Final report - Summary

Quantification of food surplus, waste and related materials in the grocery supply chain

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CSC103-001
WRAP, 2016, Quantification of food surplus, waste and related materials in the grocery supply chain

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Executive summary

In early 2015 WRAP established a 'Manufacturing and Retail Working Group' to help develop resources aimed at maximising the effectiveness of actions to reduce food waste. These included a range of guidance documents, tools and case studies to facilitate the prevention of food waste arising in the first place, redistribution of food surplus that could not be prevented and diverting suitable surplus to animal feed if redistribution to people was not possible. In addition the Working Group oversaw the inception of this research project, on the amounts and types of food surplus and waste arising, as such evidence is key to prioritising activities in the future. This information will be important for those developing strategies to achieve international, national or organisational targets to prevent food waste and will inform delivery of Courtauld 2025[1].

The main objectives were to:

- Produce estimates of the amount of food surplus, waste and related materials at retail and manufacture (including third party logistics); and
- Quantify the amount of surplus and waste that might be prevented from arising, be suitable for redistribution and/or diversion to animal feed.

The methodologies used within this research are consistent with the principles outlined in the FUSIONS guidance for food waste quantification, as are the definitions of food waste[2]. Criteria for assessing suitability for prevention of food surplus and waste arising, redistribution and diversion to produce animal feed were agreed with relevant experts.

There are some inherent challenges with such a complex analysis which combines data from a range of sources with other intelligence. There are some inevitable data uncertainties and limitations which are acknowledged and explained in the report. Food by-product and waste data for retail and manufacture are linked to the latest available national data, which is for 2014, whilst food surplus data draws on more recent sources and therefore these estimates are for 2015.

Headline results

Food surplus and waste at retail amounted to 240,000 tonnes, or the equivalent of 0.7% of sales. Of this, 5,000 tonnes was redistributed to people, 27,000 tonnes used in the production of animal feed and 210,000 tonnes was food waste. Of food not sold as intended, 13% was either redistributed or sent for the production of animal feed.

In manufacture (including third-party logistics) there was 2.4 million tonnes of food surplus and waste, the equivalent of 4.2% of UK production. 42,000 tonnes was redistributed to people, 635,000 tonnes used to produce animal feed and 1.7 million tonnes was food waste. Of food not sold as intended, 28% was either redistributed or sent for the production of animal feed.

[1] *Courtauld Commitment 2025*
[2] *FUSIONS Guidance on Food Waste Quantification*

The new approach developed within this research has allowed a much better understanding of the nature of the surpluses and wastes arising at retail and manufacture, and these methodological refinements have contributed to a significantly lower estimate of food waste for manufacture:

- Wasted food products make up around 50% of the waste streams with organic material from manufacture, with the remainder consisting of water from site cleaning processes and other materials such as soil and stones. This finding together with a reduction in food waste due to waste prevention (of around 10% from 2011 to 2014) leads to a significantly lower overall estimate of food waste from manufacture compared to the one previously published by WRAP (1.7 million tonnes vs 3.9 million tonnes for 2011); and
- For the first time this research has produced an estimate of how much of the food waste could be defined as avoidable (that is could have been eaten, with or without further processing). Of the total food waste at retail and manufacture (1.9 million tonnes), around 1.1 million tonnes or 56% was avoidable (with a potential sales value of £1.9 billion).

Detailed estimates are provided for the amount of food surplus and waste arising for retail and manufacture (overall and for 11 sub-sectors), and the current fate of these materials. Five sub-sectors are responsible for around 80% of avoidable food waste in manufacture; dairy products, meat, poultry and fish, ambient products, fresh fruit and vegetable processing and bakery, cake and cereals.

The extent to which food waste could be defined as avoidable varies by sub-sector, with a higher proportion being avoidable for ambient products, bakery and pre-prepared meals.

Analysis has been carried out to assess the extent to which food surplus and waste might be prevented within the ten-year timeframe of Courtauld 2025, based on the characteristics of the material itself, knowledge of potential interventions and alignment with the food waste or utilisation hierarchy[3]. Prevention of waste arising in the first place has been prioritised, followed by redistribution (either via charitable or commercial routes), then diversion to animal feed. Both of the latter are higher up the hierarchy than sending food waste to anaerobic digestion or to composting facilities, and will contribute to the delivery of food waste prevention targets.

Various factors will influence the implementation of interventions to prevent food waste and the timescales for these, and a range of scenarios were developed to reflect this. These included one maximising the amount of food that may be suitable for redistribution (including some that may be challenging to manage), one that maximises surplus to animal feed (assuming more of the material that is suitable for animal feed is diverted to this use) and the primary scenario which prioritises the implementation of actions to prevent food waste arising, followed by redistribution and then diversion to animal feed. These scenarios give rise to a range of potential tonnages that may be prevented, and may be suitable for redistribution or diversion to animal feed.

This analysis suggests that:

- Of the current food surplus and food ending up as waste, 270,000 tonnes may be suitable for redistribution, including 37,000 tonnes currently being used to produce animal feed, 190,000 tonnes going to waste (where on average around 40% goes to anaerobic digestion and other recycling options, 40% for energy recovery and 20%

[3] *Find out more about the food waste or utilisation hierarchy here*

to landspreading) and the 47,000 tonnes already being redistributed. This suggests therefore that 18% of what may have been suitable for redistribution was actually redistributed in 2015; and
- 860,000 tonnes of food surplus and material now going to waste could be suitable for use in animal feed, compared to the 660,000 tonnes currently being used for this purpose[4].

The results from the primary scenario (which incorporates prevention of food surplus and waste arising in the first place, then prioritises redistribution followed by diversion to animal feed) indicate the potential outcomes by 2025:

- Prevention of food waste at source could save almost £300 million a year of food from being wasted (185,000 tonnes);
- Redistribution of surplus food could provide the equivalent of 360 million meals a year (from around 185,000 tonnes of food surplus, a four-fold increase compared to 2015);
- The amount of food surplus being used to produce animal feed could be increased by around 20% (to around 800,000 tonnes a year);
- A combination of preventing food waste being generated, redistributing more of the food surplus that can't be prevented to people and diverting surplus that isn't suitable for human consumption to animal feed will all be needed to achieve the Courtauld 2025 target;
- Together these actions could reduce the 1.1 million tonnes of avoidable food waste at retail and manufacture by 42% or 450,000 tonnes (resulting in a 23% reduction in total food waste); and
- Around 1.5 million tonnes of food waste may not be suitable for prevention, at least not within the shorter term, and will need to be assessed for optimal treatment and recovery.

Some of the changes required could be implemented in the shorter term (for example using the resources already available from WRAP and others) whilst some will require medium-term innovations and collaboration to bring about. Courtauld 2025 will aim to facilitate this.

The potential reduction in retail and manufacturing food waste identified in this report is broadly consistent with that modelled during the development of the Courtauld 2025 food waste prevention target. That target requires a 20% per capita reduction by 2025 across the food system, and takes in to account potential population and production growth. Achieving the target will be challenging for all sectors, but this research shows that the contribution from retail and manufacturing is stretching but realistic, and provides insights that will help deliver against it.

The potential scale of food waste reduction identified in this report, and the contributions from prevention, redistribution and diversion to animal feed are based on an overall assessment of what is realistic at a UK level. There will be significant differences between different businesses in what they may be able to achieve, and what interventions may work best for them, as a result of their product mix, size, location, policies towards mark-downs, progress made to date and so on. The estimates in this report are not therefore targets for individual businesses, but a guide to what the sectors as a whole could achieve – which WRAP will monitor through Courtauld 2025.

[4] These estimates for maximum redistribution and maximum diversion to animal feed are not additive as they arise from different scenarios.

Main recommendations

This research has applied a new approach to estimating both how much food surplus and waste comes from manufacture and retail, and how much of this might be suitable for a range of waste prevention interventions. It has pulled together data and insights from a wide range of sources, covering a diverse set of sectors and sub-sectors. It clearly identifies the potential for stopping food waste arising, redistributing more to people and diverting more surplus to produce animal feed. It should however be stressed that this forms the foundation upon which to build a more comprehensive understanding of this area, as methodologies evolve, interventions are evaluated and more targeted research undertaken.

The following represent opportunities to further improve data quality and relevance over time:

- Refine the estimates for how much food waste might be prevented from arising based on a) the evaluation of innovations in processing, equipment, packaging management etc., as these are implemented, b) from monitoring the levels of food surplus and waste arising over time and c) from feedback on the barriers to implementing relevant innovations;
- Refine the estimates for how much of the food surplus and waste might be suitable for redistribution based on learnings from both the providers and recipients of food surplus. Innovations in the types of material that could be turned in to products suitable for use by recipients could lead to an even higher percentage of future food surplus and food that might have been wasted being used to feed people; and
- It should also be noted that whilst this research provides more granular estimates of food surplus and waste for the sectors, it does not reveal priorities for action within a sub-sector. Further and more focused 'mapping' will be required for the sub-sectors with the greatest potential to prevent food waste. As a first step WRAP is working with a major dairy business to map material flows from multiple sites and a wide range of products (including milk, soft and hard cheeses, butter, yoghurt etc.), with the objective of identifying the greatest opportunities for both prevention and maximising value from the non-preventable materials.

The following are also critical for the delivery of the waste prevention opportunities identified in this report:

Collaborative action targeting priority areas:

- This research has identified areas where the greatest potential impacts can be made, and also that collaboration between businesses across the supply chain will be needed to realise the greatest benefits (for example between brands and retailers in tackling some of the in-store food waste, and retailers and manufacturers in addressing some of the opportunities around forecasting). The outputs from this research will inform decision making on where resources should be allocated, for example through working groups under Courtauld 2025, and future 'whole chain resource efficiency' projects[5].
- WRAP will establish a Redistribution Working Group under Courtauld 2025 to understand more about the implications associated with realising some of the redistribution potential identified in this study. It will be particularly helpful to share insights from retailer back of store and manufacturing trials that have been undertaken in different parts of the UK during 2015 and early 2016.

[5] *See Whole chain resource efficiency*

Awareness raising/behavioural change:

- The study found that there was often a poor understanding across the sector about the sorts of surplus that were within scope for redistribution and how businesses with food surpluses can partner with redistribution organisations. This issue should be addressed through the improved guidance and partnership tools developed by the redistribution sector and WRAP, the use of awareness raising resources such as 'Your Workplace Without Waste' and through greater engagement on this issue with individual businesses and trade associations under Courtauld 2025[6].
- In order to enable greater amounts of food surplus to be diverted to animal feed production WRAP will be working with the FSA and representatives of national and local enforcement bodies to improve the consistency and clarity of both the guidance available to food businesses and the training of staff on the ground.

Maximising value from food waste that cannot be prevented:

- Around 1.5 million tonnes of food waste may not be suitable for prevention (120,000 tonnes from retail, equivalent to 0.3% of product sold in 2014; 1.4 million tonnes from manufacture, equivalent to 2.4% of product sold), at least not within the shorter term. This will need to be assessed for optimal treatment and use. This will need to look at the balance between on-site versus off-site treatment options, both in terms of commercial and environmental benefits.

[6] For example see Surplus food redistribution, Your Workplace Without Waste, The FareShare Food Efficiency Framework

Summary report

Background

The United Nations Food and Agriculture Organisation (FAO) estimated that in 2011 roughly one-third of all food produced in the world ended up as waste[7], although some estimates put the figure as high as 50%, or up to 2 billion tonnes a year[8]. FAO also estimated that the global carbon footprint of food waste, excluding land use change, was 3.3 billion tonnes of CO_2e, equivalent to approximately 8% of global GHG emissions. There are also significant implications for water and land use of producing food that ends up not being consumed, and serious financial consequences for food producers, consumers and those responsible for managing food that is wasted[9]. Preventing food waste has been a priority for Governments in the UK and WRAP for over a decade, and a range of mechanisms have been put in place to deliver this, notably voluntary agreements with key sectors[10] and the Love Food Hate Waste consumer-facing campaign[11]. Reductions in food waste have been reported for households, retail and manufacturing and hospitality and food service, but there is the opportunity to do more[12].

In March 2016 WRAP launched the Courtauld Commitment 2025 (Courtauld 2025), an ambitious 10-year voluntary agreement that brings together a broad range of organisations involved in the food system to make food and drink production and consumption more sustainable. One of the Courtauld 2025 targets is to reduce the amount of food waste across the food system. Retailers and manufacturers have a central role to play in achieving this food waste reduction target, both in terms of tackling food waste within their own operations and how they help their suppliers and customers. Retailers and manufacturers have been working under WRAPs Courtauld 2 and 3 agreements to reduce waste in the supply chain since 2009, and achieved a 7.4% reduction in food and packaging waste between 2009 and 2012[13]. Interim results from Courtauld 3 indicated a further 3.2% reduction by 2014 compared to 2012, and a 74% increase in redistribution of surplus food by signatories[14]. WRAP and Courtauld signatories also influence non-signatories through a variety of mechanisms[15] and WRAP estimated that overall food waste in the supply chain could have reduced by around 6% between 2009 and 2012[16].

In early 2015 WRAP established a 'Manufacturing and Retail Working Group' to help develop resources aimed at maximising the effectiveness of actions to reduce food waste. These included a range of guidance documents, tools and case studies[17] to facilitate the prevention of food waste arising in the first place, redistributing surplus food that could not be prevented and diverting suitable surplus food to animal feed if redistribution to people was not possible – all three of these actions contributing to food waste prevention targets. In addition the Working Group oversaw the inception of the research project that resulted in

[7] *Global food losses and food waste study*
[8] *Food Wastage Footprint report*
[9] *Strategies to achieve economic and environmental gains by reducing food waste*
[10] *For example the Courtauld Commitment and the Hospitality and Food Service Agreement*
[11] *More on Love Food Hate Waste can be found on the campaign website*
[12] *UK Food Waste - Histoical changes and future influences; HaFSA progress 2 years on; CC3 Supply chain targets on track for success*
[13] *Courtauld Commitment 2; this is the combined reduction in the weight of food and packaging waste*
[14] *Courtauld Commitment 3 interim results and case studies; this is the combined reduction in the weight of food and packaging waste*
[15] *See UK Food Waste - historical changes and future influences*
[16] *UK Food Waste - historical changes and future influences*
[17] *These can be found at Whole Chain Resource Efficiency; Surplus food redistribution; Extending product life to reduce food waste; Food waste prevention information at your fingertips - digests and webinars; Guidance for Food and Drink Manufacturers and Retailers on the Use of Food Surplus as Animal Feed*

this report, as having updated evidence-based insights on the amounts and types of food surplus and waste arising is key to prioritising activities in the future. In addition to supporting delivery of the Courtauld 2025 targets, this information will be important for those developing strategies to achieve international, national or organisational targets to prevent food waste.

This summary provides an overview of the research objectives, methodology, limitations, headline results and key recommendations/next steps. Full details of the methodology and UK-level results are contained within the main body of the report. A series of appendices provide more detail on the findings within each food and drink manufacturing sub-sector, for example dairy and bakery.

Food by-product and waste data for retail and manufacture is linked to the latest available national data, which is for 2014, whilst food surplus data draws on more recent sources and therefore these estimates are for 2015.

Objectives

The aims of this research are to improve the understanding of food surplus and food waste in the UK grocery supply chain and to provide policy and business relevant insights, particularly in relation to the delivery of Courtauld 2025[18]. One of the Courtauld 2025 targets is to reduce the amount of food waste across the food system, and these research outputs will help focus resources on those areas where most impact might be achieved.

The key research objectives were to:

- Produce estimates of the amount of food surplus, waste and related materials at retail and manufacture (including third party logistics);
- Quantify the amount of food surplus and waste that might be prevented from arising, suitable for redistribution and/or diversion to animal feed; and
- Identify the most significant causes of food surplus and waste.

Scope

The study included UK-based food manufacturers and grocery retailers[19]. It did not extend to hospitality and foodservice or wholesalers. The agriculture sector and households were also outside of the project scope. In order to provide a structure for the research design, food and drink manufacturing activity was clustered into a number of industry sub-sectors: milling; confectionery; fruit and vegetables; ambient products; meat, poultry and fish; pre-prepared meals; dairy products; alcoholic drinks; bakery, cakes, biscuits and breakfast cereals; sugar and soft drinks and fruit juices.

The food waste definitions were aligned with those developed by the European Commission funded FUSIONS project[20]. The definition of food surplus and criteria for determining preventability and suitability for redistribution or diversion to animal feed were based on discussions with industry experts and consideration of relevant regulations and guidance.

Total food waste is any food, including inedible parts of food, removed from the food supply chain to be recovered or disposed of – that is, it contains both material that may be, or has the potential to be edible plus the inedible fractions associated with food. In this report

[18] *Courtauld Commitment 2025*
[19] *Food surplus and waste from staff and customers restaurants was also excluded*
[20] *A Food Waste Definitional Framework was published by the FUSIONS project in 2014*

WRAP uses the term 'theoretically avoidable food waste[21]' to define food waste that could in theory be edible (with or without further processing). In reality, not all theoretically avoidable food waste can be prevented and therefore the term 'practically avoidable' is used to describe what could realistically be prevented (in the timeframe of Courtauld 2025). For example during the manufacture of flavoured milk drinks some product waste will occur during line cleaning between batches, and would be defined as theoretically avoidable (as it would be edible product) but whilst improved sensors and low volume purging may reduce this (and contribute to what would be defined as practically avoidable) it would not be possible to eliminate this source of food waste altogether.

Figure S1: *Illustration of how total, theoretically and practically avoidable food waste relate to one another*

The range of data sources and methodologies used within this research are briefly discussed at the end of this summary, and more detail can be found in the main body of the report.

Results and analysis

UK estimates of food surplus and waste for 2014/15

It is estimated that total food waste (which includes materials such as inedible peelings) in the manufacturing and grocery retail sectors amounts to 1.9 million tonnes, with 56% of this theoretically avoidable (which excludes materials such as inedible peelings), which is worth £1.9 billion a year. In addition there were 710,000 tonnes of food surplus being redistributed or sent for animal feed (see Table S1) and 2.8 million tonnes of animal and other by-products.

The amounts of food surplus and waste in manufacture represent the equivalent of 4.2% of UK production (around 58 million tonnes in 2014[22]), whilst retail food surplus and waste represent the equivalent of 0.7% of product sold (around 37 million tonnes in 2014[23]).

[21] See FUSIONS Definitional Framework for Food Waste for more discussion on the definition of food waste. It should also be noted that others, such as the UN FAO, use the term 'edible' rather than 'avoidable' food waste
[22] Derived from PRODCOM data as described in Appendix K

This study did not re-estimate total food waste from the retail sector, as new estimates had been reported by the BRC in 2015 and extrapolated to the wider sector by WRAP[24]. The main focus was therefore on understanding the detail beneath the 210,000 tonnes estimated to arise from the sector in 2014.

The new approach developed within this research has allowed a much better understanding of the nature of the surpluses and wastes arising at retail and manufacture. Wasted food products make up around 50% of the organic waste streams from manufacture, with the remainder consisting of material associated with food production but not made up of food (for example cleaning water, soil and stones etc.). This improved granularity, together with a reduction in food waste being generated (of around 10% from 2011 to 2014, and amounting to around 200,000 tonnes), leads to a significantly lower overall estimate of food waste from manufacture compared to the one previously published by WRAP (1.7 million tonnes vs 3.9 million tonnes for 2011).

Table S1: *Manufacture and retail food surplus and waste (2014 for food waste; 2015 for food surplus[25])*

	Total food waste (t)	Total food surplus (t)	Total food surplus and waste (t)	% surplus and waste of production/sales
Manufacture	1,700,000	680,000	2,400,000	4.2%
Retail	210,000	32,000	240,000	0.7%
Total	1,900,000	710,000	2,600,000	

The amount of food surplus redistributed via charitable and commercial routes is estimated at 47,000 tonnes for 2015, with 660,000 tonnes of food surplus being diverted to produce animal feed (Table S2).

Table S2: *Manufacture and retail food surplus by use (2015 data)[26]*

	Food surplus to redistribution (t)	Food surplus to animal feed (t)	Overall food surplus (t)
Manufacture	42,000	635,000	680,000
Retail	5,000	27,000	32,000
Total	47,000	660,000	710,000

For the first time this research has produced an estimate of how much of the food waste could be defined as avoidable (that is it could have been edible, with or without further processing). Of the total food waste at retail and manufacture (1.9 million tonnes) around 1.1 million tonnes or 56% was avoidable (with a potential sales value of £1.9 billion). All of the food waste at retail is defined as avoidable, as all of this was originally intended to be sold, whilst 51% of food waste at manufacture is avoidable.

[23] Derived from Family Food 2014 by WRAP, as described in Household Food & Drink Waste – A Product Focus
[24] See Handy facts and figures on waste in the UK
[25] The estimate for redistribution from retail for 2015 may be an underestimate as data on store level redistribution via local charities is not held centrally by all retailers. These volumes are likely to be small compared to the current redistribution from retail distribution centres
[26] Data is rounded to 2SF and therefore the totals may not equal the sums of the contributory rows

Detailed estimates are provided below for the amount of food surplus and waste arising for retail and manufacture (overall and for 11 sub-sectors), and the current fate of these materials.

Potential for food waste prevention

Analysis has been carried out to assess the extent to which food surplus and waste might be prevented within the timeframe of Courtauld 2025, based on the characteristics of the material itself, knowledge of potential interventions and alignment with the food waste or utilisation hierarchy. Prevention of waste arising in the first place has been prioritised, followed by redistribution (either via charitable or commercial routes), then diversion to animal feed. Both of the latter are higher up the hierarchy than sending food waste to anaerobic digestion or to composting facilities, and will contribute to the delivery of food waste prevention targets

Various factors will influence the implementation of interventions to prevent food waste and the timescales for these, and a number of scenarios were developed to reflect this. These included one maximising the amount of food that may be suitable for redistribution (including some surpluses that may be challenging due to very short shelf-life), one that maximises surplus to animal feed (assuming more of the material that is suitable for animal feed is diverted to this use) and the primary scenario which prioritises the implementation of actions to prevent food waste arising, followed by redistribution and then diversion to animal feed. The different scenarios give rise to a range of potential tonnages that may be prevented, and may be suitable for redistribution or diversion to animal feed. The results from the primary scenario (which balances prevention, redistribution and diversion to animal feed) and the ranges from all scenarios are shown in Table S3.

Table S3: *Potential levels of food surplus and waste by 2025 (tonnes)*

	Total food waste (potential; t)	Food surplus (potential; t)	Redistribution (potential; t) [range; t]	Animal feed (potential; t) [range; t]
Manufacture	1,400,000	895,000	130,000 [52,000-160,000]	765,000 [615,000-805,000]
Retail	120,000	95,000	55,000 [47,000-110,000]	40,000 [10,000-50,000]
Total	1,500,000	990,000	185,000 [99,000-270,000]	805,000 [625,000-860,000]

The analysis suggests that of the current total of food surplus (710,000 tonnes) and food ending up as waste (1.9 million tonnes), 270,000 tonnes may be suitable for redistribution (25% of theoretically avoidable food waste), including 37,000 tonnes currently being used to produce animal feed, 190,000 tonnes going to waste (where on average around 40% goes to anaerobic digestion and other recycling options, 40% for energy recovery and 20% to landspreading)[27] and the 47,000 tonnes already being redistributed. This suggests therefore that 18% of what may have been suitable for redistribution was actually redistributed in 2015.

Figures S2 and S3 illustrate where the additional food suitable for redistribution could be diverted from, for manufacturing and third-party logistics and for retail. These estimates are

[27] Based on the waste treatment or disposal routes for manufacture (derived from Environment Agency data as reported in Section 6) and retail (derived from WRAP Courtauld 3 signatory reporting data). Data on food waste routes for third-party logistics is not available and it was therefire assumed that these would be similar to those for retail (as both consist primarily of finished product).

derived from the 'maximum redistribution' scenarios, and as described below, efforts to prevent food surplus and waste arising in the first place would have an impact on the amount of food available for redistribution (as shown in Figures S10 and S11).

Figure S2: *Illustration of where food suitable for redistribution might be diverted from, for manufacturing and third-party logistics (tonnes)*

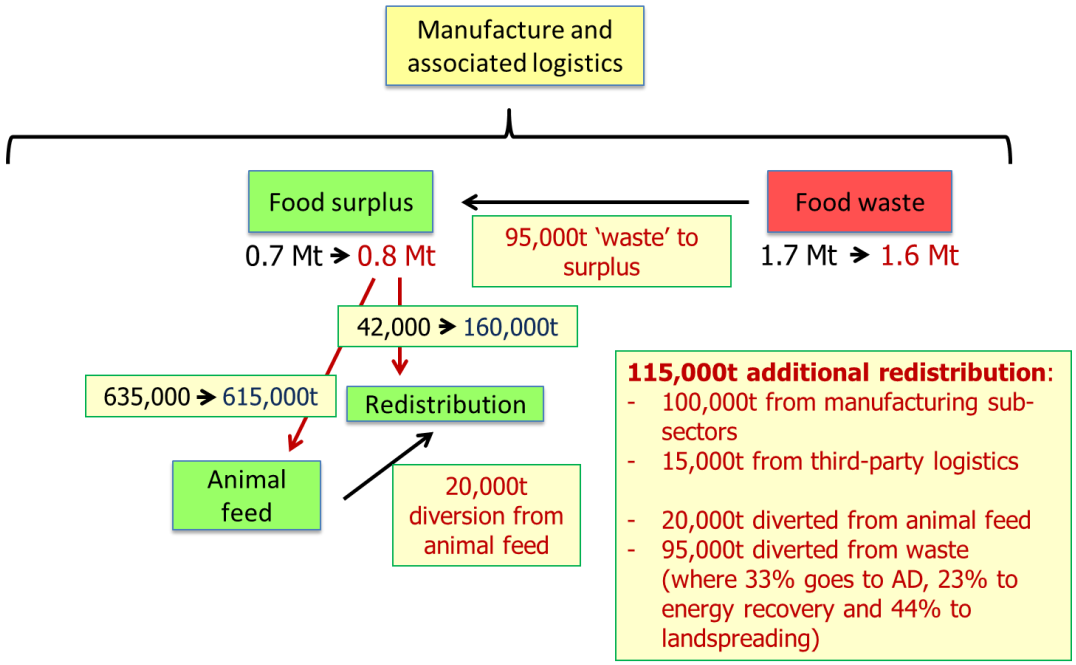
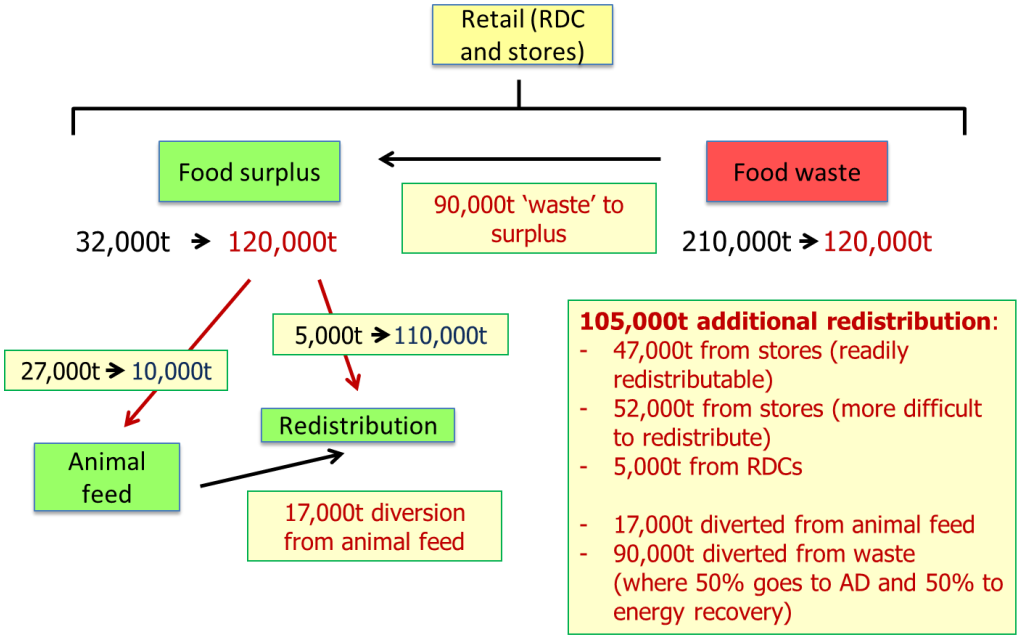


Figure S3: *Illustration of where food suitable for redistribution might be diverted from, for retail (tonnes)*



The analysis also suggests that of the current food surplus and material going to waste within manufacture and retail, 860,000 tonnes could be suitable for use in animal feed, compared to the 660,000 tonnes currently being used for this purpose. These estimates are derived from the 'maximum diversion to animal feed' scenarios, and as described below,

efforts to prevent food surplus and waste arising in the first place, and increase redistribution of surplus food would have an impact on the amount of food available for diversion to animal feed (as shown in Figures S10 and S11). It is important to stress that the estimates for maximum redistribution and maximum diversion to animal feed are not additive as they arise from different scenarios, as illustrated in Figure S14.

The results from the primary scenario (which incorporates prevention of food surplus and waste arising) reflect the potential outcomes by 2025 and suggest that of the total 1.1 million tonnes of theoretically avoidable food waste almost 450,000 tonnes or 42% is likely to be practically avoidable (in the timeframe of Courtauld 2025) (Table S4), through a combination of prevention of arisings, increased redistribution and diversion to animal feed (both of the latter are classed as waste prevention activities).

***Table S4**: Assessment of how much manufacture and retail food waste is theoretically and practically avoidable*[28]

	Total food waste (t)	Theoretically avoidable food waste (t)	Practically avoidable food waste (t)	% of total food waste practically avoidable	% of avoidable food waste practically avoidable
Manufacture	1,700,000	870,000	355,000	21%	41%
Retail	210,000	210,000[29]	93,000	44%	44%
Total	1,900,000	1,100,000	450,000	23%	42%

Around 1.5 million tonnes of food waste may not be suitable for prevention, at least not within the shorter term, and will need to be assessed for optimal treatment and recovery.

Manufacturing material flows for 2014/15

In the simplified model presented in Figure S4, it can be seen that by-products, surplus and food waste combined represent around 5.2 million tonnes, equivalent to 9% of UK manufacturing output of 58 million tonnes. Food surplus and food waste represent the equivalent of 4.2% of UK production, and theoretically avoidable food waste arisings are equivalent to 1.5% of this output. Of food not sold as intended, 28% is redistributed or sent for the production of animal feed. The majority of by-product and surplus are sent for the production of animal feed. Around half of the food waste is subject to some form of on-site treatment (such as dissolved air filtration [DAF] or anaerobic digestion [AD]) prior to being moved off site.

Figures S5 and S6 show the breakdown of total and theoretically avoidable food waste at manufacture by sub-sector. For total food waste five sub-sectors are responsible for around 80% of the sector's food waste, and a similar picture is seen for avoidable food waste (although bakery comes in to the top five and alcoholic drinks moves out).

[28] *See the glossary for definitions of these terms*
[29] *All of the food wasted at retail is defined as avoidable, as all food at retail is intended for sale*

Figure S4: *Manufacturing material flows for 2014/15 (total food waste streams shown sum to 1.65 million tonnes, an additional 90,000 tonnes is in minor streams and not shown[30])*

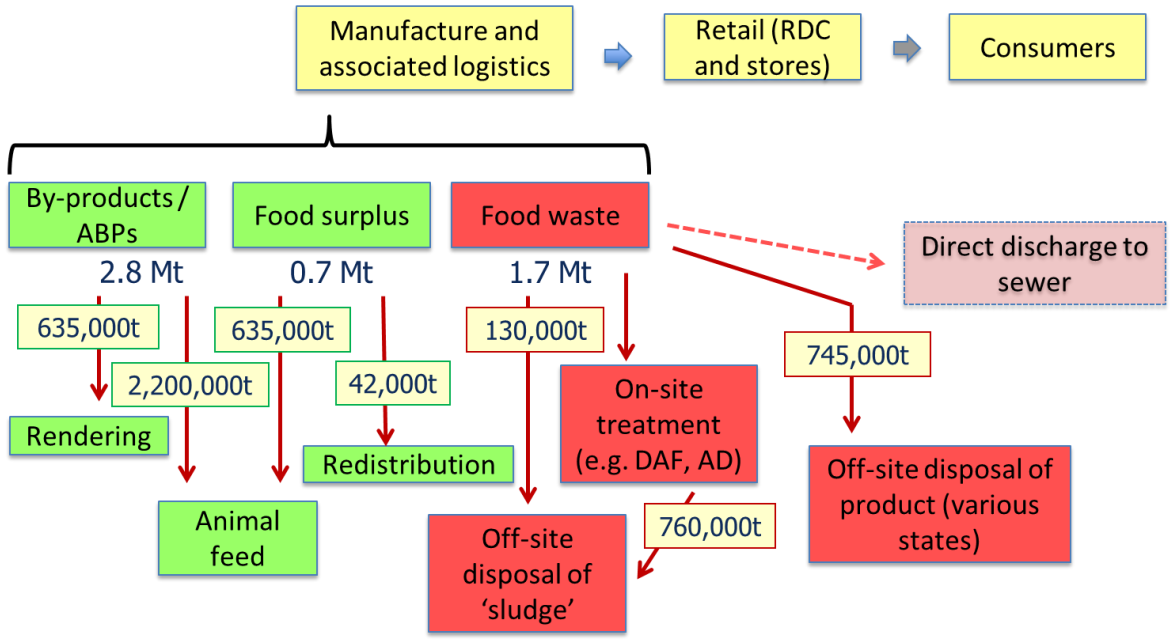
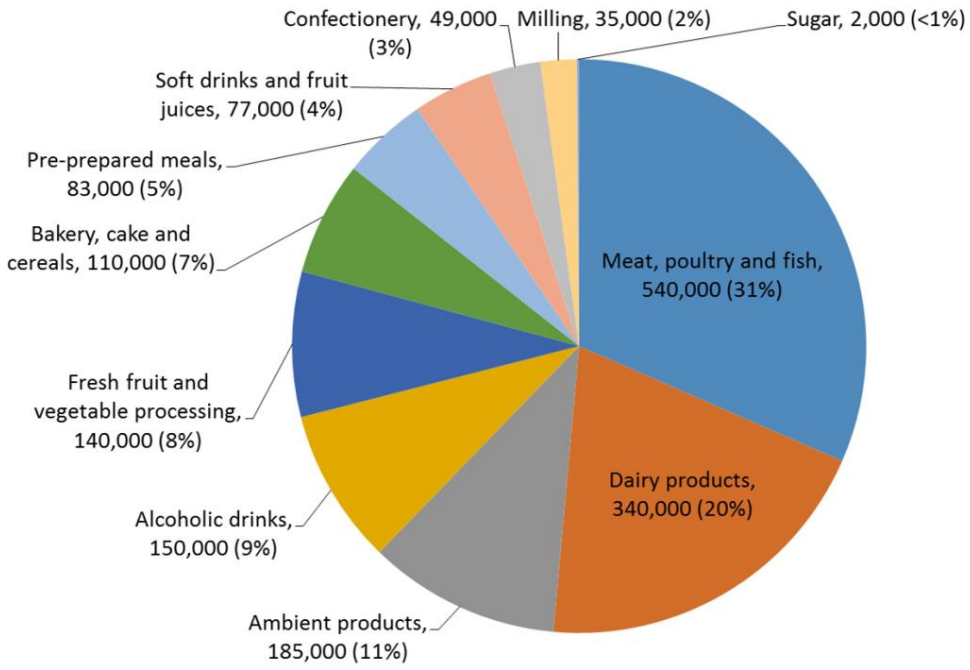
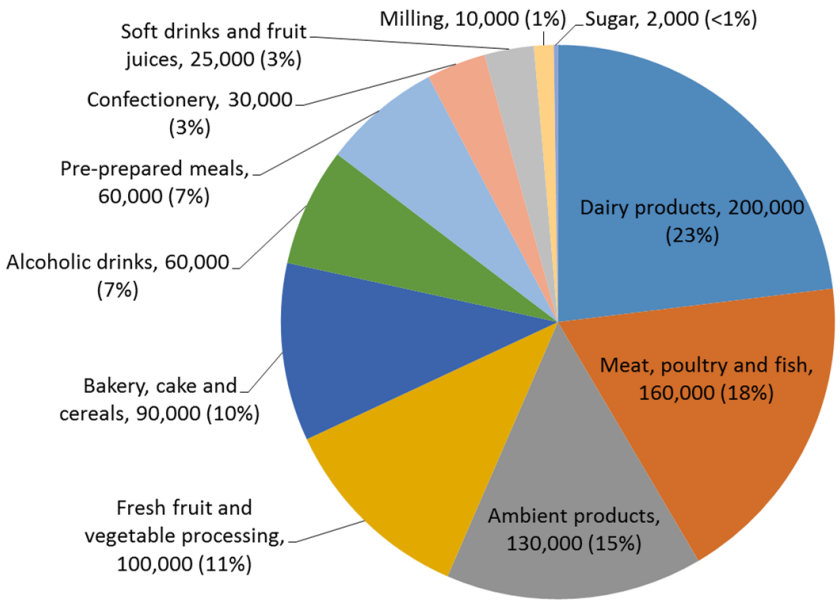


Figure S5: *Total food waste from manufacturing, split by sub-sector (tonnes; total equals 1.7 million tonnes; for 2014)[31]*



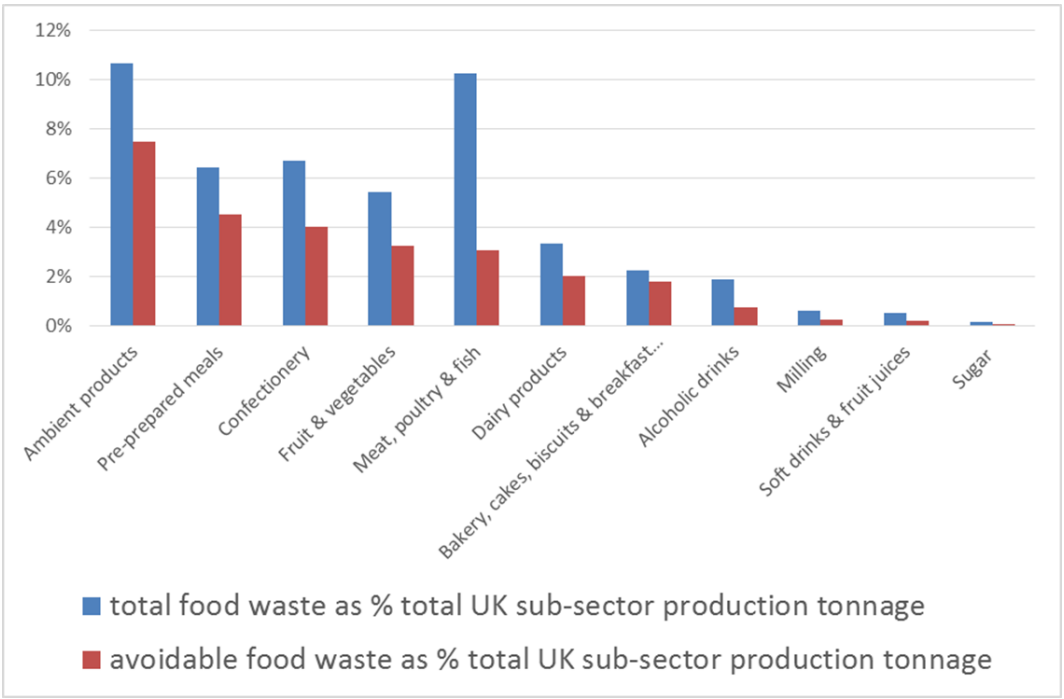
[30] *See Figure 6.3 in the main report for the full detail*
[31] *For the purposes of this analysis, the ambient sub-sector includes canned foods, preserves, jams and jellies; dried and dehydrated fruits, vegetables and soup mixes; pickled fruits and vegetables, vegetable sauces and seasonings, and salad dressings etc.*

Figure S6: *Theoretically avoidable food waste from manufacturing, split by sub-sector (tonnes; total equals 870,000 tonnes; for 2014)*



The proportion of food waste in relation to production volumes varies widely by industry sub-sector (Figure S7), with the highest proportion of theoretically avoidable food waste in ambient and pre-prepared meals sub-sectors. Generally, the wastage rate is higher in those sub-sectors which produce more complex end products involving multiple ingredients and production lines. The avoidable food waste for these two sub-sectors is equivalent to around 8% and 4% of their UK production tonnage respectively.

Figure S7: *Food and drink waste (total and theoretically avoidable as a proportion of UK food and drink manufacturing production; tonnes; for 2014)*

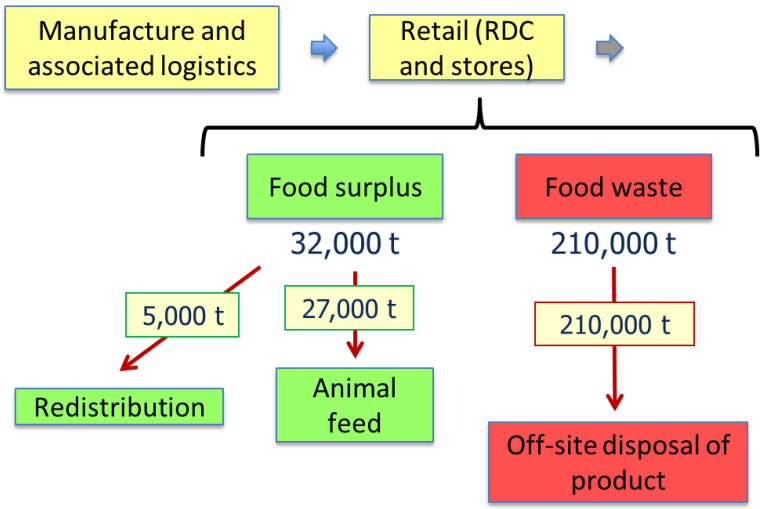


(adapted from PRODCOM data, provisional, food waste estimated from EP2014 data)

Retail material flows for 2014/15

In the simplified model presented in Figure S8, it can be seen that food surplus and food waste combined represent around 240,000 tonnes, equivalent to 0.7% of UK grocery food sales. Of food not sold as intended, 13% is redistributed or sent for the production of animal feed.

Figure S8: *Retail material flows for 2014/15*



Potential for food waste prevention, additional redistribution and diversion to animal feed

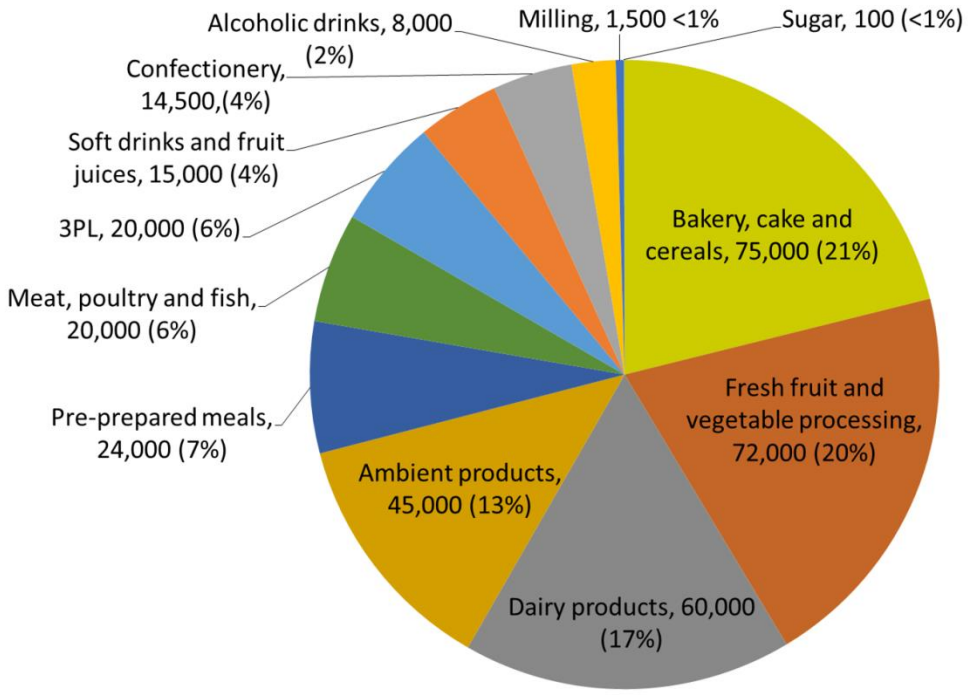
Manufacturing and third-party logistics (3PL)

Potential root causes of food surplus and waste varied considerably across the sub-sectors, depending on the product and the nature of the manufacturing operation. Sub-sector specific insights are provided in the main report, but in general the following would be relevant to the prevention of food waste:

- Better operational practices, for example application of Lean practices to food manufacturing or the application of continuous improvement methodologies to production processes, improved product handling procedures, changes to shut-down/ production line break-down procedures, batch change-overs with respect to improved line balancing and waste associated with machine breakdown;
- Improvements to process control of existing operations: such as making less 'off-spec' product through better control of raw material additions, avoidance of spoilage through improved temperature control, better stock control systems ('first-in-first-out'), better waste measurement and feedback into workplace practices and unit processes;
- Innovations in food processing technologies to improve yields and reduce waste, such as technologies to reduce product loss in cleaning system and extend product life;
- Improvements to forecasting and processes around changes to orders;
- Increased redistribution of food surplus;
- Increased diversion of food surplus for animal feed; and
- Linked to many of the above, improvements in staff training and awareness of the opportunities to address surplus and waste.

It is estimated that around 355,000 tonnes of food waste at manufacture could be practically avoidable by 2025, through a combination of preventing waste arising, additional redistribution and diversion to animal feed, equivalent to a 21% reduction in total food waste or 41% in theoretically avoidable food waste. A combination of prevention of waste arising and increases in redistribution and diversion to animal feed will be required to deliver this reduction, and a number of factors are likely to influence this balance, and how this changes over time. Four sub-sectors contribute around 75% of this potential (bakery, fresh fruit and vegetables, dairy and ambient; Figure S9).

Figure S9: *Overall prevention potential* for manufacture, by sub-sector and for 3PL (tonnes; total = 355,000 tonnes)*



The analysis suggests that around 155,000 tonnes of food waste could be prevented from arising at manufacturing and 3PL, through a wide range of awareness raising, behavioural, operational, process and product innovations. Some of the changes required could be implemented in the shorter term (for example using the resources already available from WRAP and others) whilst others will require medium-term innovations and collaboration to bring them about. Courtauld 2025 will aim to facilitate this. Five sub-sectors have more than 80% of the potential to prevent food waste arising (dairy, ambient, meat, poultry and fish, fruit and vegetables and pre-prepared meals).

The primary estimate for the amount of food that is currently wasted but could be suitable for redistribution is 70,000 tonnes (55,000 tonnes from the manufacturing sub-sectors and 15,000 tonnes from 3PL), and in addition there could be 15,000 tonnes of food surplus that is currently being diverted to animal feed that could be redistributed to people. Added to the 42,000 tonnes being redistributed in 2015 (37,000 tonnes from the sub-sectors and 5,000 tonnes from 3PL) this could mean around 130,000 tonnes of suitable food being available for redistribution. Around half of the additional food is from the fruit and vegetable sub-sector, and another 40% from 3PL, dairy, ambient, bakery and pre-prepared meals.

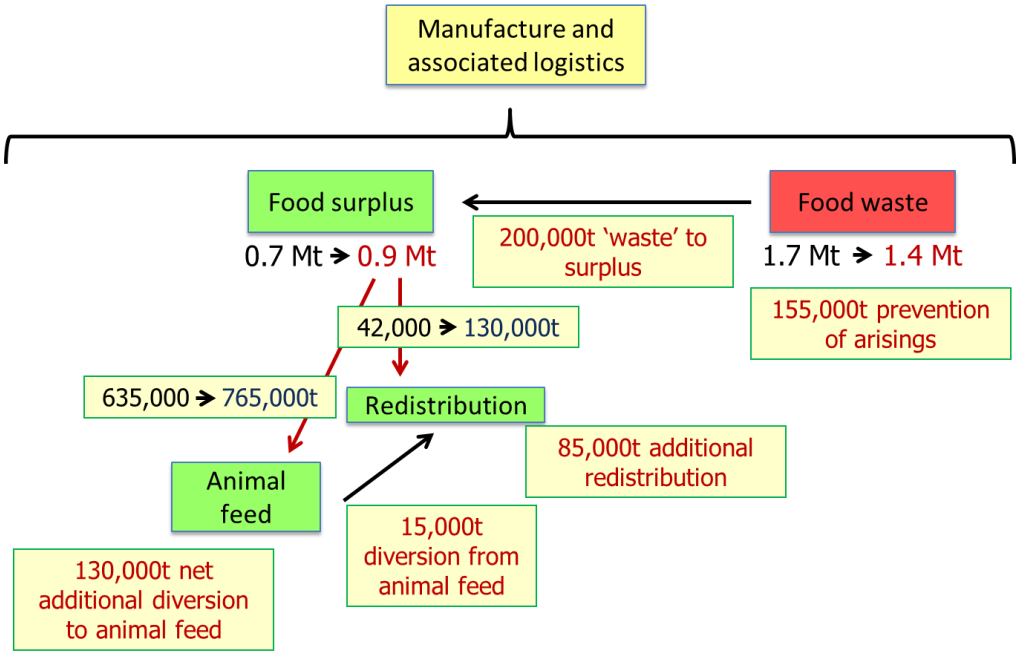
The range of future redistribution tonnages from the scenarios modelled could vary between 52,000 and 160,000 tonnes (vs 42,000 tonnes in 2015), representing between a 25% to 290% increase. The higher estimate would depend on the infrastructure and capabilities

being in place to redistribute more challenging surplus, and would reduce as the prevention of food surplus and waste arising took effect. The lower estimate assumes the full implementation of measures to prevent surplus arising and the diversion of more of the surplus to animal feed (for example from short shelf-life bakery products).

The primary estimate for the amount of food that is currently wasted but could be diverted to animal feed is 130,000 tonnes (all assumed to come from the manufacturing sub-sectors rather than 3PL). Added to the 635,000 tonnes being diverted in 2015 this could mean around 765,000 tonnes of food surplus being used for the production of animal feed. Around half of the additional food surplus is from the bakery sub-sector, and another third from fruit and vegetable and dairy sub-sectors.

Under different scenarios future tonnages diverted to animal feed could range between 615,000 and 805,000 tonnes, representing between a modest (3%) reduction to a 30% increase. These reflect differences in the amounts of food surplus being redistributed, and the extent to which measures to prevent surplus and waste arising are implemented. Figure S10 shows the potential shifts in material, by 2025, under the primary scenario.

Figure S10: *Potential prevention of food waste in the manufacturing sector by 2025*



Retail

The main causes of retail food waste relate to either product damage or product that is 'out of code' (i.e. beyond 'use by' or 'best before' dates), whilst surpluses in distribution centres can relate to a number of different causes, such as over-orders, surplus seasonal products, non-conformity with agreed 'minimum shelf-life on receipt' criteria and over-delivery by suppliers.

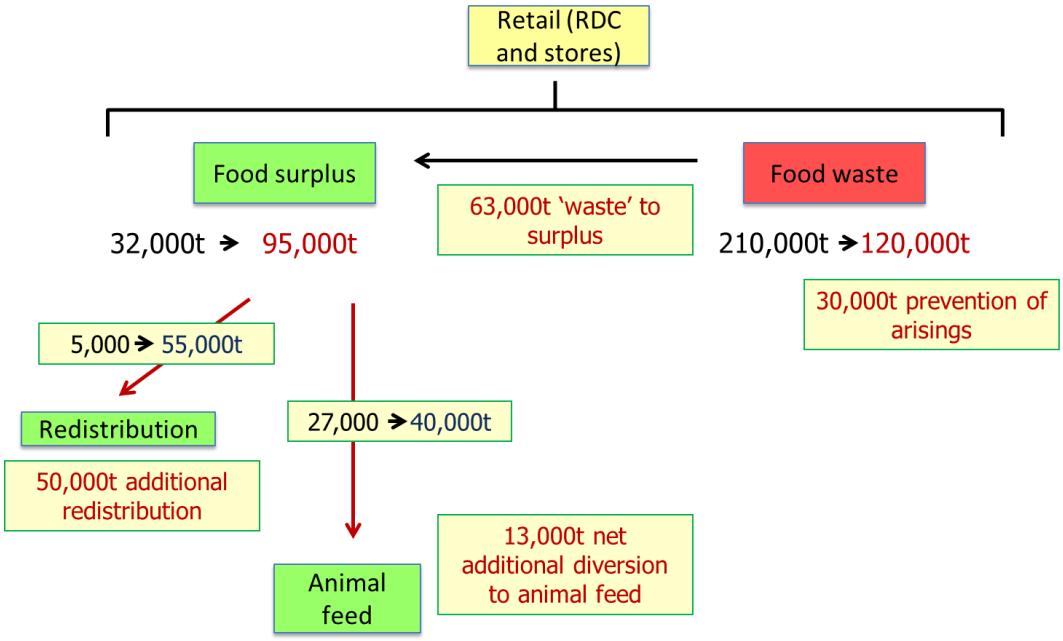
It is estimated that 93,000 tonnes could practically be avoided, through a combination of preventing waste arising, additional redistribution and diversion to animal feed, equivalent to a 44% reduction in the estimated 210,000 tonnes of total food waste. All of retail food waste can be defined as theoretically avoidable as all food at retail is intended for sale. As for manufacture, a combination of prevention of waste arising and increases in redistribution

and diversion to animal feed will be required to deliver this reduction, and a number of factors are likely to influence this balance, and how this changes over time.

It has been estimated that around 30,000 tonnes of food waste could be prevented from arising at retail via improved stock ordering and control to reduce surpluses and 'out of code', plus reducing damage by improved packaging and handling techniques.

Greater potential was identified to make use of food surplus, with 50,000 additional tonnes suitable for redistribution and a further 13,000 tonnes suitable for animal feed. Figure S11 shows the potential shifts in material, by 2025, under the most likely scenario.

Figure S11: *Potential prevention of food waste in the retail sector by 2025*



The range of future redistribution tonnages could vary between 47,000 and 110,000 tonnes (vs 5,000 tonnes in 2015), representing between a 9 to 20-fold increase. Future tonnages diverted to animal feed could range between 10,000 and 50,000 tonnes (vs. 27,000 tonnes in 2015), representing between a 60% reduction to a 190% increase.

Manufacturing and retail

For manufacturing and retail combined the range of future redistribution tonnages derived from scenario assessments could vary between 99,000 and 270,000 tonnes (vs 47,000 tonnes in 2015), representing between a 2 to 6-fold increase. Future tonnages diverted to animal feed could range between 625,000 and 860,000 tonnes (vs. 660,000 tonnes in 2015), representing between a modest (6%) reduction to a 30% increase.

Table S5 shows the overall prevention potential from the primary scenario (including the prevention of arisings, additional redistribution and diversion to animal feed) by manufacturing sub-sector alongside retail and third party logistics. The top 5 (all retail, plus the bakery, fresh fruit and vegetables, dairy, and ambient manufacturing sub-sectors) represent almost 80% of the total tonnages.

Table S5: *Overall potential for prevention for retail and manufacturing sub-sectors*

Sector	Overall potential for prevention (t)
Retail	93,000
Bakery, cake and cereals	75,000
Fresh fruit and vegetable processing	72,000
Dairy products	60,000
Ambient products	45,000
Pre-prepared meals	24,000
Meat, poultry and fish	20,000
Third party logistics	20,000
Soft drinks and fruit juices	15,000
Confectionery	14,500
Alcoholic drinks	8,000
Milling	1,500
Sugar	100
Overall total	**450,000**

Figure S12 provides a breakdown of the sources of the potential additional redistributable food and Figure S13 provides the same for additional food surplus that could be diverted to animal feed.

Figure S12: *Breakdown of potential additional redistributable food (tonnes) for retail and manufacturing sub-sectors (total = 135,000 tonnes, including 15,000 tonnes originally being sent for animal feed)*

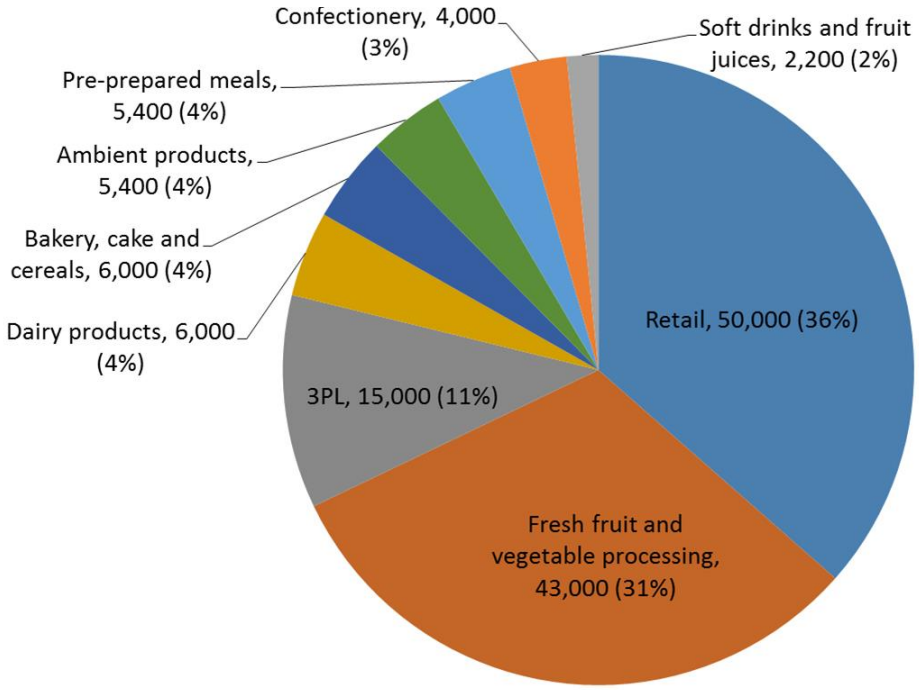


Figure S13: *Breakdown of potential additional surplus for animal feed (tonnes) for retail and manufacturing sub-sectors (total = 140,000 tonnes)*

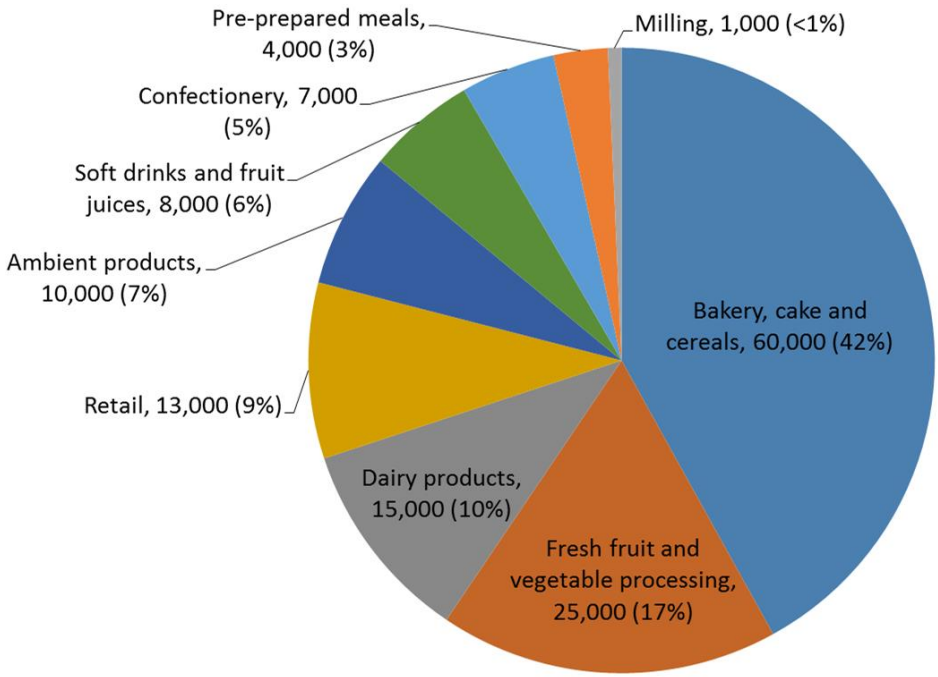


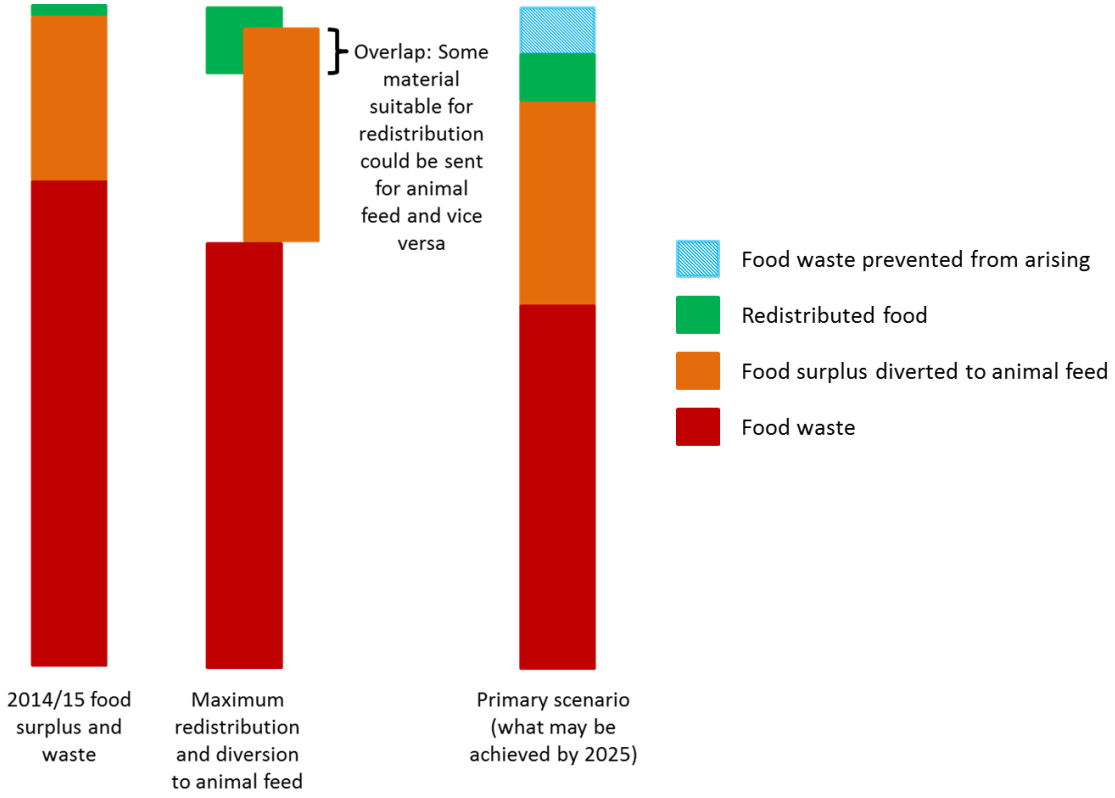
Table S6 shows the contribution to the overall potential prevention tonnage from different sectors and interventions, and clearly shows that all three types of intervention are important contributors to this.

Table S6: *Contribution to the overall potential prevention tonnage from different sectors and interventions (percentages in the table are of the total 450,000 tonnes of food waste that could be prevented)*

	Prevention of food waste arising (t)	Additional redistribution to reduce waste (t)	Additional diversion to animal feed to reduce waste (t)	Overall tonnage preventable (t)
Manufacture	155,000 (35%)	70,000 (16%)	130,000 (29%)	355,000
Retail	30,000 (7%)	50,000 (11%)	13,000 (3%)	93,000
Total	**185,000 (41%)**	**120,000 (27%)**	**140,000 (32%)**	**450,000**

It is important to reiterate that the estimates for maximum redistribution and maximum diversion to animal feed from the scenarios described above are not additive, as there will be material suitable for animal feed within the maximum redistribution estimate and vice versa. Figure S14 illustrates this and how these scenarios relate to the primary one.

Figure S14: *Illustration of how the maximum redistribution, maximum diversion to animal feed and the primary scenarios relate to one another, for manufacture and retail combined*

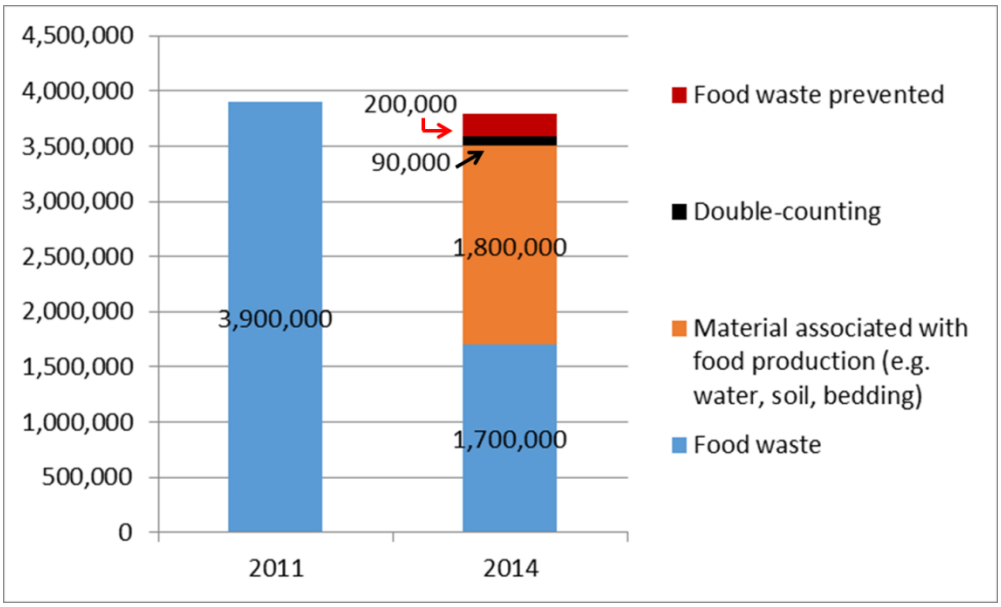


Comparison with previous estimates

This analysis has resulted in a revised estimate for food waste at manufacture for the UK of 1.7 million tonnes. This is significantly below the previous estimate of 3.9 million tonnes, published by WRAP in 2013 (for 2011). The main reason for this, as illustrated in Figure S15, is that the current research has a much better resolution of the different waste streams, which means that a significant tonnage of material associated with food production, but not made up of food, can be excluded from the estimate. This material includes non-food materials such as soil and stones (e.g. from grain milling and sugar beet), water from washing and cleaning and animal faeces and bedding (from meat processing where slaughter houses are integrated with other processing activities on the same site). An element of double-counting relating to animal tissue sent to the rendering sector was also identified and removed from the estimates. In addition efforts made by manufacturers and retailers to reduce waste arisings and amounts of surplus going to waste, for example under WRAP's Courtauld Commitment, have reduced arisings during the intervening period by around 200,000 tonnes. This is based on an analysis of data reported to WRAP by signatories, and an assessment of how signatories and WRAP have worked to influence change amongst businesses not signed up to the voluntary agreement[32].

[32] *This approach is discussed in detail in 'UK food waste – Historical changes and how amounts might be influenced in the future'*

Figure S15: *Illustration of the factors that have contributed to the lower 2014 estimate for manufacturing food waste*



Conclusions and recommendations

Building on the previous research published in 2013[33], this study has produced more detailed estimates of food surplus, food waste and by-products arising from the UK manufacturing and grocery retail sectors. In addition, this analysis has estimated the potential to shift material up the food material/waste hierarchy through prevention at source, increased redistribution and diversion to animal feed. It also shows that the food manufacturing and retail sectors in the UK are highly efficient, with less than 5% of production ending up as food surplus or waste, and that food waste levels are lower than previously reported. By building on efforts made to date, both the retail and manufacturing sectors have a significant potential to work towards better utilisation of food and drink through waste prevention measures with the overall potential to reduce avoidable food waste across these two sectors by 42% or 450,000 tonnes per annum by 2025.

Prevention at source could save almost £300 million a year of food going to waste (155,000 tonnes at manufacture and 3PL, and 30,000 tonnes at retail). In terms of adhering to the food utilisation or waste hierarchy this is the priority for action and there are a suite of resources available from WRAP to help support this. This research has highlighted again that the drivers of food waste arising are many and varied, and whilst some can be addressed through individual company action, others will need the kind of collaboration that Courtauld 2025 aims to foster.

Where food surplus or waste cannot be prevented, there is potential to increase both redistribution and diversion to animal feed.

The majority of the additional material suitable for redistribution within retail arises at store level (45,000 tonnes out of the additional 50,000 tonnes from the primary scenario), whereas currently the majority of material redistributed from retail originates from distribution centres (RDCs). Redistribution from back of store faces extra challenges due to

[33] *Estimates of waste in the food and drink supply chain, WRAP 2013*

the intermittent nature of surpluses arising across a large number of sites, often involving products with limited remaining shelf-life and the need to match the amounts and types of surplus arising with the needs and capabilities of recipients in the local area.

The 2015 estimates for redistribution from retail also pre-date the more recent and significant increase in activities by retailers working with the redistribution sector to expand redistribution from stores. All of the major retailers are carrying out initiatives aimed at store-level redistribution, and/or looking at how to maximise distribution from RDCs and make it easier for their suppliers to redistribute surplus food[34], and many have announced plans to scale these up over the coming years. A comparison between recent pilots and earlier ones[35] suggests that experience and improved guidance are leading to increases in the amounts that can be practically redistributed from stores. Data shared in confidence with WRAP from some of these initiatives suggest that the estimates from the primary scenario modelled within this research are not unrealistic.

Retailers and manufacturers are already doing a lot to ensure suitable food surplus is being made available for redistribution[36], and under Courtauld 3 signatories reported a 74% increase in the amounts being redistributed between 2012 and 2014. There are greater volumes of food surplus suitable for redistribution from manufacturing and 3PL, and encouraging this will be a priority under Courtauld 2025.

Whilst good progress has been made in the redistribution of food surplus that cannot be prevented, and the results of recent trials at back of retail stores look promising, it will be important to monitor progress over time, assess existing and potential new barriers and develop mechanisms to share learnings and overcome these barriers. From discussions with stakeholders involved in this research these barriers are likely to differ between large and small businesses, and retailers and manufacturers. There are however clear opportunities to further raise awareness of what foods are suitable for redistribution, and the benefits this can bring to businesses, staff and communities. WRAP will be developing its 'Your Workplace Without Waste' training and resources to incorporate topics around making best use of surplus food, and through Courtauld 2025 signatory meetings encouraging businesses to make use of these and other materials. This will complement on-going work by the redistribution sector with food businesses. Identifying suitable recipients for surplus food can also be a challenge, particularly if businesses want to use both national and local organisations. There are now a range of guidance materials and initiatives to facilitate this, and case studies to illustrate success.

There are opportunities to increase redistribution through reviewing redistribution sector policies to accepting food beyond their 'best before' date (where there is no food safety risk, and quality if still acceptable – for example whilst some recipients accept fresh fruit and vegetables or bread past the 'best before' date, others do not and most do not take other foods such as ambient goods beyond the date). There are also practical steps that can be taken to help increase the safe redistribution of chilled and frozen food.

The 2015 estimate of food surplus used in animal feed was dominated by two main sources: the bakery and fruit and vegetable sub-sectors which together account for 80% of the total. Additional potential to divert more to animal feed exists across all non-meat sectors, where

[34] For example see M&S launches nationwide surplus food redistribution scheme to support local food charities; Morrisons to roll out programme to find home for unsold food in stores; Tesco commits - no food that can be eaten to go to waste from stores; Waitrose surplus food and food waste disposal; Surplus food redistribution case study Sainsburys, Cardiff; Co-operative Food commits to redistributing a million meals ; Asda - we're tackling food poverty by extending our work with FareShare
[35] For example Food Connection Programme trial vs Piloting retail store surplus food redistribution and use in Wales
[36] A range of case studies can be found at Surplus food redistribution (WRAP), Who do we work with? (Fareshare) and Waste Prevention Case Studies (IGD)

surplus can be safely segregated at source thereby avoiding any risk of contamination from material containing animal by-products that are prohibited from use in animal feed. The estimates of future animal feed potential take into account the increases seen between 2011 and 2015 in amounts of food surplus being used for animal feed production, concluding that further potential exists for additional food surplus diverted to this route. For more complex manufacturing sites with multiple production lines with both 'ABP' and 'non-ABP' areas, this will require a better understanding of the flows of suitable material from production areas and the extent to which they can be safely segregated, in line with animal feed hygiene regulations.

Discussions with retailers and manufacturers highlighted the importance of both their staff and enforcement agency staff having clear and consistent guidance on how to store surplus food prior to sending this for animal feed, and identified this as a key barrier to increasing volumes sent via this route.

For diversion to animal feed, the study also noted considerable interaction with redistribution of surplus, as would be anticipated (as some sources of surplus will be suitable for both). However, whilst some food surplus that is currently being diverted to animal food is suitable for redistribution to people and should take this route, this analysis suggests that diversion of material that is currently being wasted (for example being sent to AD) to animal feed instead would lead to an overall increase in the amount of material available to animal feed producers.

The potential reduction in retail and manufacturing food waste identified in this report, of around 450,000 tonnes or 23% of total food waste, is broadly consistent with that modelled during the development of the Courtauld 2025 food waste prevention target. That target requires a 20% per capita reduction by 2025 across the food system, and takes in to account potential population and production growth. Achieving the target will be challenging for all sectors, but this research shows that the contribution from retail and manufacturing is stretching but realistic, and provides insights that will help deliver against it.

The potential scale of food waste reduction identified in this report, and the contributions from prevention, redistribution and diversion to animal feed are based on an overall assessment of what is realistic at a UK level. There will be significant differences between different businesses in what they may be able to achieve, and what interventions may work best for them, as a result of their product mix, size, location, policies towards mark-downs, progress made to date and so on. The estimates in this report are not therefore targets for individual businesses, but a guide to what the sectors as a whole could achieve – which WRAP will monitor through Courtauld 2025.

Recommendations

This research has applied a new approach to estimating both how much food surplus and waste comes from manufacture and retail, and how much of this might be suitable for a range of waste prevention interventions. It has pulled together data and insights from a wide range of sources, covering a diverse set of sectors and sub-sectors. It clearly identifies the potential for stopping food waste arising, redistributing more to people and diverting more surplus to produce animal feed. It should however be stressed that this forms the foundation upon which to build a more comprehensive understanding of this area, as methodologies evolve, interventions are evaluated and more targeted research is undertaken.

The following represent opportunities to further improve data quality and relevance over time:

- Refine the estimates for how much food waste might be prevented from arising based on a) the evaluation of innovations in processing, equipment, packaging management etc., as these are implemented, b) from monitoring the levels of food surplus and waste arising over time and c) from feedback on the barriers to implementing relevant innovations.
- Refine the estimates for how much of the food surplus and waste might be suitable for redistribution based on learnings from both the providers and recipients of food surplus. Innovations in the types of material that could be turned in to products suitable for use by recipients could lead to an even higher percentage of future food surplus and food that might have been wasted being used to feed people.
- It should also be noted that whilst this research provides more granular estimates of food surplus and waste for the sectors, it does not reveal priorities for action within a sub-sector. Further and more focused 'mapping' will be required for the sub-sectors with the greatest potential to prevent food waste. As a first step WRAP is working with a major dairy business to map material flows from multiple sites and a wide range of products (including milk, soft and hard cheeses, butter, yoghurt etc.), with the objective of identifying the greatest opportunities for both prevention and maximising value from the non-preventable materials.
- Further research into the scale and types of food surpluses and wastes occurring within the third party logistics element of the UK grocery supply chain to understand the scale and type of waste arising and identify the most effective and efficient way of handling any food surplus or waste.
- For the retail sector there is a need to establish more clarity around damages occurring both at stores and within depots and this should be used to highlight waste prevention opportunities by product category.
- Further analysis of existing datasets to show where the food waste is being disposed to (disposal routes) by sub-sector, separating out material that may have already been subject to on-site treatment (and therefore less suitable for subsequent treatment by AD or other options) from untreated sludges (such as those that contain peelings from fruit and vegetables).

The following are also critical for the delivery of the waste prevention opportunities identified in this report:

Collaborative action targeting priority areas:

- This research has identified areas where the greatest potential impacts can be made, and also that collaboration between businesses across the supply chain will be needed to realise the greatest benefits (for example between brands and retailers in tackling some of the in-store food waste, and retailers and manufacturers in addressing some of the opportunities around forecasting). The outputs from this research will inform decision making on where resources should be allocated, for example through working groups under Courtauld 2025, and future 'whole chain resource efficiency' projects[37].
- WRAP will establish a Redistribution Working Group under Courtauld 2025 to understand more about the implications associated with realising some of the redistribution potential identified in this study. It will be particularly helpful to share

[37] *See Whole chain resource efficiency*

insights from retailer back of store and manufacturing trials that have been undertaken in different parts of the UK during 2015 and early 2016.

Awareness raising/behavioural change:

- The study found that there was often a poor understanding across the sector about the sorts of surplus that were within scope for redistribution and how businesses with food surpluses can partner with redistribution organisations. This issue should be addressed through the improved guidance and partnership tools developed by the redistribution sector and WRAP, the use of awareness raising resources such as 'Your Workplace Without Waste' and through greater engagement on this issue with individual businesses and trade associations under Courtauld 2025[38].
- In order to enable greater amounts of food surplus to be diverted to animal feed production WRAP will be working with the FSA and representatives of national and local enforcement bodies to improve the consistency and clarity of both the guidance available to food businesses and the training of staff on the ground.

Maximising value from food waste that cannot be prevented:

- Around 1.5 million tonnes of food waste may not be suitable for prevention (120,000 tonnes from retail, equivalent to 0.3% of product sold in 2014; 1.4 million tonnes from manufacture, equivalent to 2.4% of product sold), at least not within the shorter term. This will need to be assessed for optimal treatment and use. This will need to look at the balance between on-site versus off-site treatment options, both in terms of commercial and environmental benefits.

Methodological improvements:

- A standard protocol for food surplus and waste measurement and more effective key performance indicators (KPIs) for monitoring would be beneficial, to overcome the wide variation in the standard of data on food surplus and waste, which varied from sites that only had basic waste returns provided by their site waste contractors, to those with systems in place delivering line-specific data against a balanced set of KPIs. This should also clarify areas of uncertainty such as the accounting for retail depot vs back of store redistribution and the relationship with third party logistics operators and suppliers. There may also be an opportunity to work with the relevant national regulatory bodies to improve the consistency and relevance (to food surplus and waste) of the data reported to them.
- Linked to the variation in data quality, there were marked differences in the resourcing and commitment to waste reduction from site to site. In some cases roles were split, with waste reduction shared with health and safety, whereas at others sites dedicated waste managers had clear lines of accountability to carry out a programme of work and report on progress. These were also the sites with a clearer picture of the wider costs to the business of avoidable food and drink waste and consequently in a better position to reduce waste more effectively.

[38] *For example see Surplus food redistribution, Your Workplace Without Waste, The FareShare Food Efficiency Framework*

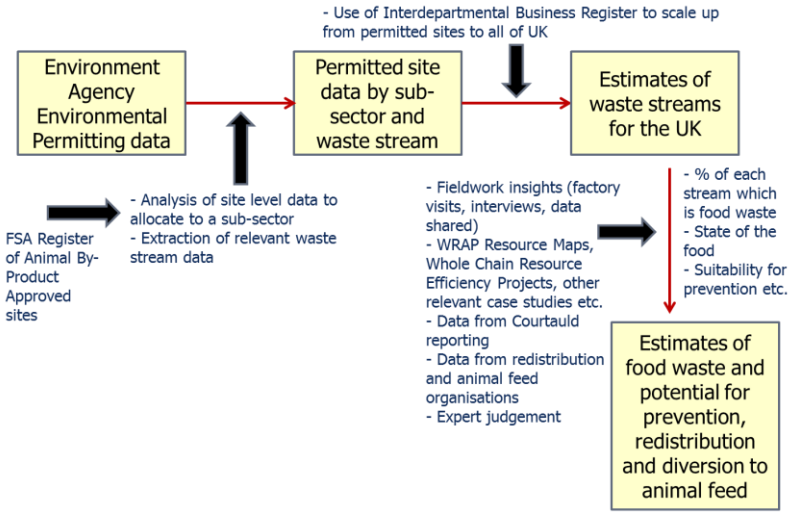
Data sources and methodology

Manufacturing

There is no single data source for the grocery supply chain that provides quantities and characteristics of food surplus or waste. Within this research a range of data sources relating to food and drink manufacturing were used in combination to produce the required estimates. The main contributing elements at a national level were Environment Agency Environmental Permitting (EP) data and the detailed European Waste Catalogue (EWC) codes relating to organic materials associated with the food and drink manufacturing sector. A variety of different data sources were then used to scale-up results to the UK as a whole and derive by-product, food surplus and food waste estimates. These included the Inter-Departmental Business Register (IDBR), UK Manufacturers' Sales by Product Survey (PRODCOM), Food Standards Agency (FSA) listings of approved premises, redistribution sector data provided by FareShare and Company Shop and surveys carried out by the European Feed Manufacturers Federation. Data and insights were also provided by a range of food businesses that participated in this research and anonymised data from Courtauld Commitment 3 signatory reporting. Site level data were combined with UK level estimates for waste, surplus and by-product flows. The method of scaling the data was similar to that used in previous WRAP studies to estimate arisings from the manufacturing sector at UK level (WRAP 2013[39] and WRAP 2014[40]).

In order to derive estimates for preventability and suitability for redistribution and diversion to animal feed, additional information from a range of published and unpublished sources was used, such as from WRAP Whole Supply Chain Resource Efficiency projects[41] and Resource Maps[42], which gave more detail across a number of key product categories (see Figure S15). In addition to data sets and reports, audits and discussions with food manufacturers provided valuable detail on all of the flows relating to food waste, surplus and by-product.

Figure S15 *– Approach to deriving estimates for manufacturing food waste[43]*



[39] *Estimates of waste in the food and drink supply chain, WRAP 2013*
[40] *UK food waste – historical changes and how amounts might be influenced in the future, WRAP 2014*
[41] *WRAP Whole supply chain resource efficiency reviews*
[42] *WRAP Resource maps*
[43] *The Environmental Permitting Regulations amongst other things implement the IPPC (Integrated Pollution Prevention and Control) Directive (EC/61/96) in England and Wales. Sites producing relevant materials above specific thresholds report annually to the Environment Agency*

Retail

A range of different data sources was used for the retail sector analysis, including primary research in the form of a series of store and RDC site visits, food waste audits and discussions with key stakeholders in the UK food retail and redistribution sectors, detailed product category data on food waste collected by supermarkets at UK level, published reports by the Industry Council for Research on Packaging and the Environment (INCPEN)[44] and the British Retail Consortium (BRC)[45] on retail food waste estimates and other material published by retailers on food waste prevention and redistribution initiatives and quantities of food surplus diverted.

The most significant element within the retail food waste evidence gathering was the analysis of food waste product-level datasets supplied by three of the major retailers. This element permitted more detailed appraisal of waste prevention opportunities and the potential to divert material that could not be prevented to redistribution schemes or to animal feed. In order to develop estimates for the sector as a whole (including the small independent retailers) data were scaled up using published estimates for total retail food waste from the BRC and WRAP[46].

Data limitations and uncertainties

The estimates for food surplus and waste reported here are based on the best available evidence, and represent a significant improvement over previous estimates. They are intended to help focus interventions and further research and form part of the process of tracking change at a sector level over time. The food surplus and waste estimates obtained from the evidence gathered by this study are however subject to a range of limitations and uncertainties to be borne in mind by the user. The four main sources of uncertainty likely to have the greatest impact on estimates are adequacy of coverage within 2014 EP data, uncertainties associated with large numbers of small and medium sized enterprises (SMEs) within IDBR, diversity of production processes and final products within some sub-sectors and the sensitivity of food waste estimates to effluent treatment sludge assumptions. These estimates are not intended to be used to benchmark individual businesses or products / product groups within the different sub-sectors. A number of gaps in this research are also acknowledged:

- Limited insights from smaller manufacturers and retailers (but these represent <10% of UK production/sales volume);
- Data for 'on-site' disposal, i.e. to sewer, is excluded (as it was in the previous WRAP research) due to the absence of usable national data for this stream and the challenges associated with quantifying the food component in effluent; and
- Availability of data varies by manufacturing sub-sector, and in particular data is limited for the alcoholic beverages and confectionary sub-sectors.

Results for manufacture and third-party logistics (3PL) are combined in the summary tables and figures in the Executive Summary, but estimates for the manufacturing sub-sectors and 3PL are presented separately in the main report.

[44] *Checking out food waste, 2013*
[45] *The Retail Industry's Contribution to Reducing Food Waste*
[46] *Handy facts and figures on waste in the UK - WRAP*

Glossary

3PL	Third Party Logistics operator
ABPs	Animal By-products
AD	Anaerobic digestion
APHA	Animal and Plant Health Agency
BOM	Bill of Materials
BRC	British Retail Consortium
CIP	Cleaning In Place
COD	Chemical Oxygen Demand
DAF	Dissolved air filtration
DC	Distribution Centre
EA	Environment Agency
EP	Environmental Permitting (previously Integrated Pollution Prevention and Control)
EWC	European Waste Catalogue
FSA	Food Standards Agency
IDBR	Inter-Departmental Business Register
INCPEN	Industry Council for Research on Packaging and the Environment
ISB	In-store Bakery
IVC	In-vessel composting
KPI	Key Performance Indicator
MOQ	Minimum Order Quantity
Mt	Million tonnes
NDA	Non-disclosure agreement
PRACTICALLY AVOIDABLE FOOD WASTE	This is the fraction of the theoretically avoidable food waste that the research suggests could be practically prevented over the course of Courtauld 2025 (i.e. to 2025), based on a realistic assessment of technological and other barriers
PRODCOM	UK Manufacturers' Sales by Product Survey (PRODCOM)
QA	Quality assurance
RDC	Regional Distribution Centre
SKU	Stock Keeping Unit
THEORETICALLY AVOIDABLE FOOD WASTE	This is the fraction of total food waste that could in theory be edible (with or without further processing). This excludes for example preparation waste that is unsuitable for consumption.
TOTAL FOOD WASTE	This is a measure of all food waste, both avoidable (also referred to as edible by some) and unavoidable (or inedible) as defined by the EU-funded FUSIONS project
UKFFPA	UK Former Foodstuffs Processors Association
WRAP	Waste & Resources Action Programme

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