Investigating the economic and environmental impact of including surplus food redistribution in the UK government's Sustainable Farming Incentive (SFI) scheme

Executive summary

Introduction

There is an established and growing food redistribution sector in the UK that successfully rescues surplus from the food supply chain and redistributes it to individuals affected by food insecurity. While only 4% of what is redistributed today comes from farms (equating to 8,000 tonnes, as per WRAP, 2023), food redistributors believe there is significantly more surplus that could be suitable for redistribution, prioritising human consumption over other surplus destinations.

The Felix Project, with the support of Argon & Co, aimed to explore incentivising farmers to redistribute their surplus. This study investigates the economic and environmental impacts of incorporating surplus food redistribution into the UK government's Sustainable Farming Incentive (SFI) scheme.

Key Findings

- **Surplus food potential**: Currently, only 4% of redistributed food comes from farms, equating to approximately 8,000 tonnes. However, there is significant potential for more surplus food to be redistributed from farms, with this study estimating between 180,000 tonnes and 270,000 tonnes of farm surplus being feasible for redistribution. Approximately two thirds of this volume is from harvested (out of specification) produce and the remainder from unharvested produce. Making this surplus accessible for redistribution could double the amount of food redistributed in the UK (191,000 tonnes in 2023), representing £150 million in value to the charity sector.
- **Focus on already harvested produce**: This study evaluated the impact and opportunities of accessing both harvested (out of specification) and unharvested produce for redistribution. The economic, environmental and practical case for harvested produce was found to be much stronger than for unharvested and therefore harvested is recommended as most suitable for a redistribution incentive. While this prioritisation of human consumption follows the food waste hierarchy and delivers social benefits, the impact of such an incentive on animal feed and anaerobic digestion markets will need to be considered.
- **Economic impact**: Redistribution of harvested surplus food to farm gate would incur additional costs for farmers of between £60-£370 per tonne, depending on the food type. These costs include additional handling, and potential loss of earnings from alternative uses such as animal feed or anaerobic digestion. An additional incentive for food redistribution could financially support farmers and deliver significant value to the charity sector.
- **Cost of incentive scheme**: The overall cost of a redistribution incentive depends on the scheme design and target areas, with several scenarios explored in the report. A scheme targeting a broad variety of harvested (out of specification) produce would have an estimated annual cost of between £10M - £23M and would unlock 120-180 kt of produce per year (averaging at ~£100/t). This cost includes a 5% additional incentive above the

'break even' point with the status quo scenario, which would support farmers financially and encourage uptake of the scheme.

- **Emissions impact**: While redistribution prioritises food for human consumption and prevents embedded emissions from food production being needlessly wasted, it also increases emissions compared to the status quo. This includes emissions associated with redistribution, mainly caused by transportation. Diverting surplus from composting and anaerobic digestion could lead to higher overall emissions as additional fertilisers would be needed to replenish soil nutrients. However, this impact is nuanced and may change with broader societal efforts to decarbonise.
- **Incentive design**: Effective incentives need to balance economic viability and practicality to implement, whilst mitigating unintended consequences. Scenarios evaluated suggest that an incentive valued per food category would best suit farming operations, increase produce variety, and reduce exploitation risk. Key design elements that would need to be considered are: ensuring sufficient flexibility for the unpredictable nature of surplus; managing cash flow impacts on farmers and charities; and mitigating unintended consequences of the scheme such as driving over-planting or disrupting commercial contracts.
- **SFI suitability**: The Sustainable Farming Incentive (SFI) offers a well-established framework with existing infrastructure and administrative processes, which could streamline the rollout of a new incentive and effective communication with farmers. Current incentives within the SFI are based on 'prior commitments', which would not be a suitable model for redistribution due to the unpredictable nature of surplus. However, assuming more flexible terms could be adopted within a renewed SFI framework, the SFI would be a well-suited vehicle for a redistribution incentive.

Methodology

The scope of the study was edible surplus fruit and vegetables grown on farms in England.

The study estimated the volume of farm surplus feasible for redistribution and modelled the costs and GHG emissions associated with redistribution compared to four status quo scenarios:

- Produce would have been left unharvested
- Produce was harvested, but graded out of specification and then
    - Sold as animal feed
    - Sold for anaerobic digestion
    - Composted and spread on the land

Data was sourced from public datasets, literature reviews and additional research, with a ±20% error margin applied to estimates to reflect uncertainty in available data.

Results were analysed to inform a discussion on elements to consider when designing an effective incentive.

Conclusion

Incorporating surplus food redistribution into the SFI scheme offers a promising opportunity to reduce food insecurity, improve access to healthy diets, and reduce waste, delivering additional value to the farming and charity sectors. Careful design and management of the incentive would be crucial to balance economic viability, environmental impact and practical implementation. Conducting a more in-depth study with broader representation from farmers would be a prudent next step to validate assumptions and refine costs, volumes and environmental impact. Pilot programmes are also suggested to refine the approach and ensure successful implementation.

Detailed report

1. Introduction

1.1. Purpose

There is an established food redistribution sector in the UK that successfully rescues surplus from the food supply chain and redistributes it to individuals affected by food insecurity. While only 4% of what is redistributed today comes from farms (equating to 8,000 tonnes (WRAP, 2024), food redistributors believe there is significantly more surplus that could be suitable for redistribution.

The Felix Project, with the support of Argon & Co, aimed to explore incentivising farmers to redistribute their surplus. At this time, one such farm incentive scheme, the Sustainable Farming Incentive (SFI), has been paused for new applications and is under review (DEFRA, 2025). As DEFRA considers their options in relation to either reforming or replacing the SFI, this report is intended as a timely and helpful contribution to the debate.

The SFI is a government scheme that financially incentivises farmers and land managers in England to adopt sustainable farming and land management practices. As a key component of the Environmental Land Management (ELM) programme, the SFI aims to support food production while enhancing the environment, improving biodiversity, and contributing to climate change mitigation. Farmers can choose from a range of actions, such as improving soil health, planting hedgerows, and reducing chemical use, to receive payments that help offset the costs of implementing these practices. The scheme is designed to be flexible, allowing farmers to select actions that best suit their land and business needs (DEFRA, 2021).

The purpose of this study is to investigate the economic and environmental impact of including surplus food redistribution as an action that farmers could adopt within the UK government's Sustainable Farming Incentive (SFI) scheme.

1.2. Approach

To investigate the opportunities and impacts, the approach was to:

- Better establish the volume of farm surplus (an area where limited data currently exists), then understand where this surplus is currently being used or disposed of (the status quo destination scenario), and estimate what proportion of it could be feasible for redistribution [See section 2]
- Once the 'size of the prize' was understood, the costs and greenhouse gas emissions of redistributing compared with the status quo destination scenarios were modelled and calculated [See sections 3 and 4]
- Finally, based on these factors and others, the design of a potential SFI incentive for farm surplus redistribution was explored, analysing the size of incentive required to make the scheme viable and considerations around delivery format, implementation practicalities and unintended consequences [See section 5]

2. Scope, key concepts and volume assumptions

2.1. Scope of the study

The geographical scope of this study was limited to farms in England, since that is where the Sustainable Farming Incentive (SFI) scheme focussed.

Common food groups produced by English farms are meat, fish, cereal crops & oils, roots & tubers, and fruit & veg (see Figure 2.1.1). After evaluating each group's suitability for redistribution, the study excluded meat, fish, and cereal crops and oils:

- Meat and fish were excluded due to the lack of accountable waste, as animals and animal products are either consumed or deemed inedible, resulting in minimal surplus on farms.
- Cereal crops and oils were excluded because they require further onward processing to become edible and therefore redistributable.

The status quo scenario surplus destinations identified were:

- Animal feed
- Anaerobic digestion (AD)
- Composting/land application (referred to as composting throughout this report)
- Incineration
- Landfill

Additionally, incineration and landfill were not considered due to their minimal contribution to waste, with the assumption that most produce incinerated or landfilled from farms is inedible.

Two scenarios were identified for composting. The first was composting of harvested surplus that was not able to be sold (e.g. due to being out of specification). The second was produce that was never harvested in the status quo scenario (e.g. ploughed into the soil or left on the plant).

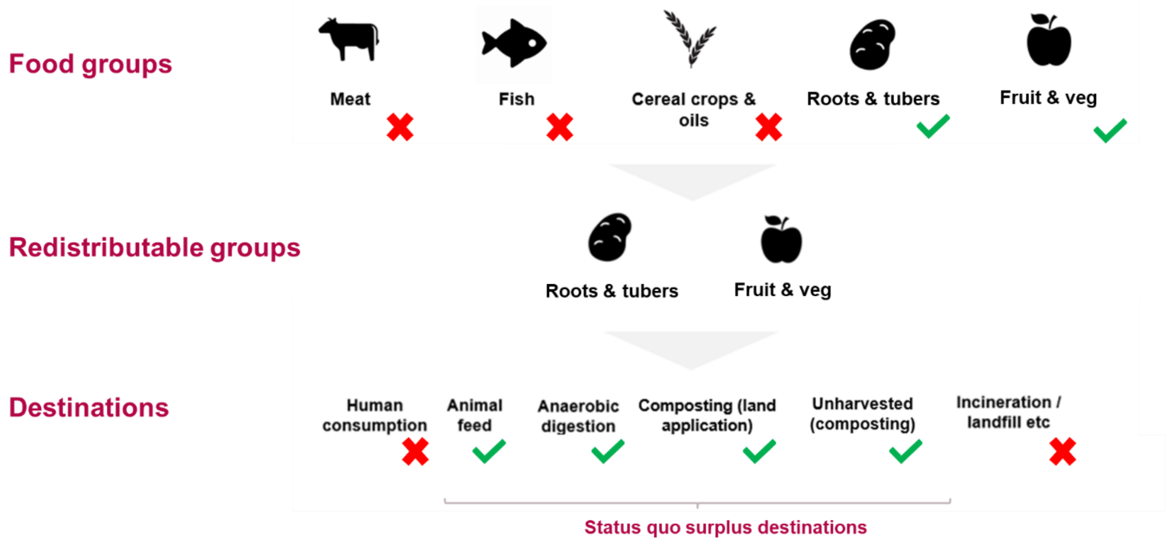


Figure 2.1.1 – Process map defining food categories and status quo surplus destinations in scope

Redistributable groups were divided into nine distinct categories (see Figure 2.1.2) based on food families and farming processes. This method ensured more accurate and representative assumptions when calculating surplus volume, value, and environmental impact. Additionally, it was deemed to provide a more detailed perspective when discussing a proposed incentive structure (see Section 5).

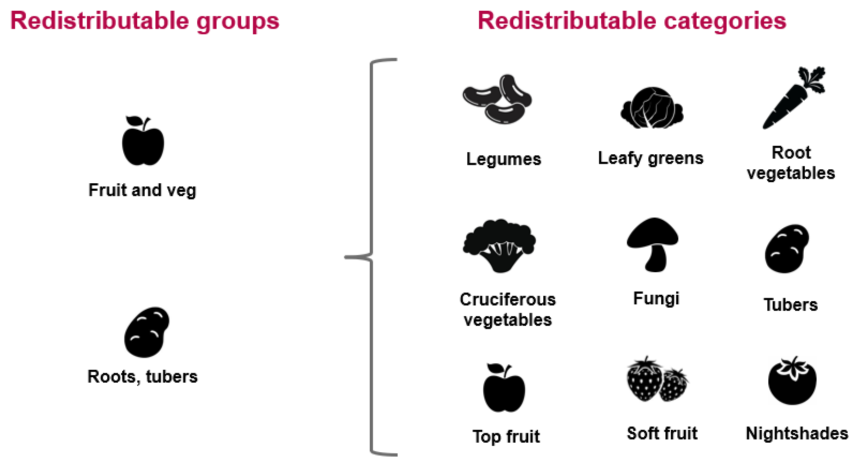


Figure 2.1.2 – Categorisation of redistributable groups into nine distinct categories

2.2. The current farm surplus landscape and definitions

This study mapped the status quo processes experienced on farms in England. Figure 2.2.1 outlines the farming procedures for all redistributable food categories once the crops are in the field and ready for harvest.

Green boxes highlight the volumes targeted by this study (edible feasible surplus) at the stages when a crop is either unharvested or harvested according to the following definitions:

- **Edible:** The proportion of the volume that is suitable for human consumption.
- **Feasible:** The proportion of the volume estimated to be viable for redistribution. Since we cannot assume a 100% uptake of the incentive for all produce within scope, an adjustment factor has been applied to estimate what is feasible.

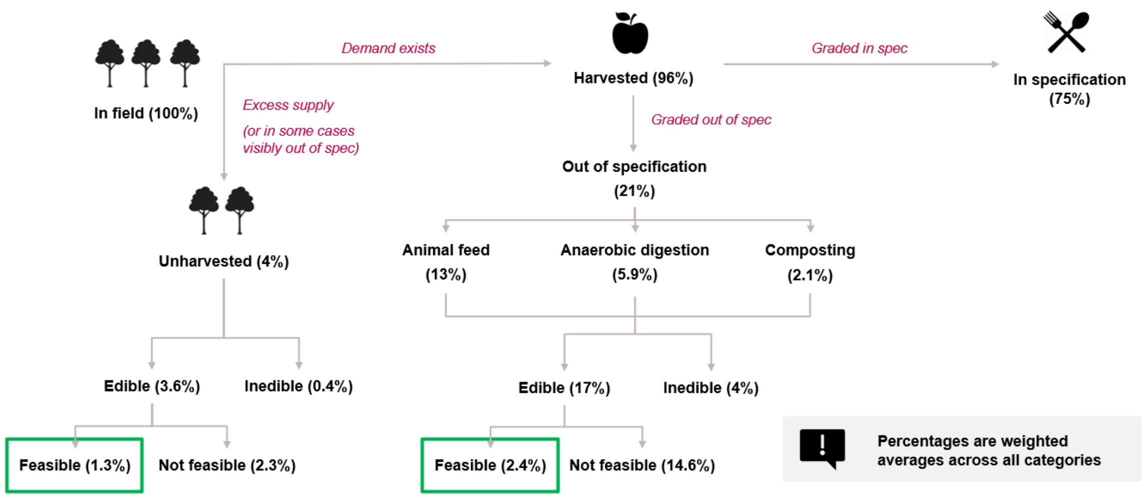


Figure 2.2.1 – Status quo farming processes on UK farms. Percentages shown are weighted averages across all categories in scope

2.3. Estimated edible, feasible surplus volumes

The edible feasible surplus volumes, which form the basis of this study's economic and environmental calculations and incentive design, were determined using the mapped process flow

(Figure 2.2.1). These volumes were estimated using a combination of available public data sets and assumptions (which can be seen in Appendix 7.2.2).

DEFRA's published data sets for UK agricultural and horticultural production and land use (2018-2022) were utilised to determine production levels in the UK and England (DEFRA, 2025). Where data was insufficient to determine percentages at each step of the process map, assumptions were made based on available literature and consultations with industry experts. Due to these assumptions, a ± 20% error margin has been applied to the volume calculations.

The resulting total feasible volume is presented in Figure 2.3.1. A visualisation of the volume distribution through the mapped process is shown in Figure 2.3.2.

	Status quo surplus destination	Feasible volume (tonnes) *Lower bound*	Feasible volume (tonnes) *Average*	Feasible volume (tonnes) *Upper bound*
	Unharvested	58,400	73,000	87,600
Harvested (out of specification)	Animal feed	73,000	91,200	109,500
	Anaerobic digestion	37,000	46,300	55,600
	Composting	12,200	15,300	18,300
	Total	180,700	225,800	271,000

Figure 2.3.1 – Calculated feasible volume for redistribution by status quo destination.

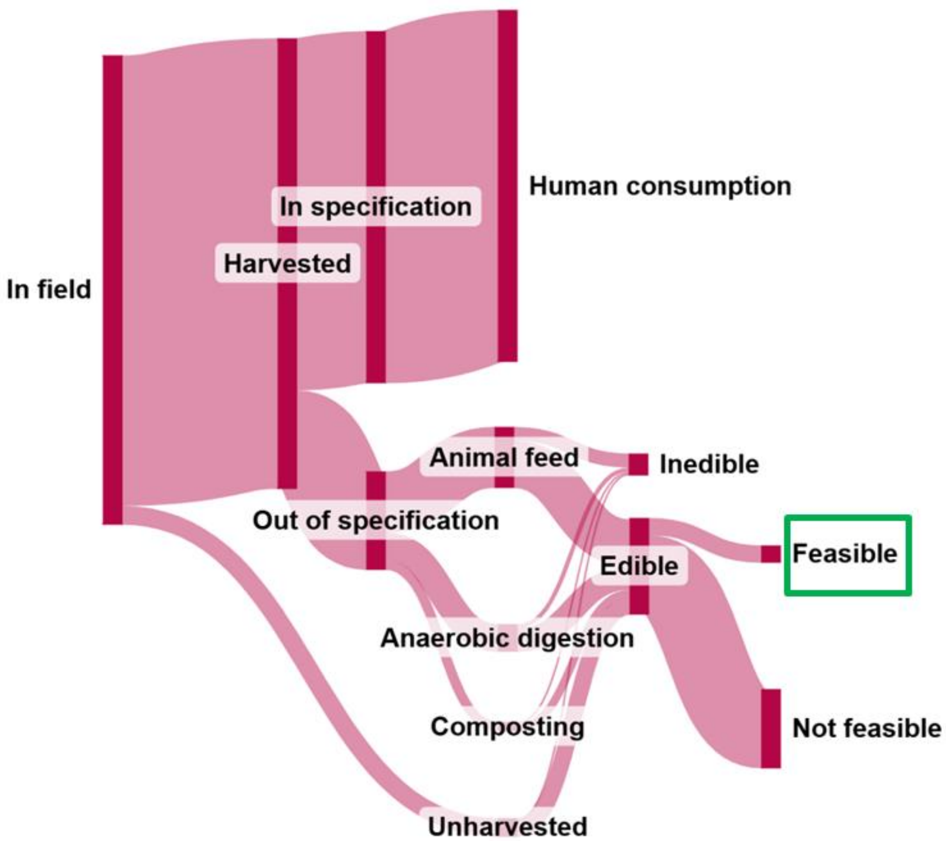


Figure 2.3.2 – Sankey diagram of volume flows from in field to feasible for redistribution [Made at SankeyMATIC.com]

2.4. Section summary

Volumes of surplus food on farms were quantified by determining applicable food groups (roots & tubers and fruit & vegetables) further broken down into nine categories. Of this, further assumptions were made about what could be considered edible and feasible.

Overall, this edible feasible volume was estimated to fall between 180 kt and 270 kt, with approximately one third from unharvested produce and the remainder from harvested (out of specification). This volume of surplus would significantly increase the current amount redistributed in the UK, which was reported by WRAP to be 191 kt (WRAP,2024).

These volumes were used to model the cost of redistribution in section 3 and the greenhouse gas emissions associated with redistribution in section 4.

3. The economic impact of incentivising redistribution

3.1. Introduction

This section explores the economic implications of sourcing food directly from farmers for redistribution. This study considered the additional costs associated with redistribution compared with the status quo scenarios up to the farm gate.

This was calculated based on:

a) **Additional cost to farmer:** Any additional costs to get the surplus food to the farm gate in a format practical for redistribution (inc. handling, storage etc.). Plus, any costs that may be incurred in future due to redistributing, such as additional artificial fertiliser being required to replace nutrients that would have been provided by the food in the unharvested scenario

b) **Loss of earnings:** Only applicable when the farmer can achieve an income from the surplus food through selling as animal feed or for anaerobic digestion

Cost of redistribution to farm gate =	Additional cost to farmer +	Loss of earnings
Compared with un-harvested status quo scenario	***Harvesting cost*** *(inc. operating and labour)* ***Handling cost*** *(inc. packaging and labour)* ***Purchase of additional artificial fertiliser*** *(to replenish nutrients that would have remained in soil)*	***Negligible***
Compared with harvested (out of specification) status quo scenario	***Handling cost*** *(inc. packaging and labour)*	***Value if sold*** *(Animal feed or anaerobic digestion)*

Figure 3.1.1 – Breakdown of the cost of redistribution to farm gate into components quantified in the model

Although not in the scope of this study, a significant increase in surplus provision for redistribution would also require additional capacity within the food redistribution sector which would come with costs. However, since this study focussed on farm incentives this additional cost has not been evaluated.

Additionally, the estimated costs outlined quantify what would be required to match the current status quo. To encourage effective uptake of a redistribution scheme, this should be considered the minimum level of incentives necessary. It may be advisable to include a further incentive above this 'break even' point which would economically benefit farmers, encourage uptake of redistribution and compensate farmers for the time required to adopt and maintain new operations. In the modelling in section 5, the figure of 5% above the 'break even' cost of redistribution has been used. It should be noted that for this incentive to genuinely benefit farmers financially, it would need to be additional to the existing budget for SFI, rather than taken from another initiative area.

3.2. Methodology and assumptions

The approach to calculating the cost of redistribution was:

1) Current farming practices were mapped to identify activities that would incur additional costs to farmers and potential loss of earnings from alternative revenue streams (such as sales for animal feed, anaerobic digestion, or composting) in a redistribution scenario.
2) For each category, the associated cost of redistribution was calculated based on:
    a. The proportion of produce going to each surplus destination (e.g., the percentage sold for animal feed versus anaerobic digestion versus composting).
    b. The cost of performing each activity that would incur additional expenses for farmers (e.g., handling costs).
    c. The loss of earnings from not selling the surplus.
    d. Data sources (more details can be found in the appendix 7.2.3):
        - Figures published by The Andersons Centre and in the Nix Farm Management Pocketbook were utilised to determine the additional costs of harvesting and handling (The Andersons Centre, 2023; Nix Farm Management Pocketbook, 2025).
        - A mixture of published figures and publicly available agricultural calculators were used to determine the loss of earnings to the farmer. Where data was insufficient to determine figures for loss of earnings, i.e. value of a particular category as animal feed, assumptions were made based on available literature and consultations with industry experts.
        - Assumptions used at each stage can be found in the appendix. Due to these assumptions, a ± 20% error margin has been applied to the cost of redistribution to farm gate calculations.

3.3. Results – additional costs associated with redistribution

Figures 3.3.1 – 3.3.3 show the results of the economical modelling. Overall, redistribution resulted in an additional cost to farmers compared with the status quo destinations, but the scale of the on-cost varied depending on status quo destination and food category.

a) Harvested produce estimated costs

The average cost of redistribution of harvested (out of specification) produce ranges between £60-£145 per tonne. In this group, redistributing compared with composting presents the lowest on cost and redistributing compared with AD has the highest on cost, with animal feed approximately equal between the two. However, the variation between all three may be marginal as the estimated cost ranges for each overlap (see error bars in Figure 3.3.2).

There are variations between food categories driven mostly by the differing handling costs, with more robust products such as tubers and root vegetables having lower cost, more mechanised handling processes than, for example, soft fruit.

b) Unharvested produce estimated costs

The unharvested produce has a significantly higher average cost of redistribution at £375-£565 per tonne. This is driven by the harvesting activity needed and associated costs.

There are stark variations also between different food categories, with soft fruit, nightshades and fungi estimated to cost ~£1350 per tonne, compared with other produce between £600-£800 per tonne.

	Status quo surplus destination	Cost of redistribution (£/tonne) *Lower bound*	Cost of redistribution (£/tonne) *Average*	Cost of redistribution (£/tonne) *Upper bound*
	Unharvested	377	472	567
Harvested (out of specification)	Animal feed	73	92	110
	Anaerobic digestion	95	119	143
	Composting	62	77	93

Figure 3.3.1 – Calculated cost of redistribution to farm gate per tonne by surplus source

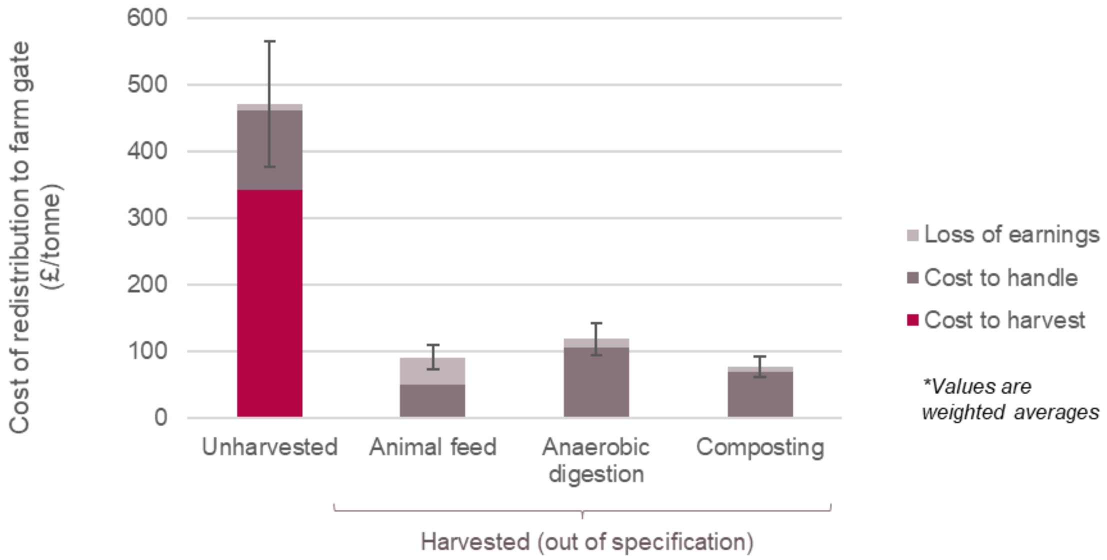


Figure 3.3.2 – Calculated cost of redistribution to farm gate per tonne by status quo destination. Error bars show range of potential costs uncertainty in calculations described in methodology.

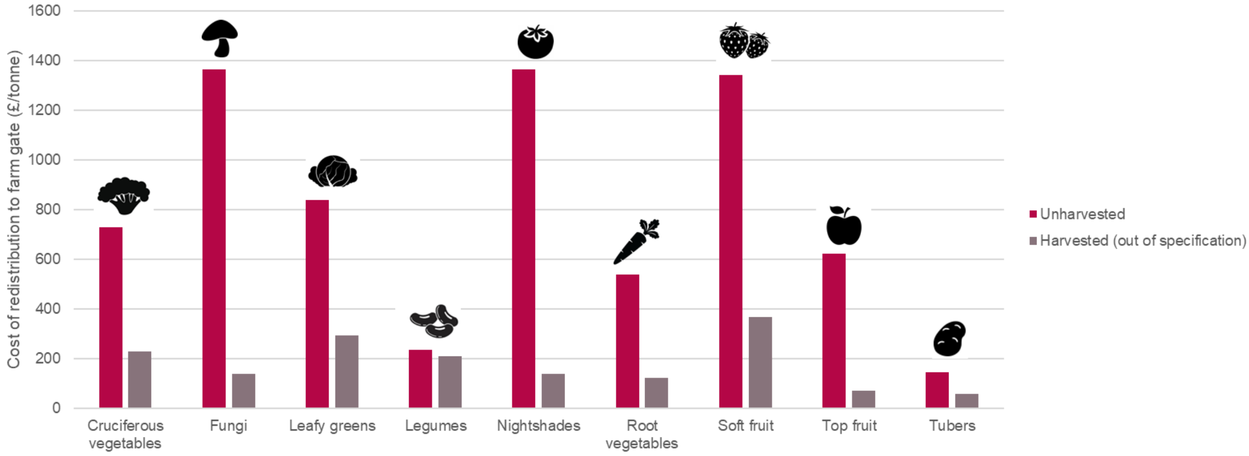


Figure 3.3.3 – Calculated cost of redistribution to farm gate per tonne for each category, split by unharvested and harvested (out of specification)

3.4. Section summary

There would be additional costs to the farm gate associated with making surplus food available for redistribution. These costs vary based on food group and category and the status quo scenario that they would be being diverted from.

If the surplus would otherwise have gone unharvested, these costs are dominated by additional harvesting costs. If the surplus would otherwise have gone to anaerobic digestion or composting, the costs are primarily made up of alternative handling costs, as opposed to loss of earnings.

While the costs explored in this section are 'break even' costs vs the status quo scenario, an incentive could financially benefit farms if (i) it was valued above the break even threshold, e.g. +5% and (ii) the budget for the incentive was additional to current farming incentives available.

4. The environmental impact of incentivising redistribution

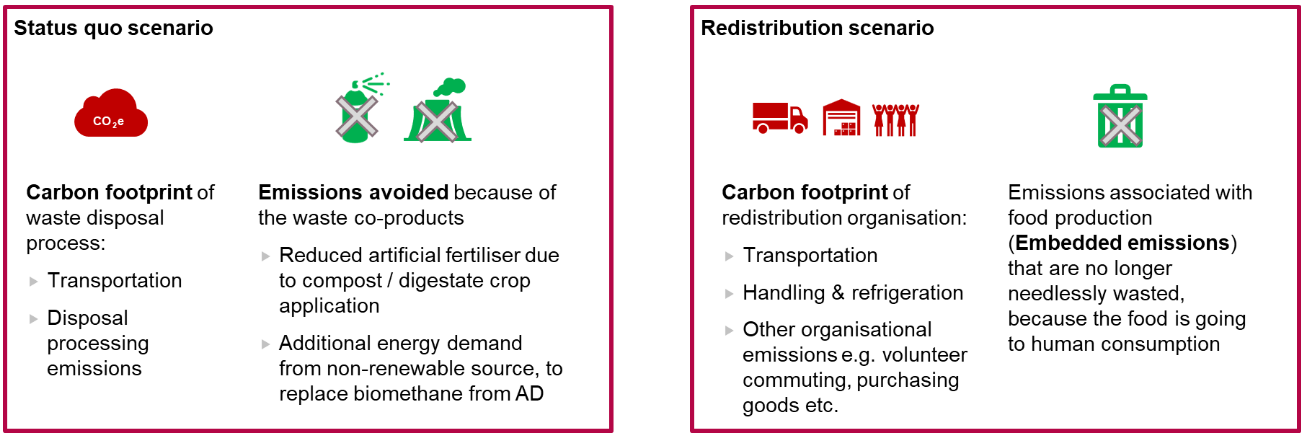
4.1. Introduction and key concepts

In addition to quantifying the costs associated with redistributing farm surplus, this study evaluated the environmental impacts of the change.

The starting position of this study was that food remaining in the human food chain is preferable to all alternative destinations, in alignment with the Food Waste Hierarchy (DEFRA, 2024), due to both the environmental (more productive use of agricultural land) and social benefits.

A model was created to quantify one aspect of environmental impact, which was the difference in greenhouse gas (GHG) emissions from a scenario where the food is redistributed. This was then compared with the status quo scenario, as well as evaluating any significant wider life cycle emissions impacts.

At a high level, the elements that were quantified are outlined in Figure 4.1.1 below:



Note: Emissions in red are carbon sources that cause global warming and those in green have an environmental benefit (e.g. reducing emissions in the wider value chain or putting produce that has already resulted in emissions to its intended productive use)

Figure 4.1.1 – Elements of GHG emissions quantified within the environmental model

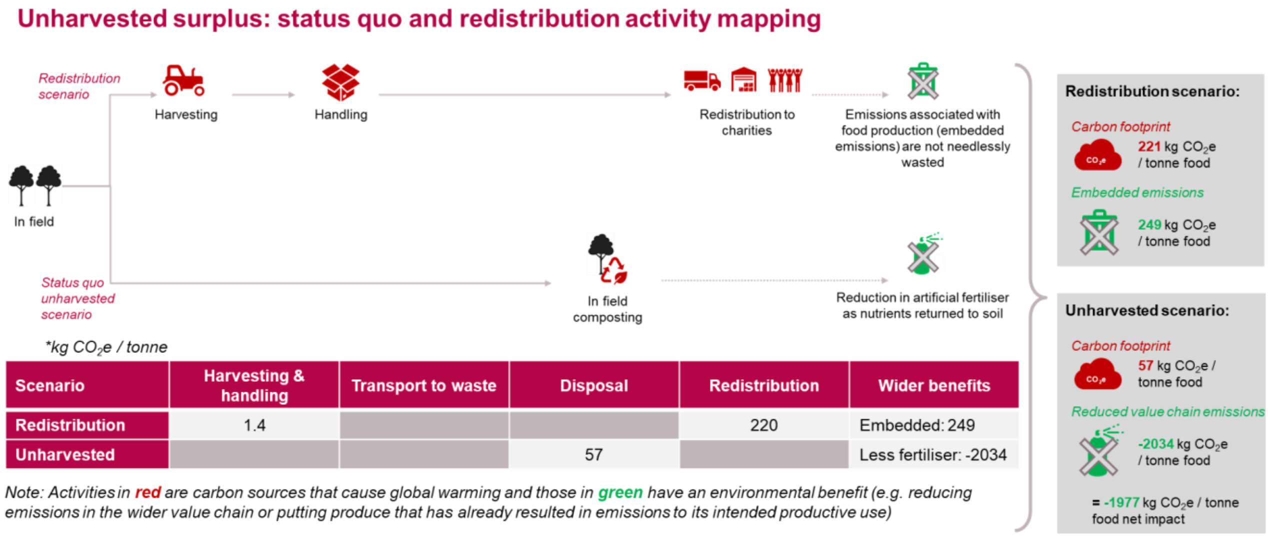
These elements were quantified for both the unharvested and harvested (out of specification) scenarios outlined in section 2.2.

4.2. Methodology and assumptions

The approach to calculating the GHG emissions was:

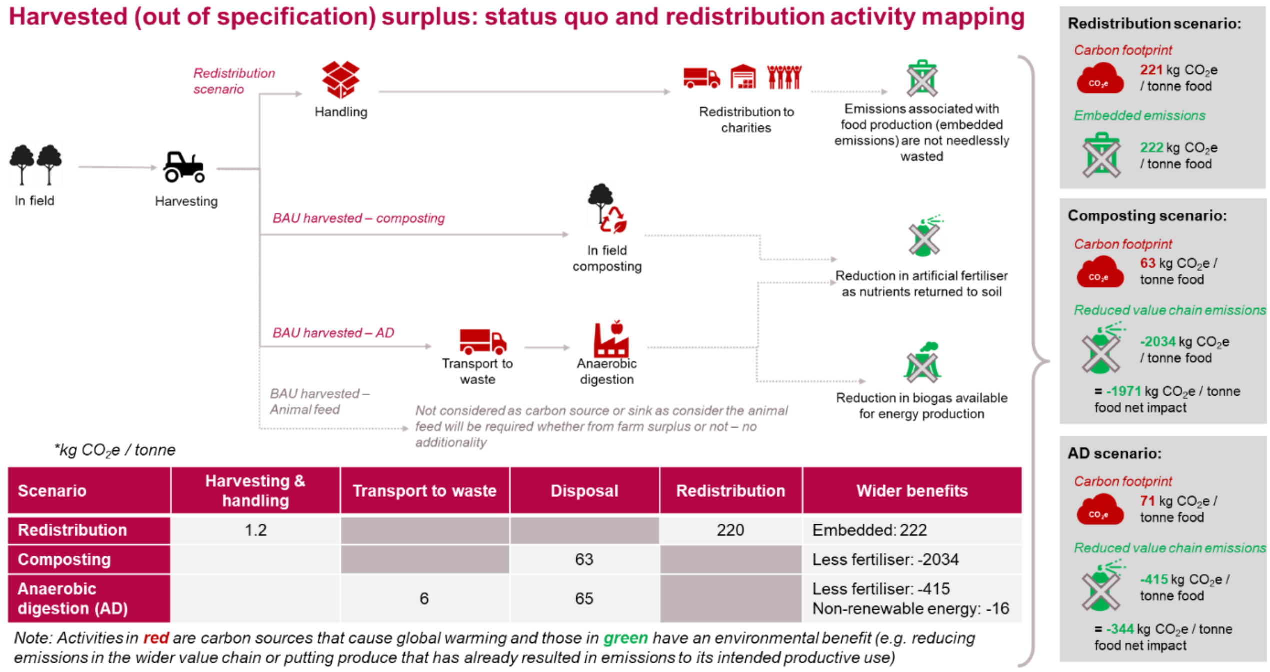
1) Status quo and redistribution scenarios were mapped, identifying the different activities that have a GHG impact (sink or source)
2) For each identified activity, the associated GHG emissions were calculated based on:
    a. Estimating the quantity of activity (e.g. volume, mileage etc.) based on the volumes per scenario outlined in section 2.
    Average volumes were used for this exercise, however a +/- 20% error margin should be expected to reflect the uncertainties in volumes as well as uncertainty in emissions calculation
    b. Applying best available emission intensity factors to convert each activity into GHG emissions
    Where possible, factors were selected from recognised published guidance (e.g. UK government conversion factors, WRAP scope 3 guidance) and where these sources did not exist other sources such as scientific journals were used.
    Please see the appendix 7.2.4 for a list of the major assumptions and data sources used.
3) The difference in overall emissions between the comparable scenarios was quantified, with results described in section 4.3

The resulting mappings and emissions per stage can be seen in Figures 4.2.1 and 4.2.2 below.



Scenario	Harvesting & handling	Transport to waste	Disposal	Redistribution	Wider benefits
Redistribution	1.4			220	Embedded: 249
Unharvested			57		Less fertiliser: -2034

Figure 4.2.1 – Activity maps and carbon emissions / benefits per stage for unharvested scenarios



Scenario	Harvesting & handling	Transport to waste	Disposal	Redistribution	Wider benefits
Redistribution	1.2			220	Embedded: 222
Composting			63		Less fertiliser: -2034
Anaerobic digestion (AD)		6	65		Less fertiliser: -415 Non-renewable energy: -16

Figure 4.2.2 – Activity maps and carbon emissions / benefits per stage for harvested (out of specification) scenarios

4.3. Results – emissions

a) Redistributing on-farm surplus means additional emissions compared with all the status quo scenarios

In all three status quo destination scenarios the GHG emissions were found to be lower than the redistribution scenario (see Figure 4.3.1). The difference was lowest compared with animal feed, where redistribution emitted an additional ~0.22 t CO_2e / tonne of food.

Note: though embedded emissions have also been calculated (Figure 4.2.2), embedded emissions cannot be 'netted' against the emissions incurred to redistribute it, as the emissions are not undone or removed. So all scenarios represent an overall increase.

	Status quo surplus destination	Additional emissions due to redistribution ($kg\ CO_2e/tonne$) *Lower bound*	Additional emissions due to redistribution ($kg\ CO_2e/tonne$) *Average*	Additional emissions due to redistribution ($kg\ CO_2e/tonne$) *Upper bound*
	Unharvested	1760	2200	2740
Harvested (out of specification)	Animal feed	180	220	260
	Anaerobic digestion	465	580	580
	Composting	1750	2190	2630

Figure 4.3.1 –Calculated GHG emissions increase to redistribute food compared with the status quo scenarios

	Embedded emissions (kg CO2e/tonne) *Lower bound*	Embedded emissions ($kg\ CO_2e/tonne$) *Average*	Embedded emissions ($kg\ CO_2e/tonne$) *Upper bound*
Average embedded emissions	185	230	275

Figure 4.3.2 –Calculated GHG embedded emissions already emitted during the production of the surplus food, that was not needlessly emitted in redistribution scenario

b) *Redistributing harvested (out of specification) surplus has a significantly lower impact than unharvested*

Figure 4.3.3 shows the average emissions impact of redistributing food vs harvested and unharvested scenarios. The unharvested scenario could cause over three times more emissions than harvested. This is mostly caused by the additional artificial fertiliser required (see section d for more information).

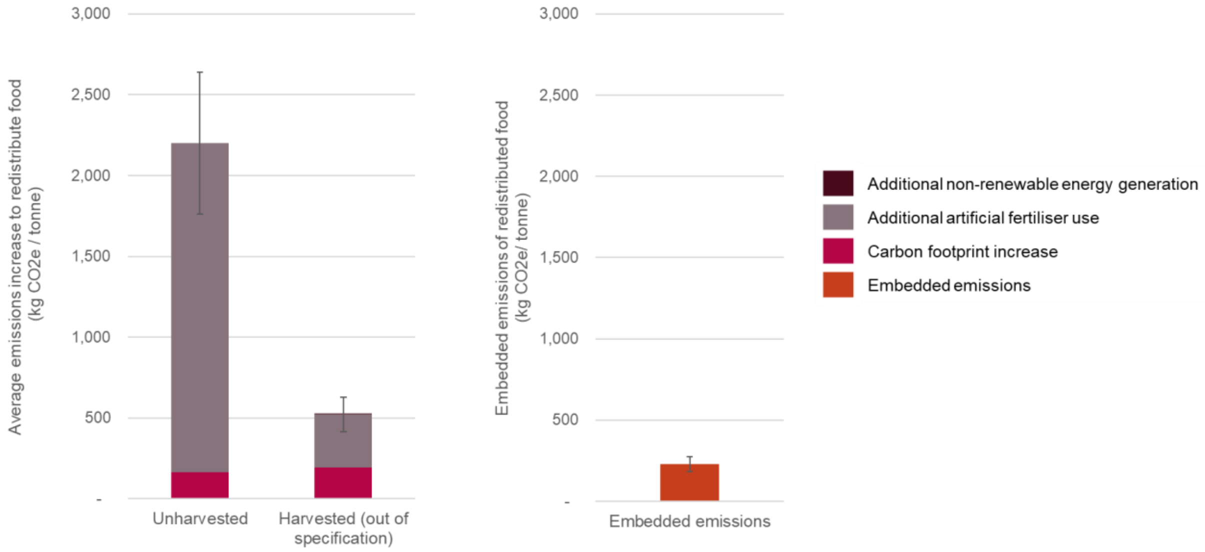


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Figure 4.3.3 – [Left] Calculated GHG emissions increase to redistribute food compared with the average unharvested and harvested scenarios, split by the different activities causing or reducing emissions and [Right] Embedded emissions associated with the redistribution scenario, that are no longer needlessly wasted as the food is consumed

c) Embedded emissions associated with the edible, feasible volume are relatively low and so whether or not this is a material benefit depends on context.

Redistributing edible, feasible farm surplus has the benefit of ensuring emissions emitted as part of food production were not done so needlessly. In some instances, where the embedded emissions are high, it may be seen as more beneficial to redistribute the product as it incurred a high environmental price to produce.

Roots & tubers and fruits & vegetables grown natively have a relatively low carbon footprint (e.g. compared with meat), meaning their embedded emissions are low. The embedded emissions benefit associated with the food in the redistribution scenario was estimated at ~0.25 t CO_2e / tonne.

While it is a positive thing not to emit GHG unnecessarily by redistributing the food, invoking this benefit needs to be seen in relation to the additional emissions redistributing the food could incur. For example, the additional emissions estimated to be incurred by diverting edible, feasible surplus from animal feed roughly equates to the estimated embedded emissions of that food (see Figures 4.3.1 and 4.3.2); however, the same is not true of food diverted from composting.

d) Redirecting volume that would otherwise have been used for composting could result in a significant adverse environmental impact by necessitating use of artificial fertilisers instead.

The significantly higher GHG emissions of redistribution compared with the AD and composting scenarios were driven by the high environmental impact of artificial fertilisers. This is due to the fossil fuel intensive production of artificial fertilisers and the generation of NOx (a potent greenhouse gas) during the application and usage of nitrogen fertilisers. In the redistribution scenario, it is assumed that the nutrients that would have been returned to the soil in the case of composting (both harvested and unharvested scenario) are replaced by artificial fertilisers. However, due to various factors – including rising artificial fertiliser costs driven by supply chain issues such as the Ukraine war, and a nationwide shift towards more sustainable and regenerative farming practices – it is likely that artificial fertiliser usage will decrease in the future. Therefore, the additional emissions estimated in this report may be overestimated.

e) Redirecting volume that would otherwise have been used for anaerobic digestion could result in more use of artificial fertilisers and reduction in the amount of renewable energy produced.

Anaerobic digestion produces digestate which can be used as a fertiliser. A reduction in food sent to AD could result in a shortfall in fertiliser would need to be made up through artificial fertilisers (though to a lesser extent than with compost, which is more nutrient-rich). This has been quantified in the model, however conversations with farmers indicated that a surplus of digestate exists and therefore the size of this shortfall (and associated emissions) could be overstated.

Anaerobic digestion produces biogas which is used to produce renewable energy. Reducing the amount of food used in AD would mean the amount of renewable energy available, which it is assumed would be backfilled by non-renewable sources.

4.4. Other environmental considerations

Beyond GHG emissions, there are many other measures of environmental impact that were not within the scope of this report however are important factors. These potential impacts of redistribution include both beneficial and detrimental impacts to the environment such as:

- Potential positive impact: there are additional embedded impacts of produce to farm gate, including water use and soil degradation. These impacts are not being needlessly caused in the redistribution / human consumption scenario.
- Potential negative impact: potential reduction in biodiversity among field-grown crops due to decreased organic matter being composted in the field.
- Potential positive impact: reduced application of digestate (product of anaerobic digestion). Recent developments indicate that pollution from digestate runoff into waterways is a concern.

This evaluation also represents a snapshot in time; trends to decarbonise all areas of the food system plus efforts to adopt low-carbon and regenerative agricultural practices could

- Lower the potential emissions impact of redistribution activities => strengthening the case for redistribution
- Lower the embedded emissions of produce that could be redistributed => weakening the case for redistribution

4.5. Section summary

The environmental impact of redistributed farm surplus depends on the type of food and status quo destination. Overall, the picture is nuanced and should be expected to evolve with overall societal moves to decarbonise.

Redistributing farm surplus would prioritise food for human consumption (as per the food waste hierarchy) over its use in other processes, and it would ensure the emissions embedded in the food from its production would not have been needlessly emitted.

However, the scale of the embedded emissions is relatively small, at approximately 50% the size of harvested scenario emissions, and one tenth of the unharvested scenario. This supports there being a stronger case for redistribution of harvested food.

5. Design of incentives for redistribution of farm surplus

The above evaluation of the economic and environmental context around redistribution of farm surplus showcases the complexities in this space and the requirement for systems thinking.

The above suggests that there could be a material volume of on-farm surplus suitable for redistribution. Its redistribution would be a social good, meaning improved access to nutritious food for individuals and helping communities facing food insecurity. It would also adhere to the food waste hierarchy. However, it would likely incur additional costs and emissions (at least in the short term), depending on the type of produce and the status quo scenario.

In this section we therefore review some of the elements that would need to be considered when designing an effective incentive to support this social benefit in a cost-effective and environmentally conscious way.

5.1. Where should incentives be targeted?

The cost and environmental modelling outlined in sections 3 and 4 demonstrated that the impact of redistributing food varies depending on the type of food and what the status quo destination of the food would have been. Because of the variation found during this study, it was decided to evaluate the circumstances where food redistribution could be most favourable to inform future discussions on prioritisation and targeting.

In order to do this, several factors that are relevant for food redistribution suitability were identified below:

- **Nutrition** – food should be fresh and healthy
  Since the focus of this study is fruits and vegetables grown in England, this condition was considered met by all farm surplus scenarios
- **Volume available** – enough to sufficiently increase the volume of available surplus and therefore justify redistribution and incentives
- **Cost of redistribution to farm gate** – the cost must be financially viable, and a lower cost is more favourable (though should be balanced with the other factors)
- **Environmental impact** – a lower environmental impact is favoured and, as per costs, should be balanced with the other factors
- **Variety and accessibility** – beyond volume, a wider variety of surplus redistributed is favourable to provide diverse diets. Linked to this, increasing the accessibility of more expensive crops such as soft fruit and leafy greens to those with food insecurity would be beneficial

Figures 5.1.1 and 5.1.2 below demonstrate the interplay between several of these factors. Figure 5.1.1 plots the cost of distribution against the feasible volume available for each of the nine categories and the three major status quo destinations – unharvested, harvested to AD and harvested to animal feed.

The same distribution can be seen more simply in Figure 5.1.2, which shows how different types and volumes of surplus are 'unlocked' as the size of incentive increases.

Key findings from these analyses were:

- A large proportion (45%) of feasible volume has a cost of redistribution under £100 /t, however the variety of produce available is very limited with over 90% represented by tubers and the remainder top fruit. Therefore, this lower cost option is not considered favourable due to the lack of variety
- Between £100-£400 /t the full variety of food groups becomes available, each group with a feasible volume of between 2-6 kt (except for the much larger root vegetable volume of ~27 kt). Most of this volume is from the harvested (out of specification) status quo scenario
- The unharvested status quo destination has a significantly higher cost of redistribution than harvested, with the same food categories being between three and ten times more costly to access. This is driven by the high cost of harvest, particularly for very manual processes (the notable exceptions being tubers and legumes that are highly mechanised)
- As well as being the highest cost area, accessing surplus from the unharvested scenario also has the highest environmental (carbon emissions) impact, driven by the reduction in artificial fertiliser needed when crops are left to compost in the ground, making it overall the least favourable option for redistribution

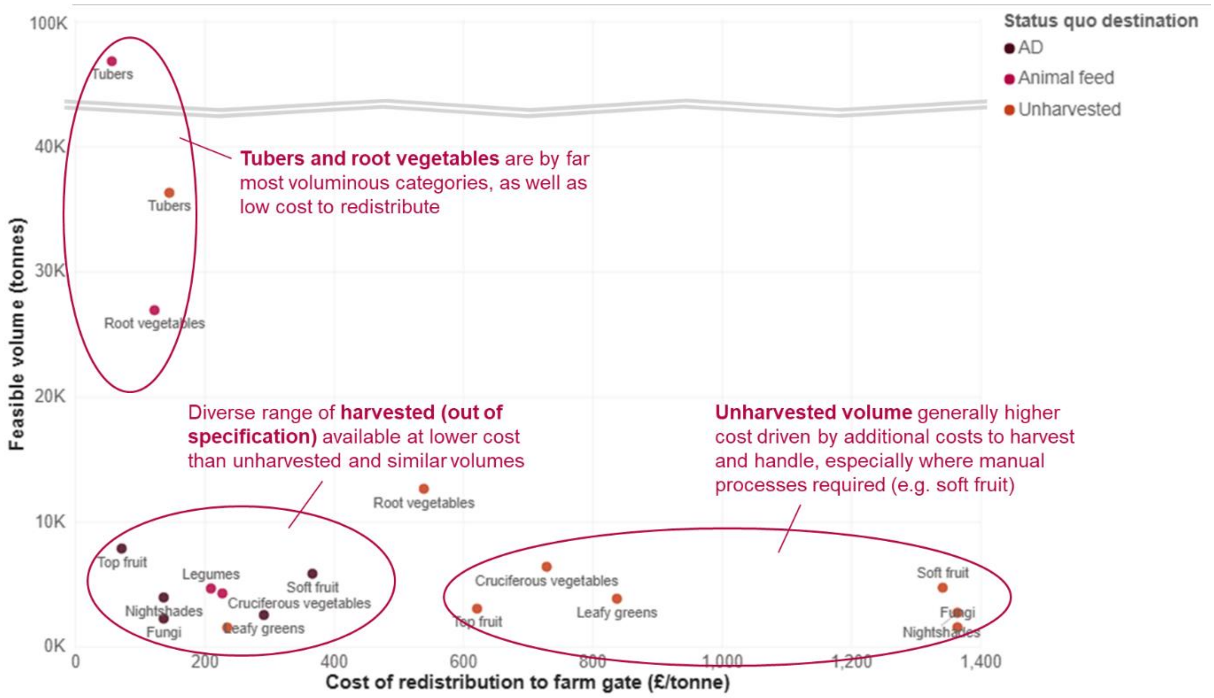

Figure 5.1.1 – Annotated plot of feasible volume vs cost of redistribution for different food categories and status quo surplus destinations

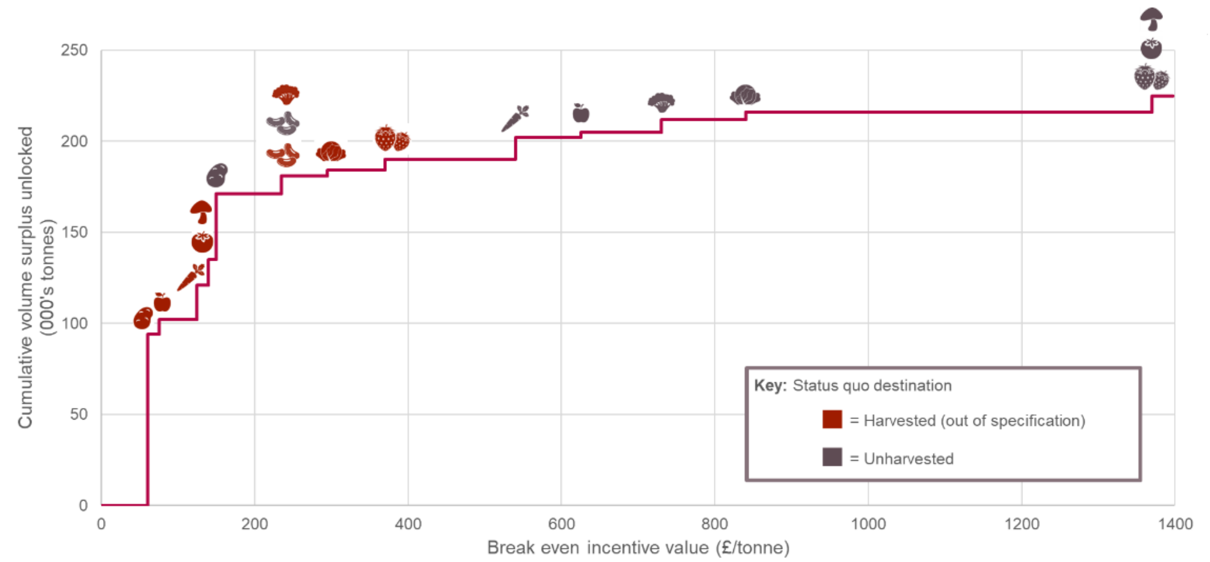

Figure 5.1.2 – Step chart showing the volume of surplus that could become available as the size of incentive increases, and the food categories making up the volumes

5.2. What value of incentives would be required?

Figures 5.1.1 and 5.1.2 showed that a 'one size fits all' approach to redistribution incentives is unlikely to be suitable, and therefore several scenarios were evaluated to demonstrate the potential options and the considerations for each, see Figure 5.2.1.

The costs used in this figure reflect the 'break even' cost of redistribution to farm gate and should therefore be considered the minimum required to enable redistribution.

Approach	Minimum value*/ tonne	Feasible volume available	Minimum cost* of scheme / year	Breakdown of available produce	Considerations & limitations
Scenario 1: **Flat incentive rate, set at the same level for all produce**	E.g. £140 /tonne redistributed *Though any value could be chosen*	135,000 t per year	£18.9 M per year	70% tubers 20% root veg 6% top fruit Remainder mixed	▶ Farmers would receive a higher margin from the lowest cost items ▶ Likely to receive potatoes and little else ▶ High overall cost of incentive as not scaled to categories
Scenario 2: **Per category rates, targeted at lower cost categories**	**Average: ~£75 / t** Tubers: £60 /t Root veg: £125 /t Top fruit: £75 /t	130,000 t per year	£9.6 M per year	75% tubers 20% root veg 5% top fruit	▶ Per category approach more aligned to farming practices ▶ Lower overall cost of incentive ▶ Only three crop types available, with large volume of tubers ▶ Redistribution volume being 'taken from' other markets (AD & animal feed)
Scenario 3: **Per category rates, targeted at all harvested (out of specification)**	**Average: ~£100 / t** As scenario 2, plus Nightshades & Fungi: £140 /t Legumes: £210 /t Cruciferous veg: £230 /t Leafy greens: £295 /t Soft fruit: £370 /t	150,000 t per year	£15.3 M per year	63% tubers 18% root veg 1-5%: per remaining category	▶ Greater complexity with more incentive values to manage ▶ Greater variety of produce available ▶ Redistribution volume being 'taken from' other markets (AD & animal feed)

Scenario 4: **Per category rates, targeting all harvested (out of specification) and unharvested surplus**	**Average: ~£335 / t** As scenario 2 for tubers & root veg, plus: Top fruit: £625 /t Nightshades & Fungi: £1400 /t Legumes: £235 /t Cruciferous veg: £730 /t Leafy greens: £840 /t Soft fruit: £1345 /t	175,000 t per year	£58.7 M per year	54% tubers 15% root veg 6%: Soft fruit, top fruit, cruciferous veg 2-4%: per remaining category	▶ Highest volume potentially available for redistribution and good variety, but highest overall cost of incentive ▶ Challenging to differentiate between the harvested / unharvested status quo destinations, therefore ▶ Significant margin possible for out of spec produce – farmers may choose to take this incentive, but leave unharvested in field
Scenario 5: **Per category rates, targeting unharvested only**	**Average: ~£460 / t** Tubers: £150 /t Root veg: £540 /t Top fruit: £625 /t Nightshades & Fungi: £1400 /t Legumes: £235 /t Cruciferous veg: £730 /t Leafy greens: £840 /t Soft fruit: £1345 /t	75,000 t per year	£34.5 M per year	50% tubers 17% root vegetables 9% cruciferous veg 6% soft fruit 2-5%: per remaining category	▶ No competition for surplus with other markets (animal feed and AD) ▶ Lowest overall volume targeted, but good variety of produce ▶ Challenge to determine surplus that would genuinely have been unharvested, without a lot of close monitoring ▶ Highest average cost per tonne redistributed

Figure 5.2.1 – Matrix showing five potential scenarios for targeting the farm surplus incentives and the associated costs and implications of each

Key findings from scenario evaluation:

- Scenario 1, the flat incentive rate, was discounted due to the large variety of costs for different produce types, and the resulting ‘loop hole’ in the approach that could result in the scheme’s adoption for only the lower cost produce. The same challenge could be seen with scenario 4, with the higher price being offered for both harvested and unharvested volume potentially resulting in uptake only for the harvested portion
- Scenario 2 had the lowest over cost and average cost per tonne, but minimal variety of produce, with 75% from tubers and therefore Scenario 3 was considered preferable
- Scenario 3, targeting harvested (out of specification) surplus, stood out as the strongest option as it delivered a large volume of surplus and good level of variety for a relatively low overall cost. However, the status quo destinations for most of the volume were AD and animal feed, so these markets could be affected by a redistribution incentive
- Scenario 5 addressed this by targeting unharvested volume, however executing this in reality would require a method of identifying which volume of surplus was harvested vs. unharvested, which would require significant monitoring. In addition, this was the highest average cost incentive

Overall, scenarios 3 and 5 stood out as the most favourable, but neither was without challenges. However, these challenges could be addressed through the right design and careful management of the incentive to avoid unintended consequences. This is explored further in sections 5.3, 5.4 and 5.5.

5.3. Sustainable Farming Incentive (SFI) and other vehicles for incentives

In the introduction to this report, the Sustainable Farming Incentive (SFI) was identified as a plausible vehicle for delivering a new food redistribution incentive for farmers. In order to determine its suitability, SFI as a vehicle for this new incentive was critically analysed, with an overview of positives and considerations below.

Positives:

Established scheme	The SFI is a well-established program. Leveraging the existing administrative processes and infrastructure of the SFI can reduce the time and resources needed to implement the new incentive.
Ease of rollout	As an already existing and widespread scheme, the SFI can be rolled out more easily. Information about the SFI is effectively communicated to farmers, often through farm advisors who assist with SFI applications.
Potential for new formats	Ongoing reforms may allow for new formats of incentives, not just those requiring upfront commitments.
Reduced resistance	Farmers may feel less overwhelmed by an additional scheme if all incentives are kept within the SFI, potentially leading to higher engagement with the new incentive.

Considerations:

Uncertain nature of surplus	The SFI's structure around future commitments does not align with the uncertain nature of food surplus (i.e., a farmer does not know what percentage of their produce will be out of specification and therefore what volume they can put forward for redistribution).
Increased complexity	Addition of a new incentive may further increase this complexity of SFI for both Defra and farmers, however this impact is likely insignificant and minimal compared to other alternative incentive delivery methods.
Cash flow	Farmers could be expected to cover any additional costs or loss of earnings (which may have otherwise been paid at farm gate) until payment has been processed.

Figure 5.3.1 – Critical analysis of the Sustainable Farming Incentive (SFI) as a method for delivering a new food redistribution incentive

In summary, the SFI could offer a well-established framework with existing infrastructure and administrative processes, making it easier to roll out a new incentive and communicate effectively with farmers. The SFI's structure around future commitments may not align with the uncertain nature of food redistribution, however encompassing flexible terms within a refreshed SFI could mitigate this issue, which is explored further in section 5.5.

SFI is not the only option for incentivising redistribution, and for completeness three other vehicles for delivering an incentive were assessed for their suitability and compared to SFI in Figure 5.3.2.

	Positives	**Considerations**
Sustainable Farming Incentive (SFI)	▶ Established scheme: Familiar to farmers, leveraging existing infrastructure and administrative processes ▶ Ease of rollout: Effectively communicated and accessible through farm advisors ▶ Potential for new formats: Ongoing reforms may allow new support formats ▶ Reduced resistance: Keeping incentives within SFI may lead to higher farmer engagement	▶ Uncertain nature of surplus: Farmers cannot predict surplus volumes for incentives ▶ Increased complexity: Adding a new incentive may increase SFI complexity but this impact is likely minimal compared to other methods ▶ Cash flow: Farmers would be expected to cover any additional costs until reimbursed

Charities to be given an annual budget	▶ Purchasing Power: Charities receive funds upfront, giving them purchasing power for the year ▶ Flexibility: Allows charities to respond to surplus availability without requiring farmers to commit ahead of time ▶ Familiar model: Comparable to anaerobic digestion (in the sense that the AD plants have purchasing power), providing a familiar framework to farmers	▶ Funding allocation: Determining the appropriate sum for each charity can be challenging ▶ Budget management: Charities need to manage the funds effectively throughout the year
Charities reimbursed for purchase	▶ Direct payment: Farmers receive immediate payment from charities for the surplus food ▶ Accountability: Charities submit for reimbursement from DEFRA, ensuring transparency and accountability ▶ Familiar model: Comparable to anaerobic digestion (in the sense that the AD plants have purchasing power), providing a familiar framework to farmers	▶ Administrative burden: Charities must handle the reimbursement process, which would likely be significantly more time-consuming than regular reporting ▶ Cash flow: Charities need to have sufficient funds upfront to make purchases before reimbursement
Grants for farmers	▶ Direct incentive: Farmers receive financial support directly tied to the volume of surplus they supply ▶ Verification: Charities can verify and cross-check the supplied volumes, ensuring accountability ▶ Familiar model: Farmers regularly apply for various grants for items such as farm equipment, fencing and machinery	▶ Application process: Farmers may find the grant application process time-consuming and burdensome ▶ Increased complexity: Charities being required to verify sale of food for redistribution will require time and resources ▶ Cash flow: Farmers would be expected to cover any additional costs until reimbursed

Figure 5.3.2 – Comparison and critical analysis of identified alternative methods for delivering an incentive for food redistribution and SFI.

All alternative options have merits and are considered workable for a farm surplus incentive.

SFI has the benefit of being a well-established incentive vehicle which offers ease of rollout, use of established infrastructure and administrative processes, and visibility to farmers.

However, it is worth noting that providing charities with purchasing power would likely mitigate many of the considerations associated with using SFI as a delivery method.

5.4. Wider considerations and unintended consequences of a surplus incentive

While the benefits of redistributing food to those affected by food insecurity are clear, and the merits of using an SFI incentive to facilitate this have been outlined, the wider implications need to be understood to avoid unintended consequences. This section includes a summary of some of the potential consequences of an incentive and, where relevant, how they might be addressed is summarised in the next section (5.5).

Potential commercial implications

- **Reduced waste to anaerobic digestion:** Less waste directed to anaerobic digestion (AD) could impact the quantify of energy available to the grid (approximately 7% of energy comes from AD, with food and crop waste contributing ~one third of the feedstock). However, this volume could be fulfilled from other routes for example an increase in crops grown exclusively for AD, such as maize contracts, which would have knock-on food system and land use impacts. The significance of the impact on AD feedstock should therefore be evaluated during the development of the incentive scheme.
- **Reduced animal feed:** Similar to the above, if focussed on harvested (out of specification) volume, the incentive could reduce available animal feed crops and increase artificial feed usage for animals. This is expected to be a low impact, as most animal feed is derived from cereals, but this should be confirmed as part of the next steps of defining the incentive.
- **Impact to farm contracts:** If the incentive value is pitched too high it could become commercially lucrative and potentially disrupt existing contracts with retailers. The incentive must be appropriately sized to avoid diverting production away from the retail market.

Potential abuse of the incentive

- **Over-planting:** Having a guaranteed customer may drive over-planting behaviour, which would mean that ‘surplus’ volumes would increase. Whilst having greater food availability may not be a wholly negative outcome, this could disrupt food prices as well as having environmental consequences. This issue could be mitigated by implementing a cap.

Potential redistribution sector implications

- **Capacity impacts:** Higher volumes of food through the redistribution network could strain existing capacity. Charities will need more resources and capacity to handle greater volumes and more seasonal flows. Discussions with The Felix Project indicate they are prepared and have planned for this.
- **Fluctuation in supply/seasonality:** Given the inherent seasonality of farming, supply fluctuations are inevitable. However, many food sector charities are adopting novel ways to extend the life of the produce they receive to be able to manage gluts (for example, through developing food preparation and preservation facilities)

5.5. Design considerations for the SFI incentive

In section 5.3, the SFI was identified as a strong option for a farm surplus redistribution incentive, however there were several considerations highlighted that would need to be addressed to make the solution work most effectively. Figure 5.5.1 considers these limitations and at a high level suggests how the incentive could be designed to manage or mitigate these challenges.

Some of these solutions have been informed by the previous work by The Anderson Centre on this topic (The Andersons Centre, 2023), as well as input from additional research and The Felix Project.

Consideration	What could it look like?
Cash flow impacts	▶ Depending on the chosen vehicle for the incentive, there could be a cashflow impact for farmers or charities ▶ Implementing a regular payments / reimbursement structure (e.g. quarterly) could help mitigate these impacts ▶ Additionally, a small retainer payment for farmers partaking in the scheme could help cover ancillary expenses such as administration costs to keep surplus records and manage the coordination with charities
Uncertain nature of surplus	▶ Unlike other SFI incentives, surplus redistribution is less well suited to making prior commitments on volumes ▶ A more flexible approach would likely attract more farmers to adopt the scheme as would mitigate fear of 'lock-in', but this could be balanced with a clear expectation to deliver some food over the course of the agreement, especially if an annual retainer were in place
Accessing unharvested produce, to avoid animal feed and AD disruption	▶ Due to the significant difference in cost of redistribution between harvested and unharvested surplus, accessing unharvested volume with a higher incentive value would require the ability to differentiate between the two sources ▶ This would be challenging as a blanket approach but could be achieved in a more targeted way. For example, by working with specific large producers and verifying the crops' 'unharvested status' on an individual basis ▶ Another approach to access unharvested food, without requiring the larger incentive, would be for charities to provide the labour needed to harvest the crops, which has been successful in schemes run by The Felix project for top fruit
Risk of driving over-planting	▶ To prevent over-planting, a limit could be implemented on how much surplus a farmer can be reimbursed for ▶ This 'incentive cap' could be scaled based on the size of farm, so that larger farms are not unfairly disadvantaged ▶ Additionally, per food category caps to serve the purpose of influencing the types of produce received by charities, which could support providing a wide variety of produce

Figure 5.5.1 – considerations required for an incentive under SFI to be effective, and suggested mitigating characteristics of a possible incentive

6. Conclusions

6.1. Conclusions of findings

This study estimated that the quantity of farm surplus feasible for redistribution in England ranges between 180 kt and 270 kt annually. If made available, this would significantly increase current redistribution volumes, which were reported by WRAP to be 191 kt in 2023. Approximately one third of this surplus would come from unharvested produce, with the remainder from harvested produce that has become surplus due to being out of specification. The surplus comprises a variety of fruit and vegetable produce, with the largest portions being tubers (~58%) and root vegetables (~18%).

The study modelled the costs and greenhouse gas (GHG) emissions associated with redistributing this surplus. Additional costs to the farm gate vary based on the food category and the status quo scenario from which the surplus is diverted. Costs are highest if the surplus would otherwise go unharvested (on average £375-£565 per tonne), due to additional harvesting expenses. If diverted from harvested (animal feed, anaerobic digestion (AD), or composting), costs are between £60-£145 per tonne on average and primarily consist of alternative handling expenses rather than loss of earnings (e.g., from not selling surplus to animal feed or AD markets).

The environmental impact of redistributing farm surplus is complex and depends on the type of food and its status quo destination. While redistributing surplus prioritises food for human consumption, adhering to the food waste hierarchy, and ensures that the emissions embedded in upstream food production are not needlessly wasted, it also increases emissions compared to the status quo. Diverting surplus from composting and anaerobic digestion could lead to negative environmental impacts due to the significant emissions associated with artificial fertiliser used to replenish soil nutrients if surplus food is removed and redistributed. However, the picture is nuanced and should be expected to evolve with overall societal moves to decarbonise.

The evaluation of the economic and environmental context around redistribution of farm surplus demonstrated the complexities in this space and the requirement for systems thinking. The report reviewed elements that need to be considered when designing an effective incentive to support the social benefit of redistribution in a cost-effective and environmentally conscious way.

Key findings of this analysis were:

- An incentive valued per food category would be best suited to farming operations, increase the variety of produce made available, and reduce the risk of the scheme being exploited.
- Accessing harvested (out of specification) produce would be the lowest cost and most straightforward to implement, but it risks disrupting existing commercial channels of animal feed and anaerobic digestion.
- Accessing unharvested produce adds complexity due to the higher cost of redistribution compared to harvested produce and the difficulty in verifying genuine 'unharvested status'. This challenge could be overcome by working directly with select producers or by providing labour for harvesting the produce (e.g., via charity volunteers) rather than a larger incentive to cover the costs of labour.

Finally, the Sustainable Farming Incentive (SFI) was evaluated as a vehicle for incentivising farm surplus redistribution. The SFI could offer a well-established framework with existing infrastructure and administrative processes, making it easier to roll out a new incentive and communicate effectively with farmers. However, the SFI's structure around future commitments may not align with the uncertain nature of food redistribution. Encompassing flexible terms within a refreshed SFI could mitigate this issue.

6.2. Recommended next steps in this study / area

This study has used best available data and informed assumptions to estimate the volume of farm surplus available and the costs and GHG emissions associated with its redistribution. Initial findings indicate that there is a promising opportunity to significantly increase the amount of surplus redistributed from farms (by more than twenty times) with costs between £60-£565 / tonne.

The following activities could support next steps by increasing confidence in findings and validating conclusions:

- A more in-depth study including broader representation from farmers and the farming industry, to validate the assumptions made on feasible volumes, status quo surplus destinations and costs. This could also include evaluating the size of incentive that would be required to encourage adoption of the scheme, over and above the 'break even' cost of redistribution that is evaluated in this report
- Further develop the environmental analysis by investigating the rationale that (a) redistributing food has a 'demand suppression' impact that could offset the carbon footprint of redistribution and (b) there is surplus digestate not being used as fertiliser, so the 'fertiliser effect' in the calculations has been overstated
- Evaluate the wider economic case for redistribution of farm surplus, in particular the public health implications of food insecurity and the reduction in healthcare costs that could be delivered by improving access to fresh nutritious produce for the UK's poorest people
- This study evaluates the cost of a farm inventive that would be paid to farmers. Other related costs that could be evaluated include:
    - Increasing the capacity and capability of redistribution infrastructure to manage the increased volumes from farms
- The costs associated with initially implementing the scheme (communication, administration, development and piloting etc.) and its ongoing management (which may be rolled up into SFI general costs)

7. Appendix

7.1. Glossary

- *Agricultural calculators*: Industry tools used to estimate various aspects of farming operations, such as fertiliser required.
- *Anaerobic digestion (AD)*: A process by which microorganisms break down biodegradable material in the absence of oxygen, producing biogas (used for energy) and digestate (used as a fertiliser).
- *Artificial fertiliser*: Man-made substances added to soil to supply nutrients necessary for plant growth.
- *Biogas*: A type of biofuel produced from the anaerobic digestion of organic matter, such as agricultural waste, manure, municipal waste, plant material, sewage, green waste, or food waste.
- *Carbon footprint*: The total amount of greenhouse gases emitted directly and indirectly by an individual, organisation, event, or product.
- *Composting*: The process of recycling organic matter, such as food scraps and yard waste, into a valuable fertiliser that can enrich soil and plants.
- *Crop yield*: The total quantity of crop that is harvested per unit of land area.
- *DEFRA*: Department for Environment, Food & Rural Affairs, a UK government department responsible for environmental protection, food production and standards, agriculture, fisheries, and rural communities.
- *Digestate*: The material remaining after the anaerobic digestion of a biodegradable feedstock, used as a fertiliser.
- *Edible surplus*: The proportion of surplus food that is suitable for human consumption.
- *Embedded emissions*: Greenhouse gas emissions that are produced during the production of food, which are 'embedded' in the food product.
- *Environmental Land Management (ELM) programme*: A UK government initiative aimed at promoting sustainable farming practices and improving the environment.
- *Feasible*: The proportion of surplus food estimated to be viable for redistribution, considering practical limitations and uptake rates.
- *Food waste hierarchy*: A prioritisation of actions to reduce and manage food waste, typically prioritising prevention, followed by redistribution for human consumption, animal feed, and other uses like composting and anaerobic digestion.
- *Food insecurity*: The state of being without reliable access to a sufficient quantity of affordable, nutritious food.
- *Food redistribution sector*: Organisations and initiatives that collect surplus food and distribute it for human consumption.
- *Handling costs*: Expenses associated with the processing, storage, and transportation of food products.
- *Greenhouse gas (GHG) emissions*: Emissions of gases that trap heat in the atmosphere, contributing to global warming and climate change. Common GHGs include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

- *Harvested (out of specification):* Crops that have been harvested but do not meet the specifications for sale due to size, shape, or other quality standards.
- *Human consumption*: The use of food products for eating by people.
- *Nutrient value*: The content of essential nutrients in food or soil that supports plant growth and human health.
- *Out of specification*: Produce that does not meet the quality standards set by retailers or processors, often due to size, shape, or cosmetic imperfections.
- *Pilot programmes*: Small-scale preliminary studies conducted to evaluate feasibility, time, cost, risk, and adverse events, and improve upon the design of a full-scale project.
- *Public health implications*: The effects of policies or practices on the health and well-being of the population.
- *Redistribution*: The process of collecting surplus food and distributing it to individuals or organisations that can use it, typically to address food insecurity.
- *Redistribution network*: The system of organisations and logistics involved in collecting and distributing surplus food.
- *Regenerative farming practices*: Agricultural methods that aim to restore and enhance the health and biodiversity of farming ecosystems.
- *Seasonality*: Variation in food production and availability depending on the time of year.
- *Soil health*: The state of the soil in terms of its biological, chemical, and physical properties, which affect its ability to support plant growth and ecosystem functions.
- *Status quo scenario/destination*: The current situation or baseline against which changes or interventions are compared.
- *Supply chain*: The sequence of processes involved in the production and distribution of a commodity.
- *Sustainable Farming Incentive (SFI):* A UK government scheme that financially incentivises farmers and land managers to adopt sustainable farming and land management practices.
- *Sustainable practices*: Methods of using resources that do not deplete them and can be maintained over the long term.
- *Unharvested*: Crops at are left in the field and not harvested, often due to market conditions, labour shortages, or quality issues.
- *Unintended consequences*: Outcomes that are not foreseen or intended by a purposeful action.
- *Value chain*: The full range of activities that businesses go through to bring a product or service from conception to delivery and beyond.
- *Waste reduction*: Efforts to minimise the amount of waste produced by individuals, organisations, and communities.
- *Water use*: The amount of water utilised in the production and processing of food.
- *WRAP*: Waste and Resources Action Programme, a UK charity that works with governments, businesses, and communities to promote sustainable resource use and waste reduction.

7.2. Overview of data, sources and assumptions, with data quality commentary

7.2.1. Food categorisations and mapping

The modelling was done at a food category level, based on the below 9 categories. Where necessary, for example if insufficient data was available, one specific produce type was selected to represent the category. These are given below in figure 7.2.1.1:

Category	**Representative Crop**
Root vegetables	Average of carrots, onions
Legumes	Peas
Cruciferous vegetables	Broccoli and cauliflower
Leafy greens	Lettuce
Tubers	Potatoes
Fungi	Mushrooms
Nightshades	Tomatoes
Top fruit	Apples
Soft fruit	Strawberries

Figure 7.2.1.1.– mapping of available crop data to categories

7.2.2. Volume modelling

First, volume modelling was completed, with the major data, sources and assumptions shown below (Figure 7.2.2.1.).

Element of calculation	**Figure**	**Sources**	**Major assumptions**	**Quality assessment**
Produced (harvested) volume of crop per category, UK	8,031,817 tonnes	DEFRA, average numbers for last 5 years data available (2018-2022)	None	Good
England proportion of total UK volume, based on farmed land area proportion	74%	All data from DEFRA – combination of 'June Survey' and Horticulture data	Assumes the mix of crops in UK is the same as the mix in England (there is variation but no crop breakdown available)	Good
Amount of crop left unharvested	3-10% of harvested volume (average = 4%)*	The Andersons Centre	Unknown	Best available - – limited understanding / reported data exists
Proportion of harvested crop that is out of specification	8-27% (average = 22%)*			
% of unharvested surplus that is edible (e.g. suitable for human consumption)	75-95% (average = 91%)*			
% of out of specification (harvested) that is edible (e.g. suitable for human consumption)	Tubers: 90%. All other categories: 20-78% (average = 82%)*			
% of edible food (unharvested) that is feasible to get for redistribution	33-50% (average = 36%)*			
% of edible food (out of spec) that is feasible to get for redistribution	10-60% (average = 14%)*			

% of harvested (out of specification) food to compost	10%	Unsourced due to lack of data - estimated	Assumes a paying destination would be used in 90% of cases to maximise available income	Low as not published data, but based on farmer input
% harvested (out of specification) food to animal feed and anaerobic digestion	70% to highest paying destination and 20% to second highest	Unsourced due to lack of data - estimated	Assumes strong preference for highest paying option but not used where route less convenient / accessible. 90% AD assumed for categories where negligible animal feed market exists	Low as not published data, but based on farmer input

*Figure 7.2.2.1.– overview of data, sources and assumptions with quality assessment for volume modelling. * Averages are weighted by volume harvested; percentages for each category can be seen in Figures 7.2.2.2. – 7.2.2.4.*

Category	% unharvested	% edible	% feasible
Root vegetables	4	85	37
Legumes	4	88	33
Cruciferous vegetables	6	80	50
Leafy greens	8	75	50
Tubers	3	95	33
Fungi	6	75	50
Nightshades	6	75	50
Top fruit	3	85	50
Soft fruit	10	80	50

Figure 7.2.2.2 – Source: The Andersons Centre, 2023 - percentages applied to England volume for each category for unharvested produce
Note: Where data for a specific produce category was not available (legumes and fungi), a best available option was selected based on similarity in harvesting processes, food characteristics and volumes.

Category	% harvested	% Out of specification	% edible	% feasible
Root vegetables	96	13	58	37
Legumes	96	21	78	22
Cruciferous vegetables	94	8	40	50
Leafy greens	92	15	20	66
Tubers	97	*27**	90	10
Fungi	94	15	33	66
Nightshades	94	15	33	66
Top fruit	97	20	66	25
Soft fruit	90	15	50	66

Figure 7.2.1.3.– Source: The Andersons Centre, 2023 - Percentages applied to England volume for each category for unharvested produce.
**Calculated from data published by DEFRA, average numbers for last 5 years data available (2018-2022)*
Note: Where data for a specific produce category was not available (legumes and fungi), a best available option was selected based on similarity in harvesting processes, food characteristics and volumes.

Category	% Animal feed (status quo)	% Anaerobic digestion (status quo)	% Compost (status quo)
Root vegetables	70	20	10
Legumes	70	20	10
Cruciferous vegetables	70	20	10
Leafy greens	0	90	10
Tubers	70	20	10
Fungi	0	90	10
Nightshades	0	90	10
Top fruit	0	90	10
Soft fruit	0	90	10

Figure 7.2.2.4.– Source: The Andersons Centre, 2023 - Status quo surplus destination for each category
Note: Where data for a specific produce category was not available (legumes and fungi), a best available option was selected based on similarity in harvesting processes, food characteristics and volumes.

Much of the volume, and consequently the economic and environmental calculations, rely on these percentages. Therefore, in future iterations of this research, primary research could be conducted to improve accuracy.

7.2.3. Economic modelling

The data, sources, and major assumptions used in the economic modelling are detailed below. The economic modelling utilised the sum of the additional cost to the farmer and the loss of earnings. Assumptions include the cost to harvest, cost to handle, and value at the status quo destinations.

a) Additional cost to farmer

Economic calculations for the additional cost to farmer includes values for harvesting and handling each category to farm gate (Figure 7.2.3.1.), and for the purchase of additional artificial fertiliser to replace nutrient value that would have been provided through composting (Figure 7.2.3.2.).

Category	Cost to harvest (£/tonne)	Cost to handle (£/tonne)	Source	Major assumptions	Quality assessment
Root vegetables	355	95	The Andersons Centre, 2023, and Nix Farm Management Pocketbook, 2025	N/A	Good – best available published/public data
Legumes	147.50	50			
Cruciferous vegetables	375	200			
Leafy greens	340	280			
Tubers	100	30			
Fungi	890	125			
Nightshades	890	125			
Top fruit	460	60			
Soft fruit	710	355			

Figure 7.2.3.1.– Cost to harvest and cost to handle for each category (cost to harvest only applicable to unharvested)
Note: Where data for a specific produce category was not available (legumes and fungi), a best available option was selected based on similarity in harvesting processes, food characteristics and volumes.

Element of calculation	Figure	Sources	Major assumptions	Quality assessment
Purchase of additional artificial fertiliser	£8.50 / tonne	AHBD Organic materials value calculator	N/A	Good – reputable agronomy source

Figure 7.2.3.2.– Cost per tonne for the purchase of additional artificial fertiliser

The assumptions in Figure 7.2.3.2 are considered consistent across all crops. However, there is likely some variability as nutritional content will vary by crop, and soil type application method by farm etc.

b) Loss of earnings

Economic calculations for the loss of earnings includes values for each category as animal feed (Figure 7.2.3.3.) and a value for sale as feedstock for anaerobic digestion (Figure 7.2.3.4.).

Category	Value as animal feed (£/tonne)	Sources	Major assumptions	Quality assessment
Legumes	224	Nix Farm Management Pocketbook	N/A	Average –published data and assumptions
Root vegetables	35			

Cruciferous vegetables	35		Assumes that figure for potatoes is representative of root vegetables and cruciferous vegetable categories	
Tubers	35		N/A	
Leafy greens	N/A	N/A	No established market for leafy greens, fungi, nightshades, top fruit, or soft fruit. While there likely is a market, it is considered small and unregulated, with farmers typically selling locally and directly to other farmers	N/A
Fungi				
Nightshades				
Top fruit				
Soft fruit				

Figure 7.2.3.3.– Value of each category as animal feed

Element of calculation	**Figure**	**Sources**	**Major assumptions**	**Quality assessment**
Value of anaerobic digestion	£8.50 / tonne	Shared by commercial anaerobic digestion facility based on fruit/veg feedstock	Assumes that figure is representative of produce from all categories	Average – best available data

Figure 7.2.3.4.– Value for anaerobic digestion

7.2.4. Environmental modelling

Data, sources, and major assumptions for the environmental modelling are detailed in Figure 7.2.4.1. These assumptions were used to calculate emissions per tonne of produce for each status quo destination.

Element of calculation	**Figure**	**Sources**	**Major assumptions**	**Quality assessment**
Embedded emissions	See Figure 7.2.4.2.	WRAP scope 3 reporting emission factor database	Best available emission factors to farm gate were selected. Slight over-estimate of unharvested scenario as will include harvesting stage in number.	Good – industry approved source
Harvesting and handling emissions	1.2 kg CO2e / tonne	NIX farm management pocketbook	Harvesting emissions for potatoes applied to all foods here as produce specific numbers not available	Average – Harvesting emissions will vary, but number is small in context of total footprint
Transportation distance to status quo destination	64.6 km	UK Department for Transport (via GFN)	UK average for all waste, assumes applicable to food waste context on average	Good – national statistic
Emissions for the assumed vehicle type used for transport to status quo destination	0.09752 kg CO2e / tonne.km	Department for Energy Security and Net Zero conversion factors	Average of all HGVs with average laden is representative of all transport to waste disposal	Good – government source
Carbon footprint of redistribution	220 kg CO2e / tonne	The Felix Project / Argon & Co	Organisational footprint for 2023 used – assumes representative of other UK redistribution organisations. Total scope 1/2/3 footprint used, with rationale that all activities related to food redistribution and would need to scale in line with increased volumes.	Good – based on activity data where possible

			Note: other studies have used only emissions directly related to redistribution here (transport, warehousing) which would result in a lower number	
Emissions from the production of additional electricity	0.20707 kg CO2e per kWh	Department for Energy Security and Net Zero conversion factors	Additional electricity will be needed to compensate for the reduced production of biomethane. The average emissions factor for the national grid will represent this additional energy production.	Good – government source
Emissions from the usage of additional artificial fertiliser	N: 2600 kg CO2e / tonne P: 1700 kg CO2e / tonne K: 600 kg CO2e / tonne	Carbon Chain	Nutrient content which would have been provided by digestate or compost would be supplied in entirety by artificial fertiliser. Assumed all categories have the same nutrient value. **Note: This is considered most accurate as it reflects lifecycle emissions, but does extend beyond the direct environmental impact, and may result in a comparatively lower environmental benefit of redistribution that other studies.**	Average – best available public data
Emissions for each disposal stage	AD: 0.457 tCO2e / t dry matter (DM) Compost: 0.392 tCO2e / t DM	Carbon Trust	Assumes dry AD is most common form of anaerobic digestion used	Good – published data
Animal feed not in scope of calculation	N/A	N/A	Environmental impact of animal feed scenario not included in environmental calculation as not considered 'additional' – In the case of AD and compost, additional emissions are being caused through disposal. For animal feed, the assumption is that the animal would have been fed either way, whether from farm surplus or another source) and therefore there is no additional environmental impact.	N/A

Figure 7.2.4.1.– overview of data, sources and assumptions with quality assessment for environmental modelling

To calculate embedded emissions for each category, we selected a representative crop based on the largest volume within that category. For example, carrots were chosen for the root vegetables category because they have the largest volume. You can find a complete list of emissions factors in figure 7.2.4.2.

Category	**Representative crop**	**Embedded emissions to farm gate (kg CO2e / tonne)**
Root vegetables	Carrots	160
Legumes	Peas	410
Cruciferous vegetables	Cabbage	280
Leafy greens	Lettuce	170
Tubers	Potatoes	180
Fungi	Mushrooms	270
Nightshades	Tomatoes	290
Top fruit	Apples	150
Soft fruit	Strawberries	1041

Figure 7.2.4.2.– Embedded emissions factors for each category – Source: WRAP

7.3. About Argon & Co

Argon & Co is a global management consultancy specialising in sustainability, operations strategy and transformation. The company works across various industries, including food and drink, to implement solutions that enhance both operational efficiency and environmental sustainability. By combining industry knowledge with advanced methodologies, Argon & Co delivers tailored solutions that address the specific needs of its clients. We bring a combination of deep technical expertise, operational experience and broad business knowledge to deliver lasting results. We stay the course, so our clients see real change.

7.4. References

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