used for animal feed fall outside the legal definition of "waste", see Table 24 in Annex System boundaries from literature review.

Weight loss is another major decision for the system boundaries of food waste in the industrial processing stage of the supply chain. How is water additions/losses regarded when studying, from a mass balance perspective, waste in a production system? Water is added bound to the raw material; as a raw material in its own and e.g. as added water during cleaning in the production process. Water losses are e.g. losses during evaporation (e.g. when baking bread); water bound in food waste or effluent water. If the moisture content of the raw materials entering the system is higher or lower than the products leaving the system, this introduces difficulties when quantifying waste from a mass balance perspective (C-Tech_Innovation 2004), see Table 15 in Annex Definitions from literature review and Table 24 in Annex System boundaries from literature review.

Food waste and packaging waste are not always separated in available food waste data (Morley 2008) (Organics_Report 2009). Sometimes companies collect data on "food waste"; "packaging waste" but also a "mixed food and packaging waste" fraction. Other reports have reported problems with separating food waste from other types of bio-waste (could be e.g. waste from plants etc.) (Jensen 2011), see Table 24 in Annex System boundaries from literature review.

B.7.6 Wholesale and logistics

The wholesale and logistic part of the food supply chain is not mentioned very prominent within the reviewed literature. Although it is mentioned in some research, information on the specific boundaries which were drawn is missing in most cases. Sometimes wholesale was surveyed together with other parts of the food supply chain (Monier 2010; WRAP 2011; WRAP 2011; WRAP 2012) and one cannot clear distinguish between the different stages. Also logistics was mentioned to be summarized with other parts of the food supply chain (Berlin, Sonesson et al. 2008; Monier 2010). Some approaches vary across the system, so that a general assumption is difficult to make and wholesale processes could be considered to be part of other steps of the supply chain, for example storage of apples could be mentioned to be part of processing of agricultural staple products or wholesale (Milà i Canals, Cowell et al. 2007), see Table 16 in Annex Definitions from literature review.

The reviewed product groups vary from a very general point of view (Monier 2010; Kranert 2012) to all food items of wholesale (Stenmarck 2011) or retail (Hanssen 2010; Hanssen 2011) to specific ones such as fresh meat (WRAP 2011) apples (Milà i Canals, Cowell et al. 2007), fish (WRAP 2011; WRAP 2012), dairy products (Berlin, Sonesson et al. 2008) or fruit and vegetable (WRAP 2011), see Table 25 in Annex System boundaries from literature review.

Some studies mention that within the data also mass of packaging material is included (Stenmarck 2011; Kranert 2012) while others do not state, if non-food wastes are included or not, see Table 25 in Annex System boundaries from literature review.

WRAP note that they exclude fish processed at sea and from aquaculture activities within their studies and therefore show a clear focus (WRAP 2012) while others state that they only consider negligible amounts of food which is returned to whole sale centers from retailers within their study (Hanssen 2010; Hanssen 2011). WRAP provide a very detailed list which describes the included meat wastes by cause and/or final disposal (WRAP 2011), see Table 25 in Annex System boundaries from literature review.

B.7.7 Retail

In the review process, there are three main approaches to the definitions of food waste categories, see Table 17 in Annex Definitions from literature review:

- Approach I where food waste is defined in different categories according to the place in the value chain where it appears, i.e. food loss is used for the upstream processes, whereas food waste is used for the downstream processes.
- Approach II where food waste is defined according to a functional dimension, with main categories like food waste, avoidable food waste and potentially avoidable food waste
- Approach III where food waste is defined according to a qualitative reduction of the qualitative, nutritional and/or monetary value of the product.

Food waste from the retail sector is comprised of finished products and covers all types of products that are distributed from producers to consumers. There are relatively few studies with primary data on food waste from retail shops, see Table 26 in Annex System boundaries from literature review.

System boundaries for the retail shops are well defined, but it is important to be aware of potential double counting of waste being redistributed to suppliers or including avoided food that are registered as not sold, but which is used in Deli departments, in canteens or given to food banks or charity organizations. One study distinguishes between pre-store food waste and in-store food waste. Pre-store waste is paid for by suppliers, but is wasted in the retail shops; see Table 26 in Annex System boundaries from literature review.

B.7.8 Markets

In the studies and reports reviewed, no specific definition was found that was specific for food waste in the markets segment. Only very few reports address food waste arising at markets. FAO (2011) stated that wet markets – together with wholesale, supermarkets, and retailers – are in the distribution segment of the supply chain (FAO 2011), but any other information that could help to explain the meaning of the food waste at this stage and the boundaries of this segment were not included. In addition, the study suggested that these kinds of markets (particularly farmers' markets) could be useful to reduce the amount of rejected crops, because they allow selling farm crops closer to consumers without having to pass the strict quality standards set up by supermarkets on weight, size and appearance, see Table 27 in Annex System boundaries from literature review.

Another report stated that unsold fresh produce from farmers' markets could be considered as recoverable food for human consumption. This can be interpreted as an indirect definition of food waste at this stage as "unsold food". However, no more information about the boundaries are included (Kantor 1997), see Table 27 in Annex System boundaries from literature review.

B.7.9 Redistribution

The redistribution part of the food supply chain is not mentioned very prominent within the reviewed literature. Although it is mentioned in some research, information on the specific system boundaries which were drawn is missing in most cases. Thus, only information from two studies could be used to describe the system boundaries more in detail (Alexander 2008; Mason 2011), see Table 19 in Annex Definitions from literature review.

The types of donated food products are similar to those offered by retailers and include pre-packed, fresh, frozen, canned and staple food, see Table 28 in Annex System boundaries from literature review.

The donated food could not be used for human consumption by 100 %, parts could not be accepted and has to be discarded at the donating company (Alexander 2008), see Table 28 in Annex System boundaries from literature review.

B.7.10 Food services

The main definitions used in the reviewed reports are "avoidable/unavoidable food waste" (7 out of 22 in total). The definitions have different wording, but the meaning is the same. One definition includes "overestimation of need and poor storage" (Mason 2011), which is quite interesting for food services. Some reports mentions overestimation of need as an important cause for food waste from plates, see Table 20 in Annex Definitions from literature review.

The activities producing food waste is for all the reports food services, contains activities in restaurants, catering and canteens. Restaurant seems to be a fairly homogeneous group, but catering and canteens are more complex. It is difficult to split catering and canteens, it seems more relevant to split on public services and private sector. In the report reviewed the public services consisted of hospital, schools, universities, prisons, institutions and the private of companies and flights, see Table 29 in Annex System boundaries from literature review.

B.7.11 Households

Certain reports include excessive nutrition as a form of food waste (Parfitt, Barthel et al. 2010; Almeida 2011; Foresight 2011; BCFN 2012). This perhaps derives from their focus on food security, human health and / or their use of nutrition data to estimate food waste arising. Including excessive nutrition certainly has its advantages in the broader context of a sustainable food system and healthy, sustainable diet. However, excessive nutrition is not a loss to human consumption or a waste, but could be viewed as inefficiency in the food system. It is recommended inefficiencies in the food system (which could also include sub-optimal agricultural productivity) are excluded from the FUSIONS definition of 'wasted food', see Table 21 in Annex Definitions from literature review.

There are several terms used to describe the extent to which 'wasted food' is 'edible'. The purpose of making a distinction is to target waste effectively for prevention (avoidable) or treatment (unavoidable). There is little disagreement in the literature on this point, however, there are a range of terms used, which merits discussion, see Table 21 in Annex Definitions from literature review.

- *Edible* – used to refer to material that could have been eaten. Mostly makes no distinction between what are elsewhere called 'possibly avoidable' or 'preference loss'.
- *Inedible* – used to refer to material that could not have been eaten, generally refers to what is elsewhere called 'unavoidable' or 'preparation residues' (Lebersorger 2004; Obersteiner 2006; Glanz 2009; Lebersorger and Schneider 2011; Beretta 2012; Kranert 2012).

On the face of it, this distinction is helpful & clear. However, an important note – waste may not be edible at the point of disposal – it may have spoiled prior to this point; but food that is inedible at the point of disposal should not be excluded (WRAP 2008; WRAP 2009; WRAP 2009; Katajajuuri 2012). By 'spoiled' we refer both to storage spoilage e.g. milk going sour, and preparation spoilage e.g. toast being burned.

A more important example relates to food that is thrown away after its use-by date has passed. This would be a food safety risk were it eaten at this point, but is none the less considered to be 'avoidable', because had the consumer planned more effectively, it could have been eaten before the use-by date expired. Consumers may believe that food that is 'inedible' at the point of disposal doesn't count as waste – indeed some literature makes this distinction (Wenlock 1980; Kranert 2012) and some consumers may 'wait' until the date has passed in order to justify throwing it away. It is essential that FUSIONS is clear that all food that was edible at the point of purchase is in scope, see Table 21 in Annex Definitions from literature review.

WRAP has, to date, made a distinction between what would be uncontested as edible and what some people prefer not to eat ('avoidable' and 'possibly avoidable'). This appears to be a useful distinction but would benefit from further discussion. While some reports use this middle category for mixed 'avoidable' and 'unavoidable' materials (Kranert 2012), gunge and dregs (WRAP 2008; WRAP 2009; Lebersorger and Schneider 2011; Kranert 2012) or spoiled food (Wenlock 1980), on the whole it refers to 'edible' / 'avoidable' food (WRAP 2008; WRAP 2009; WRAP 2009; WRAP 2011; WRAP 2011; Kranert 2012). Some reports use the term 'preference loss' (Beretta 2012) which more clearly indicates that it refers to foods some may eat but others may not eat simply because they find them unpalatable (Kranert 2012). But given it includes 'loss' this term is not recommended. Furthermore, FUSIONS could usefully take a position on reducing the quantity of food wasted due to personal taste. Bread crusts, potato skins and offal are excellent examples; see Table 21 in Annex Definitions from literature review.

Some studies discuss food waste at the household level as *planned or unplanned* (Almeida 2011; FAO 2011; BCFN 2012).

- Planned – used to refer to material that could have been eaten but wasn't, also called preparation waste and generally refers to what is elsewhere called 'unavoidable' or 'inedible'.
- Unplanned – used to refer to material that could have been eaten but wasn't, generally refers to what is elsewhere called 'avoidable' or 'edible'.

The system boundaries for this supply chain step are fairly straight forward. They include all wasted food and drink arising in the home. This is regardless of:

- its source: retail store, takeaway or hospitality outlet home grown (WRAP 2008; WRAP 2009; WRAP 2009; Parfitt, Barthel et al. 2010; WRAP 2011; WRAP 2011)
- its disposal route: collected by local authority (any waste stream), fed to pets, animals or birds, home composted, disposed to sewer (Muth 2007; WRAP 2008; WRAP 2009; WRAP 2009; WRAP 2011; WRAP 2011)

- its end-of-life treatment: landfill, in-vessel composting, anaerobic digestion (BCFN 2012)
- the reason it arises: preparation waste, leftovers, poor storage, too much purchased etc. (WRAP 2008; Glanz 2009; WRAP 2009; WRAP 2009; WRAP 2011)
- disposal point: after acquisition, during storage, during / after preparation (AWARENET 2003; Griffin, Sobal et al. 2009; Parfitt, Barthel et al. 2010; Foresight 2011)
- how much is thrown away: part used / prepared, unused / unopened
- whether it is edible (avoidable; even if inedible at point of disposal) or inedible (unavoidable) (see above)
- in general, where a system boundary is clearly described in the literature, it is in line with this description. Areas of difference relate to the extent to which food waste that's fed to pets, animals or birds, home composted and disposed to sewer are included. Being clear on this point is essential to make comparisons between arisings.

The proposed system boundary excludes any food that might be prepared in-home but is thrown away outside the home e.g. into litter bins, as street sweepings or in the workplace (WRAP 2011). Some studies combine both consumption in-home and out of home (Muth 2007; Almeida 2011; Foresight 2011) and while this is helpful to indicate the overall level of consumption and waste, the two elements should be clearly separated given the drivers, solutions and audience will differ.

Certain studies exclude certain products e.g. alcoholic drinks, confectionary (Wenlock 1980; Kranert 2012). While there may be reasons these have been excluded to do with their nutritional attributes, we consider excluding products to be arbitrary and value-laden. Furthermore, it may mask the wider environmental impact of wasted food (for example, the environmental impact of land used to grow chocolate, sewage treatment for products disposed to drain etc.) (WRAP 2009; WRAP 2011). It is worth noting that wasted food will often be used as a shorthand for both food & drink products.

It goes without saying, that wasted food relates to all products, regardless of whether they are part used / leftovers, or wholly unused (Lebersorger 2004; Obersteiner 2006; Bernhofer 2009; Glanz 2009; WRAP 2009; Selzer 2010; Lebersorger and Schneider 2011). Also that while packaging is useful to identify the product (Lebersorger and Schneider 2011) and estimate how much of the product was consumed (WRAP 2008), food-packaging is excluded. Bio-degradable kitchen waste (Monier 2010) is not a suitable shorthand since some packaging is now biodegradable.

A key area of uncertainty relates to windfall products e.g. apples and plums. Some will be captured in waste estimates (e.g. if home composted, prepared but not eaten) but not if the consumer simply leaves them untouched in the garden. This is furthermore a problem if estimates are derived from purchase and consumption data, since they won't be included in the majority of purchase data.

B.8 Environmental aspects of relevance

B.8.1 Introduction

Objectives
Task 1 of WP1 seeks to establish a standard approach on system boundaries and definitions of food waste to improve food waste quantification across the EU27. The objective of the current sub-task 1.1 on environmental aspects of relevance is to review existing environmental impact measures for food waste. This work will contribute to sub-task 1.2 which will propose a standard approach for system boundaries and definitions of food waste, including environmental impacts. It will also provide inputs for sub-task 1.4 which will further assess the socio-economic and environmental impacts of food waste, including methodological approaches and baseline estimates. The expected outcomes of sub-task 1.1 in relation to environmental impacts are to identify key environmental impact indicators for food waste and their assessment method which are relevant for further study.

Summary
In the current exercise a literature review was undertaken of 48 studies on the environmental impacts of food waste. Of the studies examined, the production step of the food chain was the most commonly examined, followed by processing/food industry, retail, households, and wholesale and logistics. The majority of studies focused on a single food-related sector. In terms of the geographic scope of the literature sources reviewed, the majority was national, slightly less than a quarter was European and a handful was global.

Of the 48 studies reviewed, 26 were Life Cycle Assessments (LCAs), with ISO as the most commonly applied standard. Climate change, energy use, acidification, eutrophication and water use were identified as the most frequently used environmental impact indicators. Climate change was the most widely used indicator and is particularly relevant for food waste as it can capture all aspects of the food chain (e.g. emissions resulting from livestock as well as food transportation from wholesalers to retailers). Climate change is also a concept and indicator which is generally understood by the public and is often used for environmental communication.

Other assessment methods than LCA often made reference to LCA data and included mass balance, environmental damage costs, and assessment of environmental costs and benefits. An important consideration for the continued analysis of the environmental impacts of food waste in FUSIONS is the potential overlap between sectors and steps of the food chain, as the results of LCAs on the food chain are strongly dependent on the division of sectors considered and the life cycle steps included.
The FUSIONS team proposes the further examination of the LCA method, using an ISO standard, in the sub-task 1.4. This method appears to be the most widely accepted for quantifying environmental impacts.

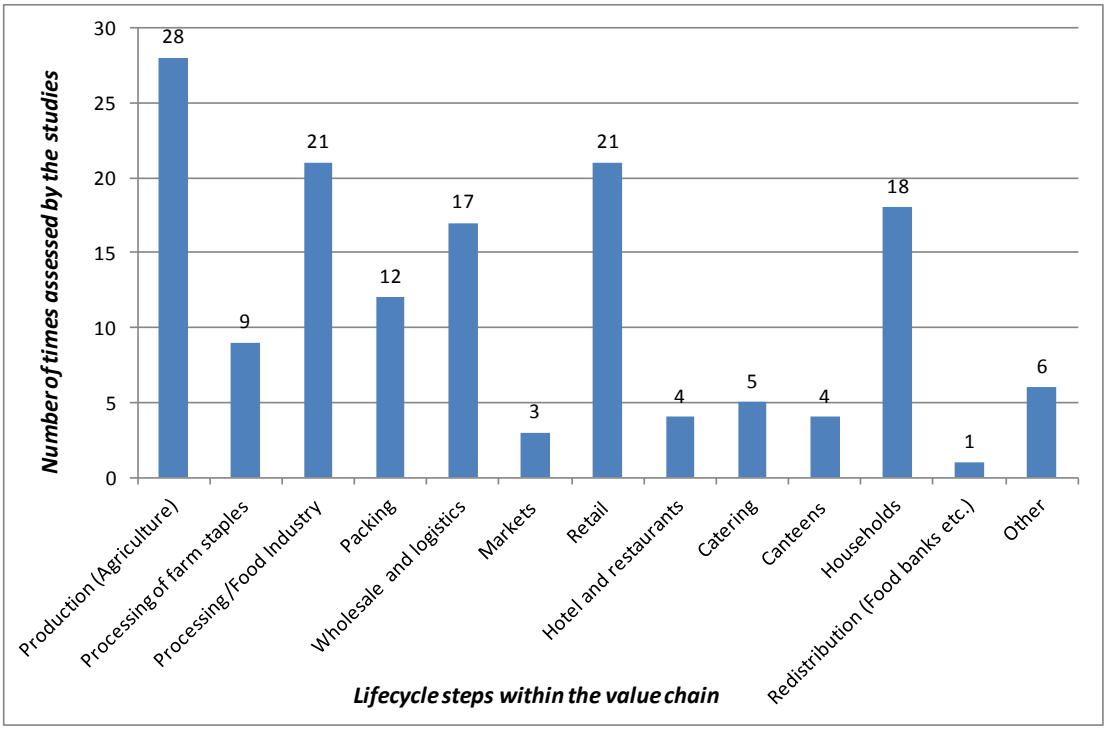
B.8.2 Profile of literature resources examined

A total of 49 studies were reviewed; 48 of which were analyzed. The studies selected for review were indicated in the FUSIONS literature database as providing estimations of the environmental impacts of food waste and having a European scope.[16] Those global studies considered to be the most relevant were also analyzed.[17] The profile of the literature resources examined is illustrated below in terms of:

- Lifecycle steps within the value chain
- Product groups or sectors
- Geographic scope

As can be seen in Figure 5 below, agricultural food production was the step of the food chain most commonly examined by the literature resources assessed. Other food chain steps examined with a high frequency by the studies include retail, processing/food industry, wholesale and logistics, and households.

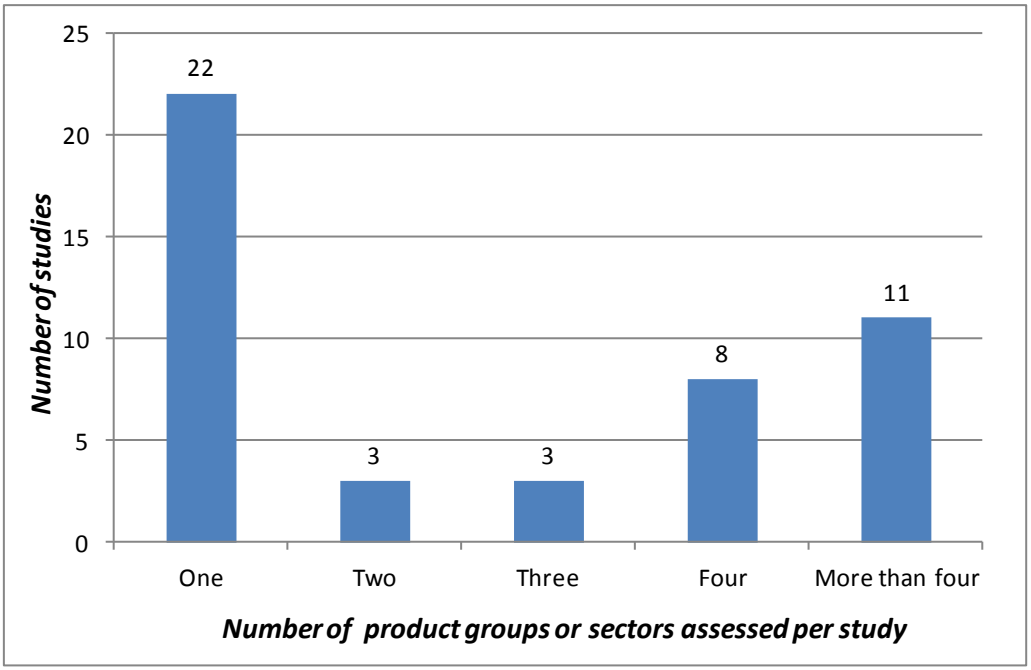
Figure 5: Lifecycle steps within the value chain assessed by the literature resources reviewed



[16] Filter "Provide Estimates of Environmental impact" (Column AK) in the FUSIONS literature database.
[17] Selection based on study author/organisation (well recognised), date (recent), and scope (global).

As shown in Figure 6, the majority of the literature resources assessed focused on one food waste-related sector or product group; a quarter considered over 4 sectors or product groups.

Figure 6: Number of product groups or sectors assessed in literature resources



In terms of the geographic scope of the literature sources reviewed, the majority were national, a quarter were European and a handful were global, as can be seen in Figure 7. Figure 8 provides further detail on the countries assessed in the national studies. Half were from the United Kingdom, a fifth were from Sweden and the remaining third represented a variety of European countries including Finland, Norway, Spain, Switzerland and Denmark. It is unsurprising that many UK studies were examined, as DEFRA and WRAP in the UK are have published a number of referential studies in the field of food waste research and policy in recent years.

Figure 7: Geographic scope of the literature resources reviewed

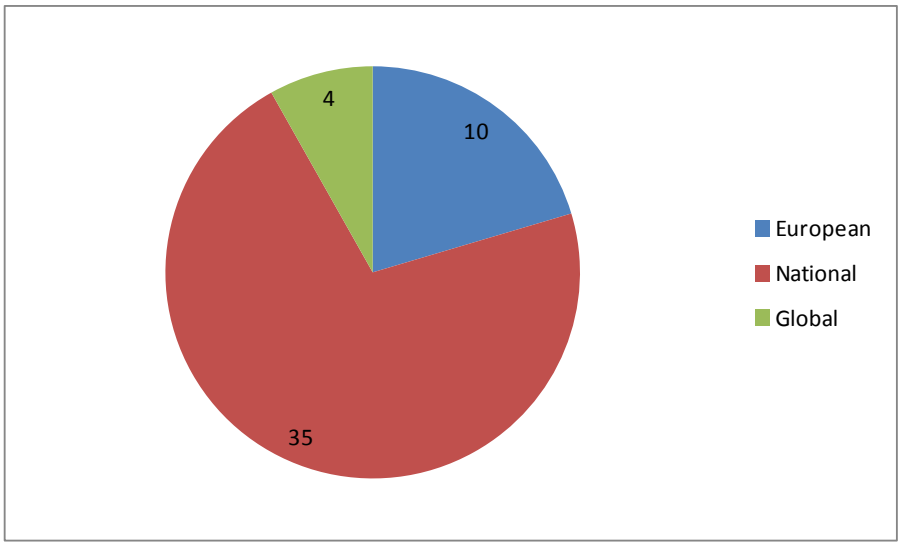
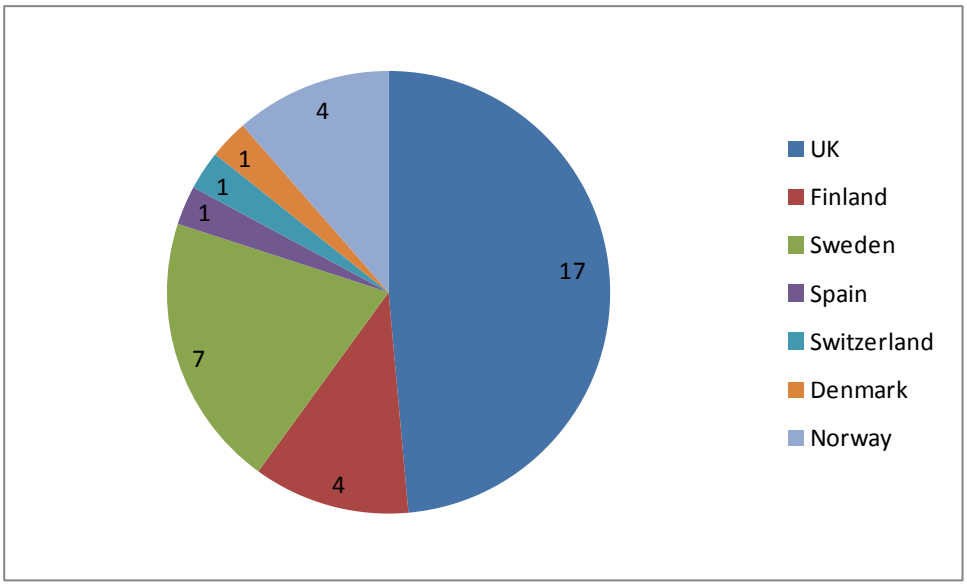


Figure 8: Detail on the geographic scope of the national literature resources reviewed



B.8.3 Environmental impacts generally relevant for food waste

Climate change, energy use, acidification, eutrophication and water use were identified as the most frequently used environmental impact indicators in the literature reviewed, as can be seen below in Figure 9.

Figure 9: Environmental impact indicators most frequently identified in literature resources reviewed

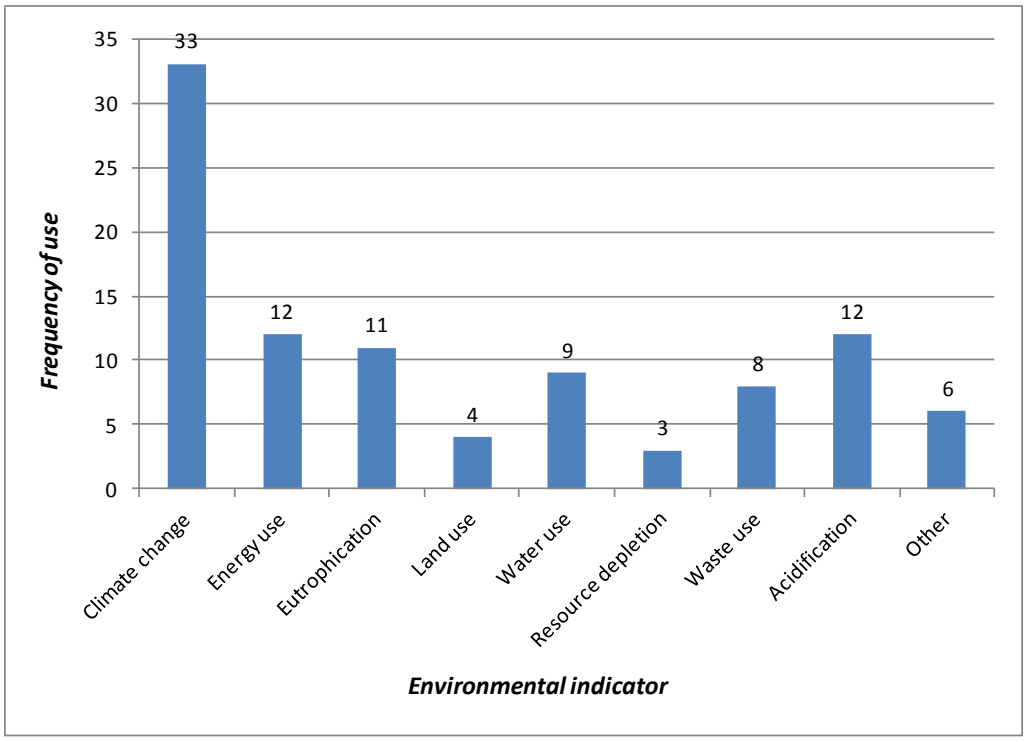


Table 9 below shows the most commonly identified environmental impact indicators and their units. A discussion follows on findings in relation to each indicator and its importance. All indicators were typically measured using a Life Cycle Assessment (LCA) approach.

Table 9: Most commonly identified environmental impacts and their units

Environmental impact	Unit
Climate change	CO2-eq
Energy use	MJ
Acidification	SO2-eq
Eutrophication	PO4-eq
Water use	m3

Climate change
Climate change potential, according to the JRC LCA glossary makes reference to "changes in the global, average surface-air temperature and subsequent change of various climate parameters and their effects such as storm frequency and intensity, rainfall intensity and frequency of floodings etc. Climate change is caused by the greenhouse effect which is induced by emission of greenhouse gases into the air."[18] In the literature resources examined climate change was typically represented in terms of CO2-eq and was referred to by various terms including Global Warming Potential (GWP) and GHG emissions. It was by far the most frequently used and discussed environmental indicator indicator for food waste. Climate change is a relevant indicator for food waste because it is globally accepted and can effectively capture all aspects of the food chain (e.g. emissions resulting from livestock as well as food transportation from wholesalers to retailers). Climate change is also a concept and indicator which is generally understood by the public and is often used for environmental communication.

Energy use
In the literature resources examined energy use typically made reference to primary energy consumption in terms of MJ or MJ/kg. Primary energy use is the energy found in raw fuels before conversion into more usable energy forms such as electricity; it can be renewable or non-renewable. Energy indicators related to the leakage of refrigerants (HFCs) and the use of oil equivalent were also cited in the literature reviewed. While the energy use is applicable along the food chain, it is particularly relevant for energy-intensive steps such as processing and transport.

Acidification
According to the JRC LCA glossary, acidification potential "is caused by direct outlets of acids or by outlets of gases that form acid in contact with air humidity and are deposited to soil and water. Examples are: Sulphur dioxide (SO2), Nitrogen oxides (NOx), Ammonia (NH3). Acid depositions have negative impacts on natural ecosystems and the man-made environment incl. buildings."[18] In the literature sources examined acidification potential was most commonly represented as sulfur dioxide equivalent (SO2-eq). Acidification is a particularly relevant indicator for the agriculture steps of the food chain and is also impacted by fossil fuel combustion which could take place throughout the food chain for electricity production, heating and transportation.

[18] Joint Research Council (Accessed 15 January 2013) *LCA Info Hub – Glossary*. JRC, Sevilla, Spain. http://lca.jrc.ec.europa.eu/lcainfohub/glossary.vm

Eutrophication
Eutrophication potential refers to "excessive enrichment of waters and continental surfaces with nutrients, and the associated adverse biological effects."[18] Eutrophication typically referred to aquatic eutrophication and was measured in terms of phosphate equivalent (PO4-eq); a few studies considered nitrate (NO3). One study also considered terrestrial eutrophication (m2 UES). As eutrophication is typically related to the entry of fertilizers and sewage into the aquatic system, the indicator is particularly relevant for agriculture and food processing.

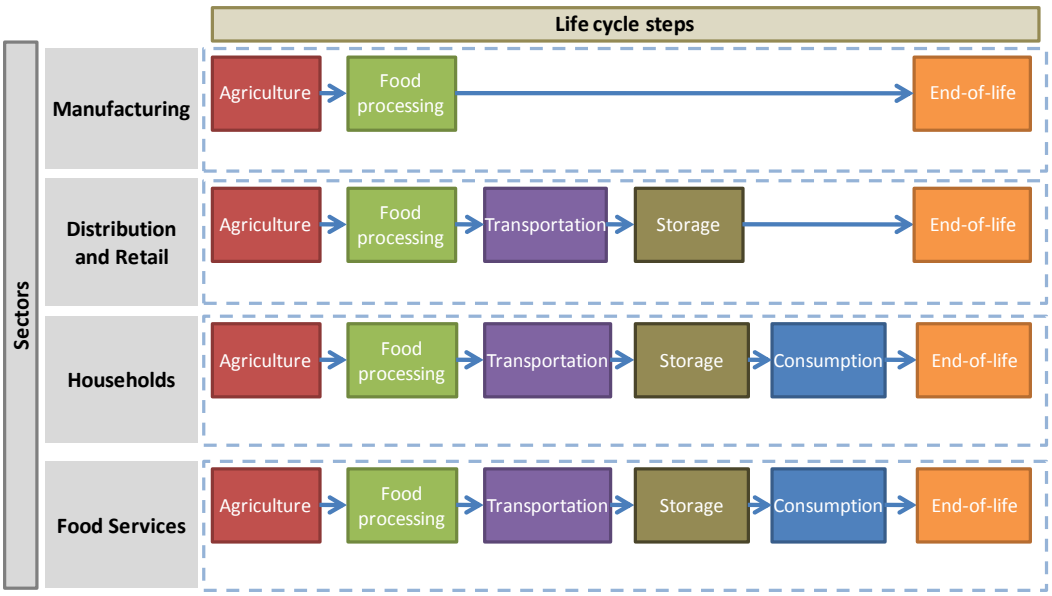
Water use
Water use refers to the amount of water used during different production steps of the food chain. In the literature resources examined water use was most commonly expressed in terms of cubic meters of water (m3) and shown on a number of different scales – by person, by year, etc. Reference was also made to a water foot print indicator, measured in terms of m3/year. Water use is a particularly relevant indicator for the agriculture steps of the food chain.

B.8.4 Environmental impacts relevant by step of the FSC

As discussed further above and visible in Figure 5, agricultural food production was the step of the food chain most commonly examined by the literature resources assessed. Other food chain steps examined with a high frequency by the studies include processing/food industry, retail, households and wholesale and logistics. The majority of the literature resources reviewed focused on one food waste-related sector, as can be seen in Figure 6.

An important consideration for the continued analysis of the environmental impacts of food waste in FUSIONS (notably Task 1.4) is the potential overlap between sectors and steps of the food chain, as can be seen below in Figure 10. The results of Life Cycle Assessments (LCAs) on the food chain are strongly dependent on the division of sectors considered and the life cycle steps included. The end-of-life treatment profile can also have an important impact.

Figure 10: Diagram showing lifecycle steps considered for each sector examined in the study "Preparatory Study on Food Waste Across EU 27"[19]



B.8.5 Methods in use for measuring the environmental impacts of food waste

Of the 48 studies assessed, 26 were LCAs, with ISO as the most commonly applied standard. The remaining studies involved a variety of approaches and often made reference to LCA data, for example via case studies inspired by LCA. Other assessment methods used were mass balance, environmental damage costs, and assessment of environmental costs and benefits. Some studies involved a general discussion of the environmental impacts of food waste rather than a quantification exercise.
The FUSIONS team proposes the further examination of the LCA method, using an ISO standard, in the sub-task 1.4. This method appears to be the most widely accepted for quantifying environmental impacts.

B.8.6 Limitations of the assessment

Studies which were entered into the FUSIONS literature database were selected and recommended by the FUSIONS project partners. Those studies considered in the current exercise were indicated in the FUSIONS literature database as containing information on the environmental impacts of food waste. All those studies with a focus on European countries were considered and a limited number of international studies were also assessed. Most studies dated from 2008 or afterwards, with 1 study from 2005 and 4 dating from 2007. Therefore the results of the current exercise can be considered as accurate for Europe.
However, further searching was not undertaken outside of those studies indicated by FUSIONS partners in the database, as it was assumed that the relevant studies would have largely been identified. More global studies could have been considered; however, the primary focus of the project was deemed to be European.

[19] Monier V., Escalon V., O'Connor C. (2010) *Preparatory Study on Food Waste Across EU 27*, European Commission, Brussels, Belgium.

B.9 Socio-economic and economic aspects of relevance

B.9.1 Introduction

The review process with respect to the socio-economic and economic aspects of relevance was based on the FUSIONS literature data base which was generated by the FUSIONS WP1 consortium. The literature which was included until January 8th, 2013 was screened.

The literature was classified by the participants of the FUSIONS consortium if relevant information with respect to socio-economic and economic aspects are included. Each relevant literature was marked with an "x" in the respective column. The organizations co-working on the topic, BOKU and DLO, screened all literature marked with an "x". In addition, if other literature seems to be relevant it was added to the review.

According to an agreement within the WP1 task leader which was set on December 10th, 2012, the main focus of the review was set on European studies. Therefore most of the studies from Oceania, Africa, Asia, Latin America were not reviewed up to now, while some others from the US were included (Buzby, Hyman et al. 2011).

Each co-worker conducted part of the review and filled in one standardized template per literature. The information from these templates was summarized after the review process in the present report.

Table 10 Information about the review

No. of studies "socio-economic & economic" in database	No. of studies reviewed	No. of studies relevant
63	53	42

In the FUSIONS database 63 studies were classified as "socio-economic and economic" studies at the beginning of the review. Within the 53 studies which were reviewed 2 were written in French, 6 in German and the remaining in English language.

B.9.2 Socio-economic aspects of relevance

Table 11 lists the socio-economic aspects with respect to food waste which were found in literature.

Table 11 Summary of the different socio-economic aspects researched in different parts of the food chain with respect to their influence on food waste and a list of the references which have been reviewed and in which each aspect has occurred.

Socio-economic aspect	description	References
Number of persons in household and food waste	e.g. single person households	(Wenlock 1980; Wassermann 2005; Glanz 2009; WRAP 2009; Monier 2010; Selzer 2010; Pham 2011; Koivupuro 2012)
Household size and self-stated disposal of edibles	never, seldom, sometimes, often	(Wassermann 2005)
Household size and costs of food and drink waste	in pounds/household.year	(WRAP 2009)
Age of people in household and food waste	e.g. young	(Glanz 2009; Monier 2010)
age of the oldest person in household and food waste		(Koivupuro 2012)
Age of interviewed persons and self-stated disposal of edibles	never, seldom, sometimes, often	(Wassermann 2005)
Barriers seen to reduce food waste and age of interviewed person		(Doron 2012)
Amount of food related waste and share of persons in employable age		(Wassermann 2005)
settlement structure and food waste	e.g. rural/urban; centre of larger city, suburb of a larger city, small city or town, smaller population centre, country side	(Wenlock 1980; Glanz 2009; Schneider 2009; Lebersorger and Schneider 2011; Koivupuro 2012)
house type and food waste	single or multi-family dwelling; owner occupied/rental; flat/detached house/row house	(Glanz 2009; Schneider 2009; Lebersorger and Schneider 2011; Koivupuro 2012)
Education and food waste	e.g. compulsory school, vocational school, school leaving examination, university	(Glanz 2009; Selzer 2010)
Education of interviewed persons and self-stated disposal of edibles	never, seldom, sometimes, often	(Wassermann 2005)
educational level and type of work of adults in the family (e.g. income class and type of employment of adults (full-time job, part-		(Koivupuro 2012)

time job, unemployed etc.) and food waste		
Income and food waste	e.g. < 750 Euro, 750 -1500 Euro, 1501-2250 Euro, >2251 Euro; Pesos per day; mass-related, Kcal per person and day; % share of dietary energy consumption; affluent areas/less affluent areas; low, middle, high	(Wenlock 1980; FAO 2006; Glanz 2009; Selzer 2010; WRAP 2010; Pham 2011; WRAP 2011; Nahman, de Lange et al. 2012)
Consumption behavior and food patterns and food waste		(Glanz 2009)
environmental consciousness and food waste	e.g. high environmental consciousness	(Williams 2012)
Distance between the place of residence and grocery store and food waste		(Koivupuro 2012)
Main way of going to the grocery store (by car, bike, foot or public transport) and food waste		(Koivupuro 2012)
Self-reported behavior with respect to planning and food waste		(WRAP 2011)
Using of shopping lists and food waste		(Selzer 2010; WRAP 2010)
Generation of food waste (low, medium, high) and usage of canned food (hardly ever, not often, often)		(Lebersorger 2004)
Generation of food waste (low, medium, high) and where meals are taken (more outside, partly outside, partly at home, mostly at home, only at home)		(Lebersorger 2004)
Generation of food waste (low, medium, high) and usage of fresh food (not often, often, very often)		(Lebersorger 2004)
Frequency of shopping and food waste		(Glanz 2009)
Eating food after passed expire date and food waste		(Glanz 2009)
Growing own vegetables and food waste		(Glanz 2009)
respondent's view of the effect of purchasing the most appropriate package sizes and food waste		(Koivupuro 2012; Williams 2012)

Feeding animals and food waste		(Glanz 2009)
Pets in the household and food waste		(Koivupuro 2012)
Cultural issues and food waste		(Glanz 2009)
Share of household budget spent on food per household and food waste		(Glanz 2009)
weight-based measure of food and drink purchases and food and drink waste		(WRAP 2011)
appreciation of low food prices and food waste		(Koivupuro 2012)
Agreement on "buying food on offer leads to more food being thrown away"	But no indication that this is really true	(WRAP 2011)
Price level of products and their wasted share		(Defra 2010)
food prices and food waste	influence of food prices on food waste (Consumer Price Index),	(WRAP 2010; WRAP 2011)
type of household and food waste	e.g. young singles, single middle age, young couple, couple middle age, old couple, single with child(ren), family with small child(ren), family with school child(ren), flat-sharing community	(Selzer 2010; Koivupuro 2012)
Percentage of edible purchases wasted by household type (single person, other)		(Defra 2010)
Households with and without children and food waste		(WRAP 2009; Selzer 2010; Koivupuro 2012)
Number of children in hh and food waste		(Wenlock 1980)
One person responsible for shopping, cooking and wasting and food waste		(Selzer 2010)
gender of person mainly responsible for grocery shopping and food waste		(Koivupuro 2012)
Type of employment and food waste	e.g. self-employed, fulltime, part-time, student, unemployed, retired	(Selzer 2010)
Amount of food related waste and share of persons with full-time employment		(Wassermann 2005)
Type of employment of interviewed persons and self-stated disposal of edibles	never, seldom, sometimes, often	(Wassermann 2005)

Self-evaluation of wastage and food waste	e.g. wasting little, rather little, rather much, much	(Selzer 2010; WRAP 2010)
self-reported levels of food waste and quantities of food waste generated		(WRAP 2011)
household view of potential to reduce food waste and food waste		(Koivupuro 2012)
Waste sorting habits (e.g. organic waste, other waste) and food waste		(Koivupuro 2012)
Generation of residual waste (low, medium, high) and frequency of spoilage of food (never, seldom, sometimes)		(Lebersorger 2004)
Generation of food waste (low, medium, high) and frequency of spoilage of food (never, seldom, sometimes)		(Lebersorger 2004)
Shopping (e.g. shopping frequency, type of grocery store), food preparation and eating habits (e.g. frequencies of cooking at home, eating out and eating ready meals) and food waste		(Koivupuro 2012; Williams 2012)
Age, education, household type as well as equivalent income level and frequency of spoilage of food (never, seldom, sometimes)		(Lebersorger 2004)
time spend at home during week, absence on weekend as well as number of vacation more than 5 days and frequency of spoilage of food		(Lebersorger 2004)
Socio-economic strata and food waste	4 strata (city, urban, suburban, rural) due to cluster analysis according to criteria: purchasing power, population density, household size, share of employed people within primary sector	(Obersteiner 2006)
Composition residual waste in the different areas (mass%)	nine test areas with different socio-demographic background	(Wassermann 2005)
Specific amount of preparation residues and leftovers in different areas	kg/inhabitant.year, nine test areas with different socio-demographic background	(Wassermann 2005)

Specific amount of superposed edibles original and superposed edibles partially used in different areas	kg/inhabitant.year, nine test areas with different socio-demographic background	(Wassermann 2005)
availability of a container for the collection of bio waste on the property and food waste	Yes/no	(Schneider 2009; Lebersorger and Schneider 2011)
collection system for waste and food waste		(Waldron 2004; WRAP 2010; WRAP 2011)
Friends and family are the most trusted sources of information about food waste.		(Doron 2012)
Effect on poverty relief of charity donation by British retailers		(Alexander 2008)
Household food intake and household income level		(FAO 2006)
Agreement that food waste should be addressed by authorities and businesses		(Doron 2012)
Population growth/ demographic evolution		(Franckx 2010; Monier 2010)
GDP	as an indicator for changing consumption patterns – relation between waste generation and GDP (decoupling)	(Franckx 2010)
Evolution of the Composition of the Generated Household Waste		(Franckx 2010)
Composition of the Generated Bio- Waste		(Franckx 2010)
Co st-benefit analysis	Very complex scenarios modelled within study for each member state with different policy options	(Franckx 2010)
Evolution in Collection Quantities Before and After Introduction of Garden Waste Collection		(Hogg 2007)
Home Composting	Effects of Home Composting in Terms of Reduction in Biowaste Delivered through Different Collection Routes (kg/household/year)	(Hogg 2007)
Garden Size	Scenarios based on different assumptions, e.g. Area with Garden Size more or less than 200 m^2 with different collection schemes, quantities and	(Hogg 2007)

	composition of waste	
Disposable income of household		(Monier 2010)
Food prices and infant and child mortality	food crisis could lead to an elevation of the mortality rate of infant and children under five years old by as much as 5–25% in several countries	(Nellemann 2009)
Income and population growth	Along with rising population are the increasing incomes of a large fraction of the world's population	(Nellemann 2009)
Income and diets	With growing incomes increasing consumption of food per capita results as well as changes in diets towards a higher proportion of meat and quantity of waste or discarded food – increases substantially	(Lundqvist, de Fraiture et al. 2008; Nellemann 2009)
price incentives	Poor transmission of price incentives to producers results in broadening the gap between consumers and producers, especially in periods of changing diets.	(Nellemann 2009)
food prices and the oil price	Correlation is shown	(Nellemann 2009)
supply of food and risk of over eating and wastage	with increasing supply of food – provided that access is ensured – the risk for over eating and wastage is likely to increase when food becomes more abundant in society.	(Lundqvist, de Fraiture et al. 2008)
Food supply and population groups		(Lundqvist, de Fraiture et al. 2008)
Over eating, costs and health	Overeating leads to poor health and increased costs to individuals, family and society	(Lundqvist, de Fraiture et al. 2008)

Table 11 shows a large number of socio-economic issues addressed in the reviewed literature. The issues were grouped according to similar content and separated with bold lines. To summarize it briefly, the most important issues are:

- Number of persons in household and generated food waste
- Age of persons in household and generated food waste
- Settlement structure/house type/region and generated food waste
- Education of persons in household and generated food waste
- Income of persons in household respectively turn over in retail and generated food waste
- Consumption patterns of persons in household and generated food waste
- Presence of animals and generated food waste
- Cultural issues and generated food waste
- Food price, patterns with respect to price issues and generated food waste
- Type of household and generated food waste
- Responsibilities and generated food waste
- Employment and generated food waste
- Real or self-evaluated waste generation and generated food waste
- Multi-variable socio-economic issues and generated food waste
- Provided waste system and generated food waste
- National/global socio-economic issues and food waste related issues

It has to be mentioned that a lot of the studies include much more issues than listed in Table 11 as here only that issues are presented which show a more or less direct link to food waste in a larger context.

The review was solely focused on the socio-economic issues of households respectively society and food waste. It could be discussed, if there also socio-economic issues from retail (Eriksson 2012) or catering (Barton 2000) – meaning food waste different turn-over of branches or wards - should be included.

Gender aspects appear very seldom, only one study reported about it (Koivupuro 2012). (Gender and socio-economic issues were however studied in WRAP report on consumer behaviour: http://www.wrap.org.uk/sites/files/wrap/Food%20behaviour%20consumer%20research%20quantitative%20jun%202007.pdf.

Looking at the descriptions and the used classifications, one can see that there is no consensus about the used classes. For example, to classify the income level some authors defined clear ranges in Euro (Selzer 2010) or used absolute values (FAO 2006), while others distinguish more subjectively between affluent and less affluent areas (Pham 2011). Besides other methodological issues, this often leads to the case that results cannot be compared to each other.

Although the results of the studies were not reviewed in detail and thus are not presented in this report, it should be mentioned that some socio-economic issues lead to inconsistent results. This means, that in some studies there was a correlation between the mentioned socio-economic issues and food waste generation and in others not.

B.9.3 Economic aspects of relevance

Table 12 lists the economic aspects with respect to food waste which were found in literature according to the part of the food chain. The identified parts of food chains are separated with bold lines.

Table 12 Summary of the different economic aspects reviewed according to the food chain; used units and a list of the references which have been reviewed and in which each aspect has occurred. If several references have been using the same aspect, list all references.

Part of food chain	Economic aspect	used units	References
Primary Production	storage costs	in mass equivalents and US$	(World_Bank 2011)
Primary production	Economic losses due to mastitis in dairy cows (cost estimation of production losses including missing milk production and discarded milk)	In euros per kg of non- produced milk and per kg of discarded milk	(Huijps, De Vliegher et al. 2009)
Processing /Food Industry	Loss by waste bread due to material costs and manpower as well as disposal costs respectively income from disposal paths (e.g. animal feed production)	Euro per year	(Salak-Johnsson 2009; Schneider 2009)
Processing /Food Industry	Costs for treatment/disposal of waste	Verbal description	(WRAP 2012)
Processing /Food Industry	economic benefits of other treatment options than fishmeal industry	Verbal description	(WRAP 2012)
Processing /Food Industry	production yield, losses during processing of poultry and potatoes for French fries – represents the costs of purchased raw material	Units were % of weight and Yield Index (without dimension) which is a ratio of realized yield in weight and maximum yield in weight	(Somsen 2004)
Processing /Food Industry	costs and volume (estimated number of products) waste for various aspects in the processing factory	In pounds per year, pounds per week	(Darlington, Staikos et al. 2009)
Processing /Food Industry	There is no incentive to reduce waste	Qualitative only	(Foresight 2011)
Wholesale and logistics	transport costs; cost for hired labour	Transport in percentage of total marketing costs; Labour in US$	(World_Bank 2011)
Wholesale	Food donations are	Verbal description	(Redlingshöfer

and logistics	included in calculation of the tax base of companies in France - encouraged distribution to food banks		2012)
Wholesale and logistics	avoidable waste	in billion USD per year	(Venkat 2011)
retailer	Retailer´s sale volume due to bulk sales	Qualitative description	(Almeida 2011)
retailer	Food donations are included in calculation of the tax base of companies in France - encouraged distribution to food banks	Verbal description	(Redlingshöfer 2012)
retailer	Do not have to pay for donations in Austria.	Verbal description	(Schneider 2009)
retailer	Do not have to pay for returned waste bread to bakeries.	Verbal description	(Schneider 2009)
retailer	shifting disposal costs from in-store waste to pre-store waste by increasing quality level of FFV	qualitative discussion	(Eriksson 2012)
Retailer	There is no incentive to reduce waste	Qualitative only	(Foresight 2011)
retailer	Costs connected to donation to FareShare	costs are only described qualitatively	(Alexander 2008)
retailer	Food loss is calculated in money on product (!) level for fruit and vegetables	money on product (!) level for fruit and vegetables	(Buzby, Hyman et al. 2011)
retailer	avoidable waste	in billion USD per year	(Venkat 2011)
markets	Food donations are included in calculation of the tax base of companies in France - encouraged distribution to food banks	Verbal description	(Redlingshöfer 2012)
Catering	cost of wasted food in different specialities of a hospital (25 wards)	Pounds per year	(Barton 2000)
Catering	costs associated with avoidable food waste from hospitality sector excluding hospitals, military, jails etc.; includes food costs, haulage and disposal to landfill	in million £, figures also given in pounds per tonne food waste	(WRAP 2011)
household	average consumer price of the product group	e.g. Euro/kg product group; pence (£) per gram of product	(Bernhofer 2009; Schneider 2009; Defra 2010; Kranert 2012)

household	Food purchase value according to invoices	Euro in sum, Euro per person and month, Euro per kg, Euro purchase value per kg	(Selzer 2010)
household	Consumer price index for food and non-alcoholic beverages compared to overall consumer price index (CPI) from 2007 to 2010 is displayed	-	(WRAP 2010)
household	influence of food prices on food waste; Impact of rising food prices on food expenditure patterns	Consumer Price Index, qualitatively discussed	(WRAP 2010; WRAP 2011)
household	influence of household income on food waste		(WRAP 2011)
household	Food loss for fruit and vegetables	money on product (!) level for fruit and vegetables	(Buzby, Hyman et al. 2011)
household	economic value of avoidable and partly (optional) avoidable food waste (product groups)	EURO/cap.yr, Euro/4-person household and year, billion Euro/yr	(Schneider 2009; Kranert 2012)
household	economic value of avoidable and partly (optional) avoidable food waste (product groups)	Euro per stratum (rural, urban) and year, Euro in the region and year, share of consumer expenditures	(Schneider 2009)
household	economic value of avoidable and partly (optional) avoidable food waste (product groups)	Euro wasted value per kg, Euro per type of household	(Selzer 2010)
household	economic value of avoidable food waste (original and partly used)	minimum, average and maximum cost in Euro per household and year	(Bernhofer 2009)
household	Economic value of edible purchases	% of edible purchases that is wasted by product groups as well as for specific products; cost of Fruit and vegetables wasted by all UK households in million pounds	(Defra 2010)
household	economic value of avoidable food waste (original and partly used)	Pounds per UK; pounds per household (also split into product groups and according to causes for wastage), share of household expenditures for food	(WRAP 2009; WRAP 2009)

Household	Value of avoidable waste	in billion USD per year	(Venkat 2011)
Household	savings of prevented food waste	in million pounds	(WRAP 2010)
Household	Food waste on national level; also split up by socio-economic class	billion Rand/year	(Nahman, de Lange et al. 2012)
household	Cost for wasted meat	pounds	(WRAP 2012)
household	share of product groups on economic value (minimum, average and maximum costs)	%	(Bernhofer 2009)
household	Share of household expenditures on food	%	(Glanz 2009)
household	Financial costs of wasted food		(Franckx 2010)
household	Economic value of food waste	in GBP	(Lundqvist, de Fraiture et al. 2008)
household	price incentives for prevention of food waste	-	(Lundqvist, de Fraiture et al. 2008)
household	Correlation between food waste generation and change in disposable income, for EU15, EU12 and EU 27	-	(Monier 2010)
households	Economic Intuition from the Consumers' Perspective	modelled using a mathematic formula	(Almeida 2011)
redistribution	Costs connected to donation to FareShare	only described qualitatively	(Alexander 2008)
Waste treatment	Cost of separate collection followed by composting	Euro/tonne	(Monier 2010)
Waste treatment	Cost of separate collection of bio-waste followed by anaerobic digestion	Euro/tonne	(Monier 2010)
Waste treatment	assessment of different scenarios with respect to economic costs	Qualitative with --- to +++	(Monier 2010)
Waste treatment	qualitative assessment of costs for implementation of scenarios for Europe and Member States	sometimes only „minor" or „high", sometimes in Euro	(Monier 2010)
Waste treatment	haulage costs included in collection costs		(Hogg 2007)
Waste treatment	effluent charges	Verbal description	(WRAP 2012)
Waste treatment	reducing cost for disposal due to source separation	Verbal description	(WRAP 2012)

Per EU member state	financial costs and the environmental costs and benefits for different approaches of bio-waste management	Million Euro	(Franckx 2010)
Per EU member state	Environmental Damage Costs of Each Scenario	Million Euro	(Franckx 2010)
Per EU member state	Cost of treatment methods, financial cost for home composting for authority; costs for collection of separate collection schemes and many others	ITL/kg; SKK/day, SKK/yr; Euro/inhab.yr; pounds/hh.yr	(Franckx 2010)
Per EU member state	Indicative External Damage Costs for the Landfill of Food Waste	in Euro	(Franckx 2010)
US	avoidable waste	in billion USD per year, also per capita	(Venkat 2011)
Sub-Saharan Africa	value of Post-harvest Losses in Sub- Saharan Africa	US$4 billion a year	(World_Bank 2011)
Not to classify	Economic Intuition from the Firms' Perspective	modelled in theory by using several mathematic formula	(Almeida 2011)
Not to classify	Cost of flour losses and Cost of bread losses	calculated within case study in CHF	(Almeida 2011)
Not to classify	cost for the composting of garden waste and food waste	in £ per tonne	(Hogg 2007)
Not to classify	Costs for Separate and Joint Treatment of Food Waste and Kitchen Waste Under Varying Assumptions Concerning Proportions Collected and Treatment Costs and others	in £ per tonne	(Hogg 2007)
Not to classify	cost saving due to better household meal planning (including purchased food and associated waste treatment amounts)	Million Euro	(Weidema 2008)
Not to classify	FAO Food price index	-	(Nellemann 2009)
Not to classify	FAO Commodity Price Indices	-	(Nellemann 2009)
Not to classify	relation food & oil prices	-	(Nellemann 2009)
Not to classify	cost due to overeating for individual, household and society		(Lundqvist, de Fraiture et al. 2008)
Not to classify	loss of total economic value due to reduced		(Lundqvist, de Fraiture et al.

	quality		2008)
Not to classify	economic loss of dairy products in different countries	in USD	(Lundqvist, de Fraiture et al. 2008)
Not to classify	increase sales and reduces disposal costs due to alternative usage of animal carcasses	Million pounds	(WRAP 2012)
Not to classify	Marginal benefit to society of reduced waste	SEK/kg	(Eriksson 2012)
Not to classify	Marginal benefit to individual or company of reduced waste	SEK/kg	(Eriksson 2012)

It has to be mentioned that more economic data are available from the reviewed literature (Nellemann 2009; Franckx 2010) as the review was focused on the context of economic issue and food waste.

It can be summarized that most literature deals with economic issues at household level while the food chain parts of primary production (World_Bank 2011), markets (Redlingshöfer 2012), catering (Barton 2000; WRAP 2011) and redistribution (Alexander 2008) are under-represented. One reason for that could be that the mentioned food chain parts are in some cases part of a more aggregated point of view and are not mentioned in particular. As it can be seen in the lower part of Table 12, some literature could not be classified according the food supply chain parts to a specific stakeholder.

The economic aspects listed in Table 12 deal with different issues:

- General economic issues related to food consumption (e.g. household expenditures, Consumer price index, Economic Intuition, FAO Commodity Price Indices)
- Costs for raw materials used for production of later wasted food products
- Direct value/savings of wasted/prevented food (mostly edible/avoidable/partly avoidable food waste)
- Costs for waste treatment of (food) waste respectively donation of food
- Costs appearing due to impact of food (waste) related issues in society (e.g. health cost due to over-eating, environmental cost due to (improper) food waste disposal)

Another aspect which can be seen in the results of the review is that economic aspects often are discussed in a qualitative way without presenting specific values (Alexander 2008; Almeida 2011; Foresight 2011; Redlingshöfer 2012; WRAP 2012). Thus, the potential impacts of different scenarios on the economic performance of a company or society system are shown.

In case that an absolute value is provided, often a total amount of money lost due to wasted food (Lundqvist, de Fraiture et al. 2008; Defra 2010) was calculated while others also provide data on specific value per household (Schneider 2009; WRAP 2009; Kranert 2012), per capita (Schneider 2009; Kranert 2012), per socio-economic class (Nahman, de Lange et al. 2012) or per wasted food product group (WRAP 2009; WRAP 2012). Some literature claims that economic issues could be seen as positive incentive to prevent food waste. One example is that donations could be calculated for tax reduction (Redlingshöfer 2012) or that they are free of charge for the companies (Schneider 2009). Others report that some economic issues also serve as negative incentive to prevent food waste. One study noted that retailers do not have to pay for their waste bread as they

could return it to the suppliers without paying for the bread or the disposal which is no incentive for prevention on retail level (Schneider 2009)l. Another stated that retailers have no incentive to reduce waste (Foresight 2011).

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C Annex Definitions from literature review

Table 13 Summary for production of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Overview reports		
Food waste	1. Wholesome edible material intended for human consumption, arising at any point in the food supply chain (FSC) that is instead discarded, lost, degraded or consumed by pests (FAO 1981);. 2. As (1), but including edible material that is intentionally fed to animals or is a by-product of food processing diverted away from the human food (Stuart 2009). 3. As definitions (1) and (2) but including over-nutrition - the gap between the energy value of consumed food per capita and the energy value of food needed per capita (Smil 2004).	(Parfitt, Barthel et al. 2010) (Parfitt 2011) (Foresight 2011)
Food waste	Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behavior.	(FAO 2011)
Food waste	*Food Waste* is the waste that takes place during industrial processing, distribution, and final consumption. Also included in this are intentional choices, based on which perfectly edible food is discarded and "thrown away."	(BCFN 2012)
Food waste	any activity that costs more than the value it creates	(Gooch 2010)
Food waste	Organic waste produced during the post-harvest production and consumption of food	(Mason 2011)
Food waste	Waste composed of raw or cooked food materials and includes food materials discarded before, during or after food preparation, in the process of manufacturing, distribution, retail or food service activities, and includes materials such as vegetable peelings, meat trimmings, and spoiled or excess ingredients or prepared food.	(Reisinger 2011)
Food waste	- "food waste" is the subset of food loss that is potentially recoverable for human consumption"	(Hodges 2011)

Wastage of food	Food products that could be eaten but they do not meet specific criteria for further trade. Such food products are represented by seasonal goods, storage surplus, over production, food which is incorrectly labeled and that is damaged during transport.	(Schneider 2008)
Wastage of food	Generally refers to the deliberate discarding and through away of food that is "fit for purpose and perfectly good to eat". This occurs in the latter part of the food chain, in food companies, wholesaling, retailing and households.	(Lundqvist, de Fraiture et al. 2008)
Food losses (or field losses)	Losses generally refer both to quantitative and qualitative reductions in the amount of and the value of the food.	(Lundqvist, de Fraiture et al. 2008)
Food losses	Losses that take place upstream of the FSC, mainly during the harvesting, processing, and primary agricultural transformation stages.	(BCFN 2012)
Food losses	Refer to the decrease in edible food mass throughout the *part of the* supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain.	(FAO 2011)
Food losses	Food loss refers to the decrease in food quantity or quality, which makes it unfit for human consumption	(Parfitt, Barthel et al. 2010; Parfitt 2011)
	No specific definition given, but paper pointed out that some food losses occur at the farm level	(Kantor 1997)
Losses	Losses, according to FAO (1981), refer to "total modification or decrease of food quantity or quality which makes it unfit for human consumption". Food losses can therefore be quantitative – expresses in weight and monetary value – and qualitative – expressed in health or nutritious terms, in terms of cleanliness or purity, etc.	(Redlingshöfer 2012)
Food loss	- "food loss is a subset of PHL (post-harvest losses) and represents the part of the edible share of food that is available for consumption at either the retail or consumer levels but not consumed for any reason"	(Hodges 2011)
Losses in agriculture	Losses of crop products and livestock classified into seven major categories depending on the type of cause.	(Schneider 2008)
Postharvest loss	- Postharvest loss refers to measurable quantitative and qualitative food loss in the postharvest system.	(Hodges 2011)
Food loss at farm level	Food that is never harvested and food that is lost between harvest and sale	(Gunders 2012)

Food losses	Food losses are grouped in 3 categories (WRAP 2009): - Avoidable losses: refer to food and drink thrown away because they are no longer wanted… - possibly avoidable losses, in contrast, refer to food and drink that some people eat and others do not, or that can be eaten when prepared in one way but not in another… - Unavoidable losses comprise waste arising from food and drink preparation that is not, and has not been, edible under normal circumstances.	(Beretta, Stoessel et al. 2013)
Recoverable for human consumption	Edible food. For examples: edible crops remaining in farmers' fields after harvest.	(Kantor 1997)
Not recoverable for human consumption	Unsafe products: condemned livestock,	(Kantor 1997)
Edible food waste	Food waste which was, at some point prior to disposal, fit for human consumption; includes both avoidable food waste (e.g. slices of bread, apples, meat) and possibly avoidable food waste (e.g. bread crust, potato skins).	(Reisinger 2011)
Inedible food waste	Food waste arising from food preparation that was not any point edible (e.g. bones, egg shells, pineapple skins); inedible food waste is considered unavoidable food waste.	(Reisinger 2011)
Avoidable waste	Edible or possible edible food	(Mason 2011) (French_Ministry_of_Ecology 2011) (BCFN 2012)
Unavoidable waste	Inedible food (e.g. banana peels)	(Mason 2011) (French_Ministry_of_Ecology 2011) (BCFN 2012)
Primary production only		
Dead on arrival (DOA) or transport mortality	Animals that have died between catching and the moment of slaughter due to factors such as handling during catch, live-haul transport, yard time and holding shed conditions, furthermore due to environmental temperature fluctuations or extremes during hot summer months	(Ritz 2005) (Petracci, Bianchi et al. 2006) (Malena, Voslářová et al. 2007)

Milk losses related to mastitis	Two types of milk losses : 1) low-quality milk that has to be discarded because it is unfit for human consumption; 2) milk that is never produced due to reduction in the productive yield	(Hospido and Sonesson 2005)
Waste	Encompasses not only wasted food, by-products and packaging that enter the waste stream, but also any wasted food that does not enter the waste stream (e.g. food that is ploughed back into the ground of fed to animals at the primary production stage)	(Lyndhurst 2010)
Losses in salmon farming	Losses taken into account in mass flow balances in salmon farming are losses of adult fish occurring under normal conditions in farm management (illness etc.), and also losses occurring due to external incidents (vandalism, storms etc.).	(Agreste_Les_Dossiers 2011)
Bovine, pork and poultry meat losses	In these cases, losses refer to animal death during breeding.	(FAO 2011)
Milk losses	For milk, losses refer to decreased milk production due to dairy cow sickness	(FAO 2011)
Marine fisheries		
Discards	Discards, or discarded catch is that portion of the total organic material of animal origin in the catch, which is thrown away, or dumped at sea for whatever reason. It does not include plant materials and post-harvest waste such as offal. The discards may be dead, or alive.	(Kelleher 2005)
Losses	For fish, losses refer to discards during fishing	(FAO 2011)

Table 14 Summary for processing of farm staples of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Food losses	In this study, they refer to total losses and waste within the different steps of the FSC (production, postharvest, processing, distribution, and consumption) as FSC losses. They further differentiate these FSC losses between 'food losses' and 'food waste'. They refer to food losses as those in the production, postharvest, and processing of products (Parfitt, Barthel et al. 2010; FAO 2011).	(Kummu, de Moel et al. 2012)
Food losses	refer to the decrease in edible food mass throughout the *part of the* supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain.	(FAO 2011)
Food losses	Food loss refers to the decrease in food quantity or quality, which makes it unfit for human consumption	(Parfitt, Barthel et al. 2010; Parfitt 2011) (Foresight 2011)
Food losses	Food losses can be qualitative, such as reduced nutrient value and undesirable changes to taste, texture, or colour, or quantitative as measured by decreased weight or volume. Here, food loss is a subset of post-harvest losses (or post-production) and represents the edible amount of food available for human consumption but is not consumed. Food waste is a subset of food loss.	(Buzby and Hyman 2012)
Food loss	Economic loss can also occur if the produce is subsequently restricted to a lower value market. Here, 'food loss' is a subset of PHL and represents the part of the edible share of food that is available for consumption at either the retail or consumer levels but not consumed for any reason. 'Food waste' is the subset of food loss that is potentially recoverable for human consumption.	(Hodges 2011)
Losses	Losses, according to FAO (1981), refer to "total modification or decrease of food quantity or quality which makes it unfit for human consumption". Food losses can therefore be quantitative – expresses in weight and monetary value – and qualitative – expressed in health or nutritious terms, in terms of cleanliness or purity, etc. (Tyler and Gilman, 1979).	(Redlingshöfer 2012)
Food loss at farm level	Food that is never harvested and food that is lost between harvest and sale	(Gunders 2012)

Postharvest loss'	The term 'postharvest loss' (PHL) refers to measurable quantitative and qualitative food loss in the postharvest system (de Lucia & Assennato 1994). This system comprises interconnected activities from the time of harvest through crop processing, marketing and food preparation, to the final decision by the consumer to eat or discard the food. Losses of quantity (weight or volume) and quality (altered physical condition or characteristics) can occur at any link in the postharvest chain.	(Hodges 2011)
Food waste or loss	Food waste or loss is measured only for products that are directed to human consumption, excluding feed and parts of products which are not edible. In the early life cycle stages (production, postharvest and processing stages) food loss can be defined as loss. At later stages of the life cycle (retail and final consumption) the term food waste is applied and generally relates to behavioural issues (FAO 2011).	(Silvennoinen 2012)
Food waste	1. Wholesome edible material intended for human consumption, arising at any point in the food supply chain (FSC) that is instead discarded, lost, degraded or consumed by pests (FAO 1981);. 2. As (1), but including edible material that is intentionally fed to animals or is a by-product of food processing diverted away from the human food (Stuart 2009). 3. As definitions (1) and (2) but including over-nutrition - the gap between the energy value of consumed food per capita and the energy value of food needed per capita (Smil 2004).	(Parfitt, Barthel et al. 2010; Foresight 2011; Parfitt 2011)
Food waste	Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behaviour.	(FAO 2011)
Food waste	Waste occurs at every level of the food value chain and there are many causes. The website www.lovefoodhatewaste.com (2010) used cheese as an example of how waste impacts us financially and environmentally. It is not just the products themselves that are lost; it is the energy, water, packaging and human resources used in production, transportation, retailing/food service and home storage: "…(from) feeding and milking the cows, cooling and transporting the milk, processing it into cheese, packing it, getting it to the shops, keeping it at the right temperature. If it then gets thrown away, it may end up in a landfill site, where rather than harmlessly decomposing as many people think, it rots and actually releases methane, a powerful greenhouse gas."	(Gooch 2010)
Food waste	They refer to food waste as losses during distribution and consumption, in line with other studies (Parfitt, Barthel et al. 2010; FAO 2011).	(Kummu, de Moel et al. 2012)
Food waste	Food waste occurs when an edible item goes unconsumed as a result of human action or inaction and is often the result of a decision made farm-to-fork by businesses, governments, and individual consumers.	(Buzby and Hyman 2012)

Food waste	Food waste is defined as all food produced or purchased that is discarded by humans (Gallo 1980).	(Griffin, Sobal et al. 2009)
Food waste	The amount of food waste is calculated from the total supply of meat and dairy products from Chapter 8.2 and the waste percentage from Chapter 8.4.11, assuming an average carcass cutting yield of 63 % and dry matter contents of 25 %, 12 % and 40 % in meat, milk, and food wastes, respectively. This gives an annual amount of post-consumer food waste of 2.5 Tg of meat and meat products and 6.9 Tg of dairy products.	(Weidema 2008)
Dead-on-arrival (DOA)	The DOA are those birds that have died between catching and the moment of slaughter.	(Ritz 2005)
Product waste	A great deal of the residual material that is currently being disposed of by rendering could be diverted into products that could either be consumed by humans or pets (and livestock if and when regulatory changes allow). Within the current regulatory framework, the meat industry could obtain benefits estimated at around £110M from reduced disposal costs and increased revenue. This could be achieved through better separation of source material, coupled with collaborative programs between abattoirs. Initial work in Scotland has shown results of this magnitude to be achievable. The benefits may be expected to vary between rural and urban-based operations, which often face contrasting challenges.	(WRAP 2011)
Wastage	Wastage is the "deliberate discarding and throwing away of food that is fit for purpose and perfectly good to eat" (Lundqvist, de Fraiture et al. 2008).	(Redlingshöfer 2012)
Avoidable food waste	In this study we concentrated on avoidable food waste, i.e. all wasted food and raw material that could have been consumed had it been stored or prepared differently. Other bio-waste, such as coffee grounds and bones, was measured only for the food service sector. Of the liquid foodstuffs we included milk, being integral part of Finnish food culture.	(Katajajuuri 2012)

Table 15 Summary for processing of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Waste	"Any substance or object which the holder discards or is required to discard".	(C-Tech_Innovation 2004) (Mena and Yurt 2011) (Morley 2008) (Organics_Report 2009) (AWARENET 2003)
Food waste: "Matavfall" (SWE)	All biologically degradable waste that appears in connection with food handling and that could be used for food; also includes liquid food. ("*Allt biologiskt nedbrytbart avfall som uppkommer i och med livsmedelshanteringen som skulle kunna användas som livsmedel*").	(Jensen 2011)
Food and drink waste	Food or drink products that are disposed of (includes all waste disposal and treatment methods) by manufacturers, packers/fillers, distributors, retailers and consumers as a result of being damaged, reaching their end-of-life, are off cuts or deformed (out graded).	(WRAP 2010)
Avoidable food waste: "Nyttbart matavfall" (NO) "Mat-/livsmedelssvinn" (SWE)	"Food that is thrown away, but that could have been eaten by humans if treated properly throughout the food supply chain".	(Hanssen 2010) (Hanssen 2011) (WRAP 2011)
Unavoidable food waste	"Waste arising in seafood supply chains which is not edible under normal circumstances, for example bones, shell or viscera".	(WRAP 2011)
Co-products	"Unavoidable secondary products of (fish) processing, which cannot be utilized for human food products but have a marketable value to the producer".	(WRAP 2011)
Edible co-product	Major organs from the animal not suitable for human consumption in their unprocessed state, e.g. stomach, bladder, intestine.	(WRAP 2011)
Residual material	Can include offal, edible co-products, and animal by-products.	(WRAP 2011)
Food losses:	Food losses refer to the decrease in edible food mass throughout the *part of the* supply chain that specifically leads to edible food for human consumption.	(FAO 2011) (Kummu, de Moel et al. 2012) (Almeida 2011)

Food waste	Food losses occurring at the end of the food chain (retail and final consumption) are called "food waste", which relates to retailers' and consumers' behavior.	(FAO 2011) (Kummu, de Moel et al. 2012) (Almeida 2011)
Food losses "Spill/förluster" (SWE)	Waste which is more difficult to prevent compared to other types of waste and which to a higher extent arise early in the food supply chain. "…svinn som är svårare att motverka än övrigt svinn, och som i högre grad uppstår i tidiga led i livsmedelskedjan än i senare led".	(Jensen 2011)
Food loss	Food that is not suitable for sale at the full price, but is required instead to be sent to various kinds of waste management.	(Møller 2012)
Edible food loss	Process waste or products where the intention has been to manufacture an article of food, but where the product ends up as food loss.	(Møller 2012)
Potentially edible food loss	Ingredients or products that are unsuitable for full price sale because of production errors, or where the product is not within the specified quality range.	(Møller 2012)
Inedible food loss	Ingredients or products which are not suitable for consumption according to today's food standards	(Møller 2012)
Wanted losses	"Are necessary to transform raw material into desired final products".	(Somsen 2004)
Unwanted losses	"Will results in additional raw material usage and generate additional waste and will therefore put the company's profit under pressure".	(Somsen 2004)
By-products: "Bi-produkter" (SWE)	According to the Swedish environmental law (Miljöbalken kap 15 §1): 1. Has appeared in a manufacturing processes in which the main purpose is not to produce the substance or thing, 2. Can be used directly without further treatment than that which is normal in the industrial praxis and 3. Will in the future be used in a way that is acceptable considering health and environmental issues and which is not illegal.	(Jensen 2011)
By-products	"Unavoidable secondary products from processing (of fish)".	(WRAP 2011)
By-products	Parts of the raw material that are not included in the final food product.	(AWARENET 2003)
Animal by-product	Material from the animal not intended for human consumption and categorized into three groups, Categories 1, 2 and 3.	(WRAP 2011)
Remainder product	All excess production is defined as remainder product. (Alla överskottsprodukter och spill benämns restprodukter).	(Söderlund 2007)

Table 16 Summary for wholesale and logistics of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
food waste	leftover food from several stages from life cycle as well as raw and processed foods that are fit for consumption, consists of avoidable food waste, partly (optional) avoidable food waste, unavoidable food waste	(Kranert 2012)
Food waste	composing a large proportion of bio-waste, is waste composed of raw or cooked food materials and includes food materials discarded at any time between farm and fork; in households relating to food waste generated before, during or after food preparation, such as vegetable peelings, meat trimmings, and spoiled or excess ingredients or prepared food. Food waste can be both edible and inedible. Edible food waste is considered avoidable, although WRAP describes some of this as "possibly avoidable", given certain foods that are not unanimously considered edible.	(Monier 2010)
Food Waste	is the waste that takes place during industrial processing, distribution, and final consumption. Also included in this are intentional choices, based on which perfectly edible food is discarded and "thrown away." It is considered necessary to follow the suggestions of Professor Smil, who would like us to also take the overeating phenomenon into consideration when we talk about food waste	(BCFN 2012)
Food waste	in general, can be said to be animal or vegetal waste from manufacture, distribution, sale and consumption of food. When surveying food waste from this sector it is difficult to separate these two categories – therefore the food waste amounts presented in this report is "total food waste". This means for example that the bones from the pork chop is included. In the retail sector all food waste is in principle avoidable, and should as far as possible be prevented.	(Stenmarck 2011)

Food waste	the meat industry told the project team that it regards waste as comprising the following: .) products that are marked down by retailers and thereby do not achieve their full selling price; .) products that, for whatever reason, are out of their use by or sell by dates; .) products returned by shoppers; .) products that cannot be sold but are passed to charities, such as FareShare; .) products sent for anaerobic digestion; .) products returned from retailers to suppliers which have to be re-worked; .) products that do not meet the specification of the intended customer; .) products that are stolen; and .) product that is sent for rendering.	(WRAP 2011)
Food waste	Is used within study but not defined exactly.	(Weidema 2008)
Food waste or food loss	The masses of food lost or wasted in the part of food chains leading to "edible products going to human consumption". Therefore food that was originally meant to human consumption but which fortuity gets out the human food chain is considered as food loss or waste even if it is then directed to a non-food use (feed, bioenergy…).	(FAO 2011)
Fish waste	All fish species processed in the UK contain a high proportion of non-edible content, which ranges from 58% for white fish, such as cod, to 88% for shellfish, such as scallops. Because of the high levels of unavoidable by-products and the highly variable nature of fish processing operations, it has not been possible to quantify the avoidable waste arising from processing.	(WRAP 2012)
Food Losses	are the losses that take place upstream of the FSC, mainly during the harvesting, processing, and primary agricultural transformation stages. These are due to climatic and environmental factors (which are difficult to summarize) and accidental causes that can be traced back to the limitations of agricultural technology and infrastructure used in the area. This category also includes the losses caused by economic reasons, such as the quality and aesthetic standards imposed by the market, food regulations, and the greater or lesser convenience of harvesting operations.	(BCFN 2012)
Product losses	No definition provided	(Berlin, Sonesson et al. 2008)

Storage loss	Not specified in study but seemed to be such as product loss depending on time span of storage. It was assumed that there is a storage loss of 5% after 4 months' storage and a linear increase up to 25% loss after 10 months' storage.	(Milà i Canals, Cowell et al. 2007)
End-use losses	Food losses during end-use storage, meal preparation and final plate-waste	(Weidema 2008)
Avoidable food waste	still fully fit for human consumption at the time of discarding or would have been edible if they had been eaten in time	(Kranert 2012)
Avoidable food waste	Food that is thrown away that was, at some point prior to disposal, edible (e.g. slices of bread, apples, meat)	(Monier 2010)
Avoidable waste	Edible parts of animals which could be utilized for consumption but end up discarded. Within the supply chain defined by this report, this will include edible portions which are not removed during processing, if the maximum yield is not obtained. May also arise through quality deterioration, or from out-of-specification products.	(WRAP 2011)
Avoidable food waste in retail shops and wholesale	Food wasted that could have been eaten if well preserved.	(Hanssen 2010; Hanssen 2011)
Partly (optional) avoidable food waste	Generated because of different consumer habits (e.g. bread crusts, apple skins). This category also covers mixtures of avoidable and unavoidable waste (e.g. leftover food, canteen waste, etc.)	(Kranert 2012)
Possibly avoidable food waste	Food that some people eat and others do not (e.g. bread crusts, potato skins)	(Monier 2010)
Possibly avoidable waste	This encompasses material which may be considered edible by some people. For example, monkfish cheeks are not generally eaten within the UK but are considered a delicacy in other cultures. A second category of possibly avoidable waste is material which is edible but is not currently considered economically viable to use. An example of this type of waste may include crabmeat contained within the crab „purse“. Although edible, this meat tends to be both difficult to recover and of lower value, and is therefore not cost effective for processors.	(WRAP 2011)
Unavoidable food waste	Usually arises when food is being prepared and is discarded. This mainly encompasses both non-edible constituents (e.g. bones, banana peels or the like) and edible ones (e.g. potato peels)	(Kranert 2012)
Unavoidable food waste	Waste arising from food preparation that is not, and has not, been edible under normal circumstances (e.g. bones, egg shells, pineapple skins)	(Monier 2010)

Unavoidable waste	Waste arising in seafood supply chains which is not edible under normal circumstances, for example bones, shell or viscera. These materials should not be confused with avoidable waste which arises through a failure to obtain the maximum yield during processing.	(WRAP 2011)
Bio-waste	is defined by the European Commission in the green paper on the management of bio-waste as biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants. The definition does not include forestry or agricultural residues, manure, sewage sludge or other biodegradable waste, such as natural textiles, paper or processed wood.	(Monier 2010)
Waste	is defined by the EU Council Directive Waste 75/442/EEC [91/156/EEC] (EU, 1991) as „any substance or object the holder discards, intends to discard or is required to discard". This includes all facets of physical waste including produce and packaging. The main focus herein was waste arising during grading, packing, distribution and retailing. However, where data were available information on field waste, genetic diversity within a product category, and the effect on post-harvest loss and waste, was recorded. Some estimates of yield loss were also provided by interviewees and these are expressed as a percentage range of product lost in the field. A central range value was used to describe the most commonly reported levels of loss in the field so that extremes did not distort the results.	(WRAP 2011)
Loss	The term loss is used in this report to describe product that is not used for its intended purpose and therefore has less real monetary value (or none in extreme cases). Many activities that take place within the fruit and vegetable supply chain lead to an economic loss, i.e. planted product not making the required grade/specification and product being out-graded or down-graded at packing. Across the supply chain an economic loss arising from the types of activity described above was regarded as „waste", although clearly such activity did not lead to product being landfilled. Although such products cannot be used to supply retail customers they are used for processing or for animal feed, thus providing some revenue, though significantly lower than from the primary market. This loss should not be confused with waste (disposed to landfill or energy recovery).	(WRAP 2011)
Co-products	unavoidable secondary products of fish processing, which cannot be utilized for human food products but have a marketable value to the producer. Within the finfish industry, the majority of non-edible components is considered to be valuable co-products, and is sold to fishmeal plants for conversion into animal feed products. Non-edible material may be viewed as a co-product by one fish processor, but as a waste by another depending on the availability of outlets for the material.	(WRAP 2012)

By-products	unavoidable secondary products from the processing of fish. By-products have a negligible or negative value to the producer and are generally considered to be waste. A by-product which has value can be defined as a co-product. For example, crab shell is a by-product which is inevitably produced by crab processors. A crab processor may view this shell as a co-product if they derive a value from it or as a waste if they have to pay for its disposal.	(WRAP 2012)

Table 17 Summary for retail of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Loss from food production and distribution	Waste originating in the early phases of the value chain of food, often difficult to separate from food waste.	(Jensen 2011)
Food waste	Waste that takes place during industrial processing, distribution, and final consumption.	(Kummu, de Moel et al. 2012) (BCFN 2012)
Food loss	Losses that take place upstream of the FSC, mainly during the harvesting, processing, and primary agricultural transformation stages. These are due to climatic and environmental factors (which are difficult to summarize) and accidental causes that can be traced back to the limitations of agricultural technology and infrastructure used in the area. This category also includes the losses caused by economic reasons, such as the quality and aesthetic standards imposed by the market, food regulations, and the greater or lesser convenience of harvesting operations.	(BCFN 2012) (Kummu, de Moel et al. 2012)
Food loss	The term loss is used to describe product that is not used for its intended purpose and therefore has less real monetary value (or none in extreme cases).	(BCFN 2012)
Food waste or food loss	The masses of food lost or wasted in the part of food chains leading to "edible products going to human consumption". Therefore food that was originally meant to human consumption but which fortuity gets out the human food chain is considered as food loss or waste even if it is then directed to a non-food use (feed, bioenergy…).	(FAO 2011)
Food Waste	All organic degradable waste from treatment of food, and which could have been used as food for human, including waste to the sewage system or in original packaging ending as residual waste. Residual waste not intended for direct use by humans from the food manufacturing industry has not been included in the study.	(Jensen 2011)
Food loss:	Food products being wasted, but which should have been used as food for human beings if properly managed = Avoidable food waste.	(Jensen 2011)
Total food waste		(Monier 2010)
Food waste	Waste composed of raw or cooked food materials and includes food materials discarded at any time between farm and fork; in households relating to food waste generated before, during or after food preparation, such as vegetable peelings, meat trimmings, and spoiled or excess ingredients or prepared food. Food waste can be both edible and inedible.	(Monier 2010)

Food waste or loss	Per definition, food losses or waste are the masses of food lost or wasted in the part of food chains leading to 'edible products going to human consumption'. Therefore food that was originally meant to human consumption but which fortuity gets out the human food chain is considered as food loss or waste even if it is then directed to a non-food use (feed, bioenergy...). This approach distinguishes 'planned' non-food uses to 'unplanned' non-food uses, which are hereby accounted under losses" (FAO 2011). More in detail: .) Are all edible food parts which were not eaten and thereafter disposed? Independently if landing in landfills, burnt by incineration, composted in industrial or household decomposers, used for biogas production or used animal feed .) Can take place during or after agricultural production. E.g. field leavings (crops left in the fields), crops eaten by birds or rodents or ploughed into soil, losses due to incorrect timing of harvest, cattle sickness or death .) Account for all reductions in the available edible food arising at the moment of food processing, food preparation or consumption. E.g. losses during transportation along the FSC, losses due to processing accidents, disposed unsold quantities or waste at the household (e.g. 'plate-waste') .) Are all edible by-products from a food processing or meat industry, which purpose would be to serve as human consumption, and which are not consumed by humans. Not accounted as food waste are mostly all inedible parts wasted, or edible parts which were since the beginning of its production (i.e. planting) not intended for food consumption.	(Almeida 2011)
Food waste	Definitions used by the meat industry .) products that are marked down by retailers and thereby do not achieve their full selling price; .) products that, for whatever reason, are out of their use by or sell by dates; .) products returned by shoppers; .) products that cannot be sold but are passed to charities, such as FareShare; .) products sent for anaerobic digestion; .) products returned from retailers to suppliers which have to be re-worked; .) products that do not meet the specification of the intended customer; .) products that are stolen; and .) product that is sent for rendering.	(WRAP 2011)

Food waste	The difference between the total amount of commodity used by the food system (supply) and the total amount of food eaten (intake) is an indicator of the potential waste. A proportion of this comprises unavoidable losses such as bones and vegetable peelings that are either discarded or used in co-products such as bone-meal or as fuel for biogas. However, studies show that a significant proportion of this is avoidable waste, i.e. discarded food that could have been eaten.	(Sonigo 2012)
Waste bread and pastry	Included were: Surplus at the central bakery production Return flows from bakery outlets to central bakery production Items which were crisped up at bakery outlets after delivered in semi-raw condition Products disposed of at bakery outlets directly via residual or bio waste Return flows from retail outlets to central bakery production Products disposed of at retail outlets directly via residual or bio waste Partly data from production included also dough which was disposed of semi-baked.	(Schneider 2009)
Fish and sea food	All fish species processed in the UK contain a high proportion of non-edible content, which ranges from 58% for white fish, such as cod, to 88% for shellfish, such as scallops. Because of the high levels of unavoidable by-products and the highly variable nature of fish processing operations, it has not been possible to quantify the avoidable waste arising from processing.	(WRAP 2012)
Avoidable food waste	Food that is thrown away that was, at some point prior to disposal, edible (e.g. slices of bread, apples, meat)	(Monier 2010) (WRAP 2011)
Possible avoidable food waste	Food that some people eat and others do not (e.g. bread crusts, potato skins)	(Monier 2010) (WRAP 2011)
Unavoidable food waste	Waste arising from food preparation that is not, and has not, been edible under normal circumstances (e.g. bones, egg shells, pineapple skins)	(Monier 2010) (WRAP 2011)
Spoilage	is another term used to highlight problems with the harvested crops and other food items during transport, storage, processing and packaging.	(Lundqvist, de Fraiture et al. 2008)
retail food waste	was defined as products discarded in the supermarkets studied, irrespective of whether they belonged to the supplier or the supermarket. This meant that losses of mass due to theft or evaporation were not considered food wastage and therefore they are included in a separate category (missing quantities)	(Eriksson 2012; Eriksson, Strid et al. 2012)

Pre-store waste	consisted of items rejected by the supermarket at delivery due to non-compliance with quality requirements. This waste belongs to the supplier in accounting terms, since it is rejected by the supermarket, but is usually discarded at the supermarket. Pre-store waste is defined through documented complaints to suppliers, which according to the rules must be done within 24 hours of delivery. This waste is on rare occasions sent back to the supplier for control, but is still wasted.	(Eriksson 2012; Eriksson, Strid et al. 2012)
Recorded in-store waste	was defined as food waste occurring after purchase from the supplier. This waste is sorted out and discarded by supermarkets when there is little or no possibility of selling the products. This could be due to exceeded best-before dates or product deterioration for unpackaged FFV.	(Eriksson 2012; Eriksson, Strid et al. 2012)
Unrecorded in-store waste	Consisted of food waste that was discarded but not recorded. This means that it had the potential to be either pre-store waste or recorded in-store waste if recorded in any of these categories. Unrecorded in-store waste originated from two sources: underestimated mass when recording unpackaged waste; and unrecorded of wasted items. The latter can occur in error or as a deliberate act, e.g. it is not cost-effective to record small amounts of waste.	(Eriksson 2012; Eriksson, Strid et al. 2012)
Missing quantities	This was due to loss of mass between outgoing and ingoing flows and the two main reasons for these missing quantities are believed to be theft and mass loss due to evaporation. Stolen food is considered not to be an environmental problem, since it is believed to be eaten. Evaporation losses are also not primarily food wastage, since the food items are left, but with a higher dry matter content and smaller mass. However, when visible this might act as a secondary effect, leading to losses of food in one of the waste categories.	(Eriksson 2012; Eriksson, Strid et al. 2012)

Table 18 Summary for markets of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Overview reports		
Wastage of food	Wastage generally refers to the deliberate discarding and through away of food that is fit for purpose and perfectly good to eat. This occurs in the latter part of the food chain, in food companies, wholesaling, retailing and households.	(Lundqvist, de Fraiture et al. 2008)
Wastage of food	Food products that could be eaten but they do not meet specific criteria for further trade. Such food products are represented by seasonal goods, storage surplus, over production, food which is incorrectly labelled and that is damaged during transport.	(Schneider 2008)
Food waste	Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behaviour.	(FAO 2011)
Food losses	Refer to the decrease in edible food mass throughout the *part of the* supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain.	(FAO 2011)
Food waste	Lost / discarded food that represents an inefficient use of ecosystem and contributing to global warming once in landfills (page 29)	(Nellemann 2009)
Losses in agriculture	Losses of crop products and livestock classified into seven major categories depending on the type of cause.	(Schneider 2008)
Food waste	Food waste is an unnecessary and easily avoidable contributor to Australia's greenhouse gas emissions and reducing such waste would, in a literal sense, deliver 'least cost abatement'(page 2).	(Baker 2009)
Food losses	At the farm level, food loss falls into two categories: (1) food that is never harvested, and (2) food that is lost between harvest and sale.	(Gunders 2012)
Food losses	Decrease in quantity and quality of food. Main factors responsible for postharvest loss of fresh fruits and vegetables are mechanical damage, spoilage by fungi, bacteria, insects, and other organisms and physiological deterioration (page 2).	(Jemric 2012)
Food losses	Losses that can be both quantitative and qualitative. The causes are biological and environmental (e.g., respiration, ethylene production, water stress, temperature, humidity, atmospheric composition) or socioeconomic (e.g., insufficient marketing, communication, distribution and legislation).	(Williams and Wikström 2011)

Edible food losses	Process waste or products where the intention has been to manufacture an article of food, but where the product ends up as food loss.	(Møller 2012)
Potentially edible food loss	Refers to ingredients or products that are unsuitable for full price sale because of production errors, or where the product is not within the specified quality range.	(Møller 2012)
Non-edible food loss	This category comprises ingredients or products which are not suitable for consumption according to today's food standards. Examples of this would be peel, skin and bones.	(Møller 2012)
Food losses	Losses generally refer both to quantitative and qualitative reductions in the amount of and the value of food (page 22) At the field level, part of the crop is lost due to rodents, pest and diseases. Similarly, a part of the produce is lost during transport and storage due to the same type of problems.	(Lundqvist, de Fraiture et al. 2008)
Spoilage	Another term used to highlight problems with the harvested crops and other food items during transport, storage, processing and packaging.	(Lundqvist, de Fraiture et al. 2008)
Losses	Decrease of organic material	(WRAP 2012)

Table 19 Summary for redistribution of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Organic waste	Waste in any part of the food production and consumption chain that is organic in nature (including crop residues, manures, food processing waste, restaurant food waste)	(Mason 2011)
Food waste	food waste is considered to be a subset of organic waste and excludes liquid wastes (i.e. wastewater associated with the consumption and excretion of food ;Organic waste produced during the post-harvest production and consumption of food	(Mason 2011)
Putrescible waste	Organic waste material with sufficient moisture, carbon and nitrogen to decompose anaerobically, usually emitting foul odours and which can attract vermin	(Mason 2011)
Avoidable waste	Food waste that could be avoided in the first place through improved efficiency and planning to reduce spillages, spoilage and unnecessary disposal	(Mason 2011)
unavoidable waste	Food waste that cannot be avoided (e.g. banana peels), hence must be managed through resource recovery (e.g. composting or anaerobic digestion for use as fertilizers or energy).	(Mason 2011)

Table 20 Summary for food service of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Avoidable food waste	Waste from kitchen and from guests Food thrown but that could have been consumed if they are handled differently. Food which was edible before being thrown away Food that has been disposed of because it has become inedible for one of several reasons, including overestimation of need and poor storage Food and drinks that are thrown away despite still being edible	(Jensen 2011; Martinsen 2012) (French_Ministry_of_Ecology 2011; Mason 2011) (BCFN 2012)
Unavoidable food waste	Not edible food waste from preparation and consumption Waste due to meal preparation and which is not edible under normal circumstances Components of food that would not be considered edible under any circumstances Waste deriving from the preparation of food or drinks that are not, and could not, be edible	(French_Ministry_of_Ecology 2011; Mason 2011; Martinsen 2012) (BCFN 2012)
Possible avoidable waste	Food that some people eat and others don't Food and drinks that some people consume and some do not or food that can be edible, if cooked one way instead of another	(French_Ministry_of_Ecology 2011; BCFN 2012)
Food waste	Alt-biodegradable waste generated in the food-processing that could be used as food. The term food waste also includes waste that poured down the drain (liquid food such as milk) or washed out containers, etc.	(Jensen 2011)
Organic waste	Animal and vegetable waste	(Pocock 2010)

Table 21 Summary for households of the terms and definitions used; and a list of the references which have been reviewed and in which each definition has occurred

Terminology	Definition	References
Food & drink waste	All food & drink not eaten & discarded	(OECD 2001; AWARENET 2003; Lebersorger 2004; Wassermann 2005; WRAP 2008; Glanz 2009; Griffin, Sobal et al. 2009; WRAP 2009; WRAP 2009; Monier 2010; Parfitt, Barthel et al. 2010; Almeida 2011; Evans 2011; FAO 2011; Foresight 2011; Pham 2011; WRAP 2011; BCFN 2012; Kranert 2012) (WRAP 2011; WRAP 2011)
	Can include excessive nutrition	(Parfitt, Barthel et al. 2010; Almeida 2011; Foresight 2011; BCFN 2012)
Food & drink loss	Food & drink products lost to human consumption Usually excludes inedible foods	(Wenlock 1980; AWARENET 2003; Muth 2007; Glanz 2009; Parfitt, Barthel et al. 2010; Almeida 2011; Evans 2011; FAO 2011; Foresight 2011; BCFN 2012)
Avoidable	Edible or possibly edible foods, regardless of whether they are edible at point of disposal, unplanned waste e.g. leftovers, preference losses	(Wenlock 1980; OECD 2001; Lebersorger 2004; Obersteiner 2006; WRAP 2008; Bernhofer 2009; Glanz 2009; WRAP 2009; WRAP 2009; Selzer 2010; Lebersorger and Schneider 2011; WRAP 2011; WRAP 2011; WRAP 2011; Beretta 2012; Katajajuuri 2012; Kranert 2012)
Unavoidable	Inedible foods, also referred to as planned waste, preparation residues, cooking losses	(Wenlock 1980; Lebersorger 2004; Waldron 2004; Wassermann 2005; WRAP 2008; Griffin, Sobal et al. 2009; WRAP 2009; WRAP 2009; Monier 2010; Lebersorger and Schneider 2011; WRAP 2011; WRAP 2011; WRAP 2011; Kranert 2012)

D Annex System boundaries from literature review

Table 22 Summary for production of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
The study encompasses not only wasted food, by-products and packaging that enter the waste stream, but also any wasted food that does not enter the waste stream (e.g. food that is ploughed back into the ground of fed to animals at the primary production stage)	Food in general	plough back fruits into the soil; feed food to animals	(Lyndhurst 2010)
Food that is never harvested and food that is lost between harvest and sale	Foods in general		(Gunders 2012)
System boundaries at farming stage start with harvesting	Food in general	Mechanical damage and/or spilling during harvest operations	(Kummu, de Moel et al. 2012; Beretta, Stoessel et al. 2013)
Intermediate stage between farm and slaughtering	Animals	Losses during catching, handling and transporting animals between farm and slaughterhouse	(Ritz 2005; Petracci, Bianchi et al. 2006; Malena, Voslářová et al. 2007)
Harvest (milking)	Milk	Discard milk due to treatment of milk cows for mastitis	(Hospido and Sonesson 2005)
Production system prior to harvest	Milk	Mismanagement and other activities leading to lower yield than possible when good practice is employed	(Hospido and Sonesson 2005; FAO 2011)

Entire food supply chain, with distinction among the steps but.	All: grains, vegetables, fruit, meat …	At the production step, a large part of losses is due to climatic and environmental factors, limitations of agricultural technology and infrastructure, economic reasons (such as the quality and aesthetic standards imposed by the market, greater or lesser convenience of harvesting operations)	(BCFN 2012)
Entire food processing industry in the UK	Meat, fish, fruit and vegetables, oils and fats, dairy products, grain products, beverages…		
Supply chain, from production to consumption. Starting and ending point of primary production are not specified.	Potato	Not specified	(WRAP 2012)

Table 23 Summary for processing of farm staples of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
The research has focused on the supply of meat from farm gate onwards, including livestock slaughtering, meat preparation, processing and packaging, distribution and retail.	Meat	Product waste arises in abattoirs and cutting plants for a variety of operational reasons. These include poor process controls, for example line stops due to machine breakdown, floor waste, over-trimming and customer returns. Another specific issue that affects all species is animal contamination. Sometimes animals are presented to abattoirs in an unfit or diseased condition. The whole animal or parts of the animal will then have to be disposed of, in effect, as a Category 1 by-product.	(WRAP 2011)
The study covers the full food supply chain	Meat	The current slaughter activity allows to obtain a yield of 63% on average, with wastes of meat that are around 12%	(Weidema 2008)
Management of broilers between catching and the moment of slaughter	Meat	Dead - on - arrival (DOA)	(Ritz 2005)
Each step of food supply chain was taken in consideration, also primary processing which generally is between *storage* and *secondary processing*. The primary processing includes: cleaning, classification, de-hulling, pounding, grinding, packaging, soaking, winnowing, drying, sieving, milling.	Food/staples in general	Contamination in process causing loss of quality.	(Parfitt 2011)

Table 24 Summary for processing of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
The study describes the entire food processing industry in the UK, including prepared animal feed. Packaging waste from food production is also included.	All: • Meat & Meat products • Fish & Fish products • Fruit & Vegetables • Vegetable and animal oils and fats • Dairy products • Grain mill products and starch • Prepared animal feeds • Other food products • Beverages	Do not specify in detail the raw material flows included in the extrapolated data from each data source.	(C-Tech_Innovation 2004)
The study includes food and packaging waste, although excludes "by-products" and "mixed wrapped food" (for further sorting at the production site).	Food waste in general, not specified further.	• Food waste • Packaging waste • Mixed food and packaging waste	(Morley 2008)

The study included the food and drink industry in the UK, material sent to re-use as animal feed was not considered a food waste.	SIC codes: 151: Production & processing of meat & poultry; 152: Processing & preserving of fish & fish products; 153: Processing & preserving of fruit & vegetables; 154: Manufacturing of vegetable & animal oils & fats; 155: Manufacturing of dairy products; 156: Manufacturing of grain mill products, starches & starch products; 157: Manufacturing of prepared animal feed; 158: Manufacturing of other food products; and 159: Manufacturing of beverages.	Do not specify in detail the raw material flows included in the extrapolated data from each data source.	(WRAP 2010)
The study includes the Norwegian food manufacturing sector.	Food waste in general, not specified further.	• Ingredient storage • Processing • Packaging • Warehouse/retailing • Distribution (by producer)	(Møller 2012)
	Fish		(WRAP 2011)

A distinction is made between abattoirs; slaughter animals and cut carcass into quarters cutting plants; cutting into primals, de-boning and preparation into cuts of meat supplied to customers. Many cutting plants have also license to produce mince, meat preparation and food processing food processors;	Fresh meat	**Bold**, relevant for abattoirs, cutting plants and food processors. • products that are marked down by retailers and thereby do not achieve their full selling price; • **products that, for whatever reason, are out of their use by or sell by dates;** • **products returned by shoppers;** • products that cannot be sold but are passed to charities, such as FareShare; • **products sent for anaerobic digestion;** • **products returned from retailers to suppliers which have to be re-worked;** • **products that do not meet the specification of the intended customer;** • products that are stolen; and • **product that is sent for rendering.**	(WRAP 2011)
Along the production line in the bakery Lantmännen Axa. Only products being produced all year around were included and the start of the production line was when the dough was poured on the production line (the mixture of dough was thereby not included).	Buns	The waste was divided into three groups: Variations in weight Pieces with defects spillage	(Svenberg 2007)

All remainder products being produced at Pågen AB	Bread	• Un-baked dough • Overproduction, not sold • Discarded items • Product returns, from retail shops	(Söderlund 2007)
The measurement is carried out within Coca Cola Sweden's production plant in Sweden. The measurements are carried out in the production line from that the bottles are filled with liquid, are packaged and distributed to the storage. Waste in the storage is not included.	Drinks (Coca-Cola)	• Bottles with too low weight • Bottles with too high weight • Incorrect data labeling • Defects with the cap • Defects with the etiquette • A number of bottles are not registered since they don't fit on full pallets	(Gunnerfalk 2006)

The food and drink industry of the European Union.	Includes both waste and by-products. Fish: • Fish canning • Fish filleting, curing, salting and smoking • Crustaceans processing • Molluscs processing Meat: • Beef slaughtering • Pig slaughtering • Poultry slaughtering Dairy: • Milk, butter and cream production • Yoghurt production • Fresh, soft and cooked cheese production Wine: • White wine production • Red wine production Vegetable sector: • F & V juice production • F 6 V processing and preservation • Vegetable oil production • Corn starch production • Potato starch production • Wheat starch production Sugar production from sugar beat	Includes waste and by-products: Fish: • Rejected fish • Heads • Offal • Tails • Skins • Red meat • Bone • Scraps • (Ash of shavings) Crustaceans: • Body fluid • Head • Shells • Intestines • Scraps Molluscs: • Sand • Shell particles • Exudate • Shell • Beard Meat: • Manure, straw • Blood • Hides, heads and horns • Hooves/feet • Feathers • White offal (intestines and stomach) • Red offal (heart, liver, lungs) • Carcass fat • Meat trimming scraps • Bones • Fat • others Dairy: • sludge • "border products" • Whey • Curd waste • Cheese smear/rind	(AWARENET 2003)

Table 25 Summary for wholesale and logistics of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review.

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
Starting and ending point not mentioned in detail. At central markets the organic waste stream was included and the share of food waste was estimated, this means packaging was partly included (only specific data regarding organic waste were provided without plastic); food donations from the central markets were counted as prevented food waste	No further information on that topic, organic waste was the basis for estimations.	The organic waste registered per year was the basis to estimate the share of food waste, this means packaging was partly included (only specific data regarding organic waste were provided without plastic); food donations from the central markets were counted as prevented food waste.	(Kranert 2012)
Starting and ending point not mentioned in detail. Production sector involving the distribution and sale of food products to individuals and organisations; data for the waste streams (EWC_09) Animal and vegetal wastes, (EWC_0911) Animal waste of food preparation and products and (EWC_093) Animal faeces, urine and manure were used to calculate (EWC_09_NOT_093): Animal and vegetal waste excluding slurry and manure;	data for the waste streams (EWC_09) Animal and vegetal wastes, (EWC_0911) Animal waste of food preparation and products and (EWC_093) Animal faeces, urine and manure were used to calculate (EWC_09_NOT_093): Animal and vegetal waste excluding slurry and manure;	Not mentioned in detail.	(Monier 2010)

Starting and ending point not mentioned in detail. Literature review from Italy included farmers markets and food centres	not mentioned in detail. Literature review from Italy included food waste consisted 40 % of fruits and vegetables	The fourth stage concerns the wholesale and retail distribution processes, where a large part of the waste is made up of the food that has remained unsold through compliance with food safety legislation and quality and aesthetic standards, marketing strategies, and logistical aspects.	(BCFN 2012)
Starting and ending point not mentioned in detail for the specific food supply chain part. The main focus was waste arising during grading, packing, distribution and retailing. Also some data from field losses were included	Fruit and vegetable	However, where data were available information on field waste, genetic diversity within a product category, and the effect on post-harvest loss and waste, was recorded. Some estimates of yield loss were also provided by interviewees and these are expressed as a percentage range of product lost in the field. A central range value was used to describe the most commonly reported levels of loss in the field so that extremes did not distort the results.	(WRAP 2011)
Starting and ending point not mentioned in detail for the specific food supply chain part.	Food waste from wholesale in general. The biggest food waste groups are fresh food: Vegetables and fruits, bread, and dairy products. Cold stored products, fresh meat and fish products come next.	The interviewed wholesalers in Denmark report that they are not sorting food waste separately, but much of their waste is food waste and one of the wholesalers estimate that they generate 15-20 tons of waste per month (including packaging) but most of it being food waste.	(Stenmarck 2011)

Starting and ending point not mentioned in detail for the specific food supply chain part.	Fresh meat	the meat industry told the project team that it regards waste as comprising the following: .) products that are marked down by retailers and thereby do not achieve their full selling price; .) products that, for whatever reason, are out of their use by or sell by dates; .) products returned by shoppers; .) products that cannot be sold but are passed to charities, such as FareShare; .) products sent for anaerobic digestion; .) products returned from retailers to suppliers which have to be re-worked; .) products that do not meet the specification of the intended customer; .) products that are stolen; and .) product that is sent for rendering.	(WRAP 2011)

Wholesale was summarized with processing as several of these respondents identified themselves as being both wholesalers and fishmongers, it is not possible to assign the proportion of waste derived from each of these operations. Additionally, wholesalers may undertake some processing operations, providing a large amount of variability in the percentage of waste that would be expected within individual operations.	fish	A key aspect of these resource maps is a combined estimate of the volumes of waste and co-products derived from processing. This estimate of the total volume of material entering processing is derived on the following basis: Raw material entering processing = Total supply chain inputs – direct exports This accounts for the fact that, for some species, a significant proportion of material entering the supply chain undergoes minimal processing within the UK before being exported. However, this figure assumes that all remaining material passes through processing rather than wholesale. For most species this is a reasonable assumption, as the quantity of material that passes through wholesale is relatively low. Within the resource maps a combined figure is quoted for the total waste and co-products generated by processing operations. For many species it has not proved possible to break this figure down into sub-totals for co-products and wastes. Where a figure for the proportion of this material used as co-products is known, it is quoted in the resource map. Additionally, information on the most common methods of co-product utilization, waste disposal or recovery for a species is commented on.	(WRAP 2011)
covers waste generated by the 500 seafood processors in the UK that supply the main multiple retailers, about 600 independent fishmongers and around 100 wholesale markets.	fish	By-products from fish that are part processed at sea and from caught fish that are discarded before landing are not covered here. Fish sourced from aquaculture operations are also excluded.	(WRAP 2012)

The transport processes involved in the life cycle of meat and dairy products are generally included through the inputs from the three transport industries: 'transport by road; pipelines', 'transport by ship' and 'air transport'. Additional transport at the production industry was included to the overall results.	Meat and Dairy Products	No further information provided for sector. Sectors calculated in model together. The amount of food waste is calculated from the total supply of meat and dairy products and the waste percentage, assuming an average carcass cutting yield of 63 % and dry matter contents of 25 %, 12 % and 40 % in meat, milk, and food wastes, respectively.	(Weidema 2008)
Logistics was part of other life cycle stages, no specific information is given on food waste at logistic stage	Dairy Products	no specific information is given on food waste at logistic stage	(Berlin, Sonesson et al. 2008)
storage losses overseas are considered but it is not mentioned if this storage happens at agriculture or wholesale ware houses but there is a tendency to store the apples after the import to the EU, therefore it was assumed to be part of wholesale	apples	product loss during storage	(Milà i Canals, Cowell et al. 2007)
Starting and ending point not mentioned in detail.	Avoidable food waste in retail shops and wholesale	All food products that are being wasted from the retail shops studied (30 shops in Norway) have been scanned, including unsold food that have been used internally in canteens, in the Deli department. Internally used food has been subtracted from total food wasted. Negligible food is being returned to whole sale centers or to producers, as this is compensated for economically without any physical return.	(Hanssen 2010; Hanssen 2011)

Table 26 Summary for retail of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
Most studies cover the retail shop as one unit.	Most studies cover all or most products from the retail sector		
Eriksson et al. (2011) distinguish between pre-store waste and instore waste, where pre-store waste is food products of too bad quality to be sold in the shops (usually fruits and vegetables). Pre-store waste is also covered by other studies, and in some (very few) cases, wasted products might be send back to the supplier. However, in most cases this is probably solved through economic compensations, without physical return of products to be wasted. In those cases, it is important to consider that the waste is not double-counted.			(Eriksson 2012)
Return flows from retail outlets to central bakery production (was included in data at production level) Products disposed of at retail outlets directly via residual or bio waste Share of bread which is imported from other countries (not included in production statistics) and wasted in Austria was included	Bread and pastry products		(Schneider 2009)

Internal use of not sold products, either in canteens, in Deli departments, as product samples given to customers or through redistribution to other retail shops in the same chain.	All types of products	All food products that are being wasted from the retail shops studied (30 shops in Norway) have been scanned, including unsold food that have been used internally in canteens, in the Deli department. Internally used food has been subtracted from total food wasted. Negligible food is being returned to whole sale centres or to producers, as this is compensated for economically without any physical return.	(Hanssen 2010; Hanssen 2011)
Products given to food banks or charity organizations			

Table 27 Summary for markets of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
No specific detail on markets. The study developed a mapping method for analysing food loss in the food processing industry, which can be used across product groups The processing phases considered are: The study takes it starting point from the Ingredient storage to arrive to distribution (wholesaler or retailer), through processing, packaging, warehousing.	Every product group	The activities producing food waste are: The labelling (with errors); The use of sell-by date (some products could have passed it); The packaging process; Damages in storage.	(Møller 2012)
No specific detail on markets. The report focuses on food and environmental crisis. The study takes it starting point from the food discarded or lost during harvesting, processing, transport and distribution.	Crops, commodities and fish	activities producing waste: increasing urbanization, industrialization, energy demand and population growth. Discarded fish from marine fisheries is the single largest proportion lost of any food source produced or harvested from the wild.	(Nellemann 2009)

No specific detail on markets. This exploratory study focuses on consumer level food loss (excluding the inedible portion of food). The focus is on USA	Meat, poultry, fish, dairy products, fruits and vegetables, grain and bread products, fats and cooking oils, sugars and sweeteners	Consumer-level loss depends on cooking skills, on shelf-life of perishable foods, on the type of use of the food (as an ingredient in cooking or eaten without further preparation), on the type of consumer (children, adults, or seniors), on the type and the location of the preparation (at home or away from home).	(Muth 2007)
No specific detail on markets. The focus of the report is on uneaten food thrown out by Australian households. The study takes it starting point from the results of an online survey, where Australians were asked about the food they throw out and their attitudes and behaviour in relation to food waste.	Every product group	Behaviour, household size and income have a direct influence on levels of food waste This research shows that smaller households tend to generate more food waste per person.	(Baker 2009)
No specific detail on markets. The study takes it starting point from the water wastage due to food wastage. The study takes into consideration the entire food supply chain.	Every food product	The activities/causes producing food waste, taken into account in the study are: poor harvesting technologies in developing countries (where most losses occur at the beginning of the food chain); poor storage and transport facilities. Wholesaling, retailing and consumption in developed countries.	(Lundqvist, de Fraiture et al. 2008)

No specific detail on markets. The study takes it starting point from fruit and vegetable products, along the supply chain. This sector has been identified as the second biggest sector in the food, drink and tobacco industry in terms of waste arising. The focus of the report is on UK.	Fruits and vegetables (apples, strawberries, raspberries, citrus fruit, tomatoes, avocados, bananas, broccoli, onions, potatoes and lettuce)	The main causes of product loss: packaging and labelling	(WRAP 2012)
No specific detail on markets. The study takes it starting point from that the fish arrived to the processing phase. Connections with water use were included.	Fish	The activities producing food waste are economic/ market. There are also technological conditions.	(WRAP 2012)
No specific detail on markets. The study takes it starting point from food waste, to arrive at the description of the possible treatment methodologies. Foods of plant origin, food packaging and potential use of their treated waste are considered.	Every food product	The activities producing food waste are summarized in the imperfect management, analysed in the study.	(Arvanitoyannis 2008)

No specific detail on markets. The study takes it starting point from fruit and vegetable that entered in the cold chain systems in Croatia and Serbia. The paper analysed key factors responsible for high postharvest loss.	Fruits and vegetables	Fresh fruits and vegetables have high water contents and are generally more perishable than other crops after harvest. Approximately one third of all fresh fruits and vegetables is lost before it reaches consumers. This result is largely influenced by the environmental conditions (temperature, relative humidity, gaseous atmosphere) and also depends on fruit crop.	(Jemric 2012)
No specific detail on markets. The study takes it starting point from the results of a consumer survey, a storage trial, some packaging trials and an in-store training. The study focuses on ways of reducing levels of fresh potato waste along the retail and the household steps. It includes	Potato	Activities producing food waste: Uncooked fresh potatoes, cooked leftover potatoes and potato peeling. Passing their food date. The lack of reuse of the excess potatoes in some way.	(WRAP 2012)

No specific detail on markets. The study takes it starting point from the balance between the environmental impact of the food packaging and the environmental impact of food waste. The model considered five different food items (ketchup, milk, bread, beef, cheese). The results show that packaging's that reduce food waste can be an important tool to reduce the total environmental impact, even if there is an increase in impact from the packaging itself	Packaging	An activities producing food waste is the use of packaging that do not reduce waste food. To reduce the environmental impact from the whole food packaging system it is also important to develop the packaging's ability to reduce food waste. In some cases it may be necessary to increase the environmental impact of packaging in order to reduce food waste.	(Williams and Wikström 2011)
No specific detail on markets. The study takes it starting point from food waste that could be eaten without restrictions. Life cycle of food was considered, with a special focus on household level, in order to overcome food wasting behaviour.	Food in general	Causes producing waste are interrelated to the consumer behaviour and to other various aspects, such as age, income; time spent at home, lifestyle.	(Schneider 2008)

Table 28 Summary for redistribution of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
Australia pre-consumer food waste recovery (from the food-manufacturing sector)	Given as examples: Fresh fruit and vegetables, Cheese, Milk, Eggs, Pastry, Muffins, Bread, Pies, Red meat, Chicken, Seafood, Sandwiches and rolls, Desserts, Chocolates, Fruit juice, Soup, Miscellaneous, Biscuits, Pasta, Condiments, Prepared foods, Extras, Drinks, cereals, dairy, fish, Staple Foods, Chilled Product, Dry & Long life Products, Frozen Product	pre-consumer food waste recovery sourced through several food charities; Food donated to food charities can be eaten, either by humans or other animals, and is therefore categorized as avoidable food waste. Edible food donated to food charities is also often referred to as 'rescued', as it has been diverted from landfill and used as food by a range of welfare groups. Foodbank, FareShare, OzHarvest and SecondBite are the largest food charities in Australia and each operates in one or more states. Foodbank operates across all states and territories and is distinguished from other food charities by the large volume of food recovered, as well as the significant volume of food it recovers from the food-manufacturing sector.	(Mason 2011)
UK FareShare was assessed, follows the redistribution flow from retailers to recipients via FareShare which redistributes food donated from retailers to organisations working with homeless people and others with no or low incomes and with poor access to nutritious food	E.g. pre-packed ready meals and desserts, fresh fruit and vegetables	provides an empirical analysis of food 'flows' from donation to final consumption or discard; Some donors deliver these items to the FareShare warehouses from their depots prior to the point of dispatch to their retail outlets as part of their logistics chain. Other donors expect FareShare operatives to visit their retail outlets and collect surplus items on an ad hoc basis	(Alexander 2008)

Table 29 Summary for food service of the main supply chain step boundaries; food product(s) considered and activities producing "food waste" (according to the study's definition of "food waste") which have been identified during the review

Supply chain step boundaries	Food product(s) considered	The activities in the supply chain step, producing food waste and the raw material flows (considered as food waste) following the activities	Reference(s)
Restaurants		Excess quantity was an important factor in determining waste, whereas poor quality had a relatively small effect	(Collison and Colwill 1987)
Hospital		All food supplied and wasted where measured over a period for 28 days. Waste rate was more than 40% of the hospital food.	(Barton 2000)
Hospital		Food waste was measured; plate waste and trolley waste. The average of food waste was 24% - 39%, but big variations	(Sonnino and McWilliam 2011)
Schools and restaurants		Weighing for 2 days, 20% loss at institutions and schools, plate waste the largest source	(Engström and Carlsson-Kanyama 2004)
Schools and colleges, Hospitals, Prisons, Leisure facilities		Various conventions for grossing up have been used, based on waste generation coefficients such as: ☐ Waste per employee ☐ Waste per premises ☐ Waste per unit floor space ☐ Waste per unit of production ☐ Waste per unit of financial volume	(Pocock 2010)
Restaurants		The purpose of the survey was to capture real, measured data about restaurant food waste over the course of one day, separated into three streams: customer plate waste; prep waste and spoilage.	(SRA 2010)

E Annex Evaluation forms for the literature reviews

Table 30 Evaluation form for the literature review on definitions and system boundaries of food waste surveys

GENERAL INFORMATION	
Author(s) of the study:	
Title of the study(ies):	
DEFINITIONS	
How has "food waste" been defined in the report? What terminology has been used for the waste fractions considered and how are they defined?	
Terminology	**Definition (please describe in as precise wordings as possible and in a way that does not require expert knowledge):**
Has there been a distinction between nonedible food waste and edible food waste (food waste that normally should have been eaten if processed and handled properly), mark with an X?	O Yes O No Comment:_____

SYSTEM BOUNDARIES		
Geographical area of the study (country, region, city/municipality), specify:		
Time frame of the study (single measurement/day(s)/month(s)/year(s), specify:		
Which part(s) of the food chain has been covered by the study(ies), mark with an X?		**Specify the activity(ies) taken into account, for each included step of the food chain, when studying food waste. E.g., has crops used as animal feed been considered food waste?; has food thrown away in packaging been considered food waste?; has return flows from retail shops been included? etc.:**
Production (Agriculture) *Primary production*		
Processing of farm staples *First processing of agricultural staples aimed for further processing in the food industry e.g. milling providing flour aimed for bakeries*		
Processing /Food Industry *Industrial processing of food (other than processing of farm stables) e.g. bakeries*		
Packaging		
Wholesale and logistics		
Markets		
Retail		
Hotel and restaurants		

Catering		
Canteens		
Households		
Redistribution *Food banks and similar*		
Other_____		
Has any end of life aspects been taken into account? If so, specify e.g. waste treatment method.		

Other comments:_____
_____

In a report template for the literature reviews; the following questions were asked as guidance for the analysis of the collected information (from the evaluation form in Table 30):

Elaborate on the results in the summarizing table (try to cover all relevant issues from the evaluation form for definitions and system boundaries), for example:

- *Explain in detail the main definitions which have been used in the reports reviewed*
- *Has there been a distinction between edible and non-edible "food waste" (according to the study's definition)?*
- *Which definitions have been used most frequently?*
- *Are there drawbacks with using certain definitions of "food waste"? Elaborate on what can be learnt from the studies reviewed, regarding definitional choices.*
- *Are different definitions used depending on if the aim is to report general quantities of food waste in given regions/ countries or if the aim is to investigate and/or minimize food waste levels for given products or in a given company or food chain?*

Elaborate on the results summarized in the table (try to cover all relevant aspects from the evaluation table on definitions and system boundaries), for example:

- *Describe in detail the activities producing "food waste" (according to different definitions), for the supply chain step reviewed*
- *Are there activities which may produce raw material considered as "food waste" which are often left out of the reviewed studies' scope?*
- *Has any end of life aspects been included? If so, which waste treatment methods have been included?*

- *Consider the different approaches taken on in relation to general reporting /quantification of food waste levels (e.g. amount of food waste in a country or the EU27) and more investigative surveys/reports aiming at finding the causes for food waste and for making improvements*

Try to summarize e.g.:

- *What are the different raw material-streams considered for the supply chain step?*
- *What are the different "food waste"-streams considered for the supply chain step; (e.g. by-products/avoidable food waste/un-avoidable food waste)?*
- *What are the different "food waste"-utilization options for the supply chain step?*
- *What are the different "food waste"-treatment options for the supply chain step?*

By doing this we can get an idea of "the big picture" and see what raw material flows and what utilization and waste treatment options that need to be taken into consideration when establishing a standard approach on definitions and system boundaries and later on when establishing a quantitative technique.

You are encouraged to elaborate on other issues, you find relevant, from the studies reviewed in order to highlight pros and cons with different system boundary approaches.

Table 31 Evaluation form for the literature review on environmental aspects in food waste surveys

GENERAL INFORMATION		
Author(s) of the study:		
Title of the study(ies):		
SYSTEM BOUNDARIES		
Geographical area of the study (country, region, city/municipality), specify:		
Time frame of the study (single assessments/day(s)/month(s)/year(s), specify:		
Which part(s) of the food chain has been covered by the study(ies), mark with an X?		**Specify the material flow(s) taken into account, for each included step of the food chain, when estimating the environmental impact of food waste. E.g., has crops used as animal feed been considered food waste?; has food thrown away in packaging been considered food waste?; has return flows from retail shops been included? etc.:**
Production (Agriculture) *Primary production*		
Processing of farm staples *First processing of agricultural staples aimed for further processing in the food industry e.g. milling providing flour aimed for bakeries.*		
Processing /Food Industry *Industrial processing of food (other than processing of farm stables) e.g. bakeries*		
Packaging		
Wholesale and logistics		

Markets		
Retail		
Hotel and restaurants		
Catering		
Canteens		
Households		
Redistribution *Food banks and similar*		
Other_____		
Has any end of life aspects been taken into account? If so, specify e.g. waste treatment method.		

ENVIRONMENTAL ASSESSMENT-LCA	
Environmental impact categories included:	__ Climate change __ Energy use __ Eutrophication __ Acidification __ Land use __ Water use __ Other_____
Has any standard been applied?	__ ISO __ ILCD __ Carbon footprint __ Other_____ __ No standard approach has been applied.
Are the results of the study published transparently in open reports?	__ Yes __ No
Is the background environmental data (e.g. product LCAs) published in open reports?	__ Yes __ No
ENVIRONMENTAL ASSESSMENT – OTHER METHODS	
Type of environmental data collected in the inventory phase:	
Type of environmental results presented:	
Are the results of the study published transparently in open reports?	__ Yes __ No
Is the background environmental data (e.g. product LCAs) published in open reports?	__ Yes __ No

Other comments:_____
_____

Table 32 Evaluation form for the literature review on socio-economic and economic aspects of food waste surveys

GENERAL INFORMATION	
Author(s) of the study:	
Title of the study(ies):	
Socio-economic issues	
Geographical area of the study (country, region, city/municipality), please specify:	
Time frame of the study (single measurement/day(s)/month(s)/year(s), please specify:	
Which was the primary aim of the study (e.g. nutrition report, consumer habits, sociological study, and estimation of waste generation…)?	
Please specify the object of the study (e.g. female less than 30 yr) and the socio-economic impacts analysed (e.g. consumption pattern).	

Other comments:_____
_____

Economic issues		
Geographical area of the study (country, region, city/municipality), specify:		
Time frame of the study (single measurement/day(s)/month(s)/year(s), specify:		
Which part(s) of the food chain has been covered by the study(ies)? (mark with an X)		**Please specify the considered economic issues for each included step of the food chain. Which units were used to present the results?**
Production (Agriculture) *Primary production*		
Processing of farm staples *First processing of agricultural staples aimed for further processing in the food industry e.g. milling providing flour aimed for bakeries.*		
Processing /Food Industry *Industrial processing of food (other than processing of farm stables) e.g. bakeries*		
Packaging		
Wholesale and logistics		
Markets		
Retail		
Hotel and restaurants		
Catering		
Canteens		
Households		
Redistribution *Food banks and similar*		
Other_____		

Other comments:_____
_____

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