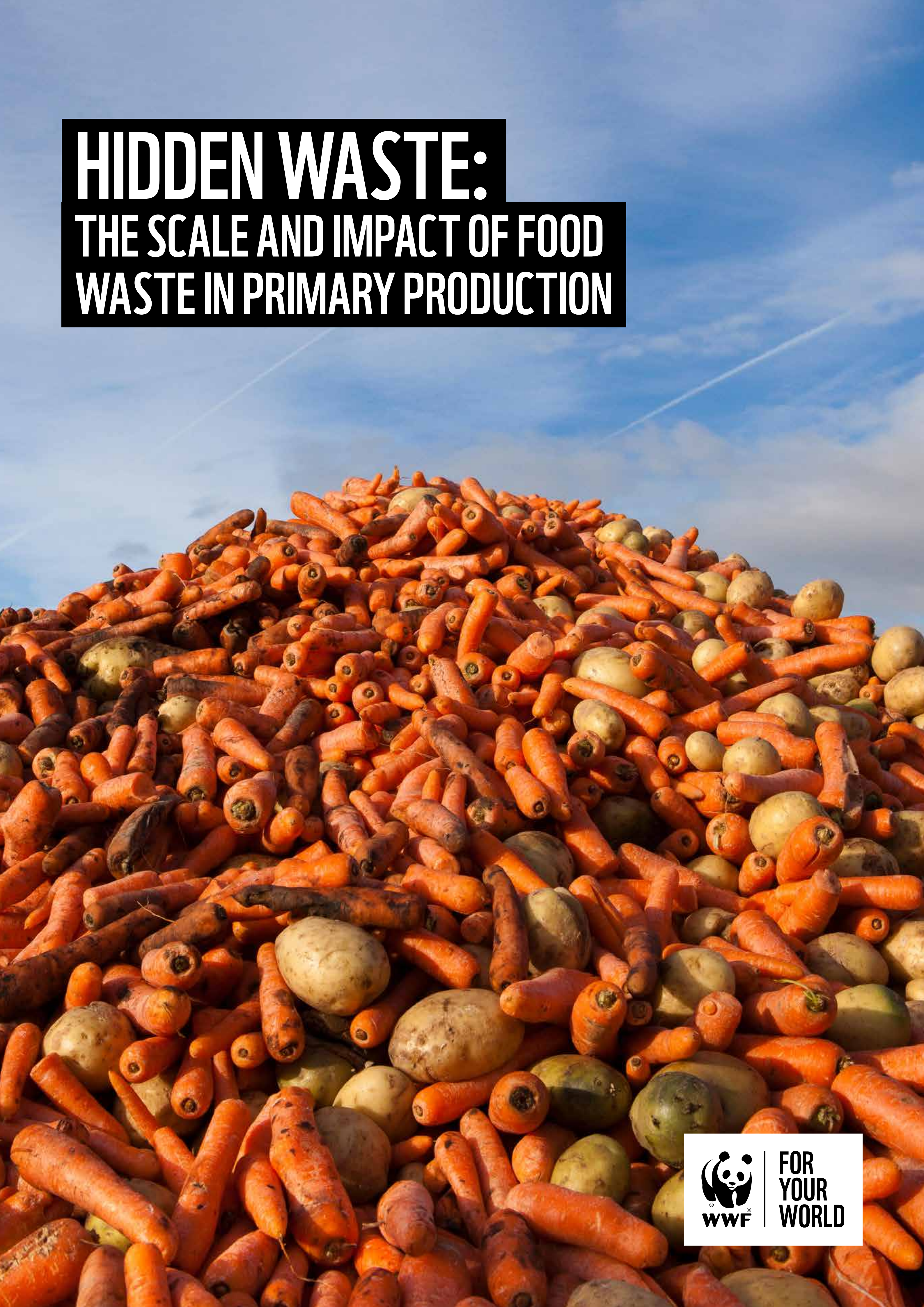
HIDDEN WASTE:
THE SCALE AND IMPACT OF FOOD WASTE IN PRIMARY PRODUCTION



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WWF-UK (2022) Hidden Waste: The scale and impact of food waste in UK primary production

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1. EXECUTIVE SUMMARY

In the UK food loss and waste (FLW) is reported as 9.5million tonnes with 70% occurring in citizen homes. However, this figure excludes food loss and waste occurring on UK farms and therefore masks the true extent of food waste in the UK and its catastrophic environmental impacts. This study finds that in UK primary production alone an estimated 3.3 million tonnes of food is lost and wasted on farms in the UK each year. This suggests food loss and waste in the UK totals 12.8million tonnes and that farm stage represents over 25% of food loss and waste (FLW) in UK, more than that occurring in manufacturing, retail and the hospitality and food sectors combined. This has a huge environmental impact, with FLW in UK primary production contributing 6million tonnes of CO2eq., equivalent to approximately 10% of UK agricultural emissions and requiring an area of land half the size of Wales.

Previous research has demonstrated that much of the food loss occurring on farms is beyond the control of the farmers, driven by poor system practices and policies. 48% of the food loss which occurs is pre-harvest, i.e. food left on fields, driven by decisions made post farmgate (e.g. standards and specifications) and an inflexible, broken food system. As such, farmers require support and system changes in order to support them in reducing loss rates and their impacts. This study finds that food lost on farms carries a value of £1.8billion, value which could potentially be handed back to farmers and which previously studies suggest can lead to an average increase in profitability on farms of 20%. Farmers stand to see significant benefits from food loss reduction but a key step in this measuring the loss occurring in order to better understand the drivers and ensure policy and practice changes which help reduce their impact on loss rates. This study also finds that 2.9 million tonnes, or 6.9 billion meals', worth of edible food is wasted on UK farms each year. Given the current cost-of-living crisis and a growing number of people in the UK facing food insecurity and poverty, this can no longer be ignored. Despite the potential of this wasted food to help combat food insecurity, and the role of such waste in driving environmental degradation, food waste on farms is not referenced in the UK's Government Food Strategy, Nationally Determined Contributions, Net Zero strategy, or the plans for mandatory food waste reporting.

This report's sister, *Hidden Waste: The roadmap to tracking and reducing food surplus and waste on UK farms*, (WWF-UK, 2022a) lays out step-by-step actions that must be taken by actors within the UK food system to support farmers in beginning to measure, report and reduce waste. The Hidden Waste Roadmap complements Courtauld 2030, the IGD-WRAP *Food Waste Reduction Roadmap*, and the Champions 12.3 *10×20×30* initiative by providing guidance for food system actors to engage with this area of food waste and support farmers in taking positive actions towards reducing this waste. In addition, action and commitment from UK governments and businesses is essential to ensure that farm stage food waste is brought into food security, climate, sustainable agriculture and food waste agendas and no longer remains hidden.

25%

of food waste in the UK occurs on farms: more than retail, manufacturing and HaFS combined

3.3 million tonnes

of food is wasted on UK farms each year.
2.9 million tonnes of this is edible, the equivalent of
6.9 billion meals

6MT CO_2e

comes from food wasted on UK farms which is approximately 10% of agricultural emissions

9,600 km^2

of land is used each year to produce food that never makes it off the farm. This is an area of land almost
half size of Wales

£1.8 billion

worth of food is wasted on-farms: whilst this isn't all avoidable reducing this has the potential to increase farm profitability by 20%

2. GLOSSARY

'Food Loss' and 'Food Waste': The term 'food loss' is used by some to represent the proportion of food that ends up being removed from the food supply chain. It is often differentiated from 'food waste' on the basis of the stage in the supply chain where the food is lost (e.g. on-farm) or the reasons why the food is lost (e.g. due to unplanned or uncontrollable events such as disease or weather). Determining the difference between what may be defined as food loss versus food waste consistently can be difficult. The term 'food waste' as defined in this document is intended to cover all stages of the supply chain.

As established in WRAP & IGD's Food Waste Reduction Roadmap (2020), for the purposes of UK guidance, the term 'Food Waste' describes any food and inedible parts sent to any of the Food Waste Destinations listed below.

- Anaerobic digestion
- Composting
- Controlled combustion
- Incineration
- Land application post-harvest
- Landfill
- Not harvested/ploughed in
- Discarded (fish) + unmanaged disposal
- Sewer

Food waste on farm: The focus of this work is on farm-stage food waste. We are defining 'food waste at farm stage' to apply to any outputs from primary food production that are, or were at some point, intended for human consumption, but which end up either not being harvested (and subsequently ploughed in) or sent to one of the eight other food waste destinations listed above. This starts by defining the point at which the food chain begins, when the outputs from primary production can be regarded as 'food'. For crops and produce this is defined in terms of crop maturity and being 'mature and ready for harvest'. For livestock, the same definitional principle is applied, i.e. loss of livestock is classed as 'food waste' when the animal has reached maturity, slaughter weight or when wild caught animals/fish are harvested.

In field food waste: This is waste which occurs once crops or animals have reached a mature or harvestable state (NB: harvestable could mean a variety of states as food is often harvested pre-ripening to allow for a greater lifespan in the supply chain). Typical examples of FLW in field is food that goes unharvested due to surplus with no secondary market, lack of affordable labour to harvest, not meeting specifications due to aesthetics, size or weather, pest or disease damage, or last-minute order cancellation. In the case of animal agriculture, 'in-field' waste refers to animals lost once they have reached maturity or harvest weight due to issues including equipment failures, accidents, disease or injury.

Post-harvest food waste: This is food that is lost post-harvest but pre-farm gate; for example, due to damage or becoming over-ripe in transport, on-farm packaging houses or in storage. Similarly with animal agriculture, food waste occurs when animals are injured during handling, transport or rejected from the slaughterhouse.

Inedible: These are components associated with a food that were never intended to be consumed by humans – such as shells or pits/stones. 'Inedible parts' do not include food that could once have been eaten but has been spoiled. To enable some consistency for UK businesses, industry stakeholders have agreed specific definitions of 'inedible parts' for relevant products. These are available in the following sector guidelines: Meat Processing Sector Guidance; and Fresh Produce Sector Guidance.

FOOD SURPLUS AND WASTE IN PRIMARY PRODUCTION

NOT INCLUDED

- Inefficiencies in production (e.g. plants which never germinated or seeded)
- Livestock that are lost before reaching a mature weigh
- Crops that are lost before they are ready to harvest
- Produce not intended for human consumption (e.g. intended for use as feed or in bio-material processing)

CAUSES OF IN-FIELD WASTE EXAMPLES

- Animals of a mature weight which die due to disease or injury
- Milk which is spilt during milking
- Eggs which don't meet specifications or are damaged

CAUSES OF POST-HARVEST WASTE EXAMPLES

- Animals which are rejected from the slaughterhouse or dead on arrival
- Milk which is rejected due to antibiotic contamination
- Eggs which are broken in storage

Meat and Animal Products

Livestock only counted as food waste once animals have reached a mature weight

CAUSES OF IN-FIELD WASTE EXAMPLES

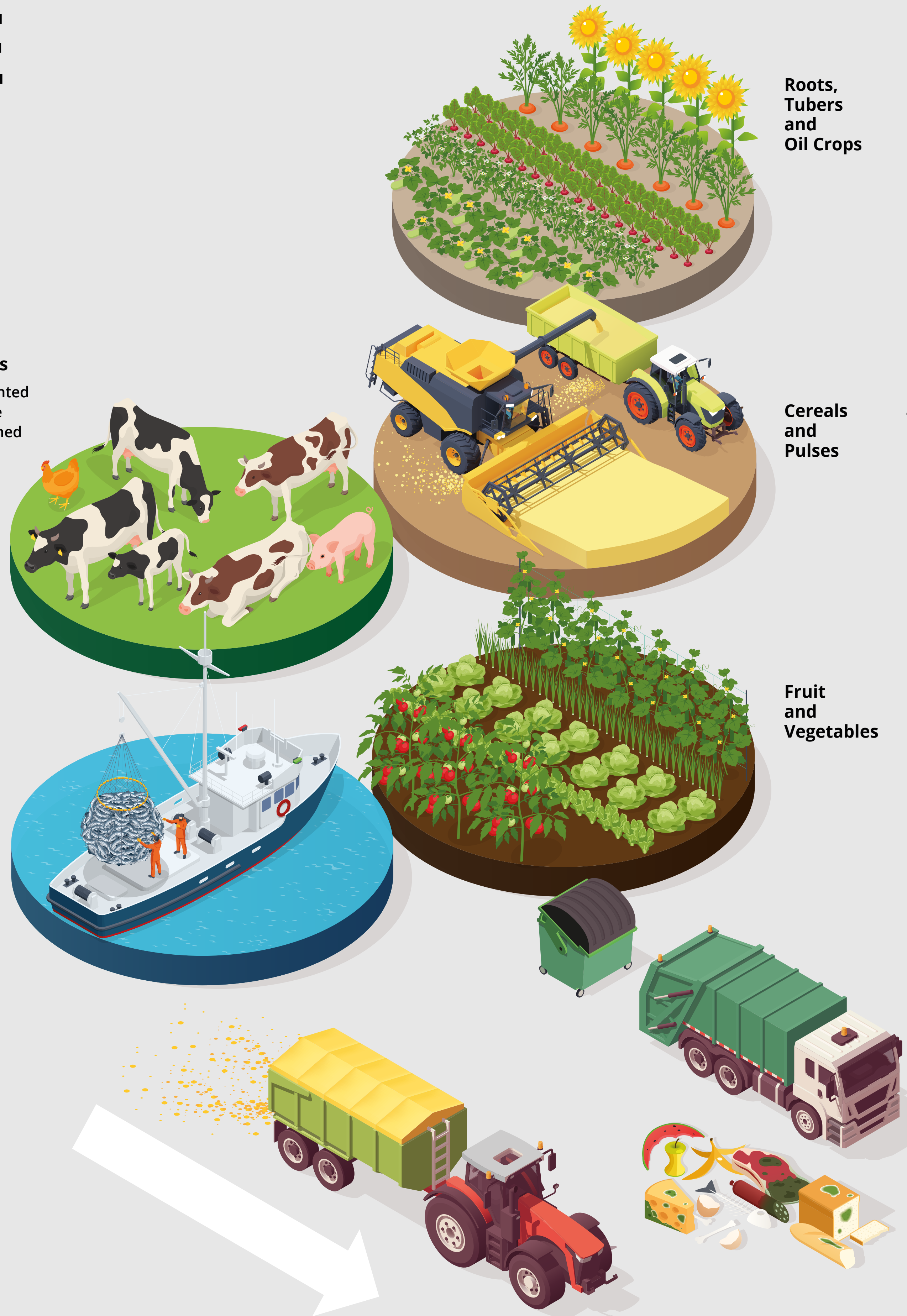
- Non-target species/non-quota species caught
- Fish caught incorrect size
- Damage during removal from nets
- Disease (aquaculture)

CAUSES OF POST-HARVEST WASTE EXAMPLES

- Delays in sales/price negotiations causing product spoilage
- Fish falling from containers during handling/transport

Fisheries and Aquaculture

Counted as food waste once caught or have reached intended weight/ harvest weight *(aquaculture)*



Roots, Tubers and Oil Crops

Cereals and Pulses

Fruit and Vegetables

Only counted as food waste once crops have reached a harvestable state

(NB: harvestable could mean a variety of states, as food is often harvested pre-ripening to allow a greater lifespan in the supply chain).

CAUSES OF IN-FIELD WASTE EXAMPLES

- Goes unharvested due to lack of market
- Left in field due to lack of affordable labour for hand harvesting
- Out-graded for not meeting specifications due to aesthetics, size criteria or weather
- Outgraded for not meeting (non-safety related) specifications due to aesthetics, size or weather
- Harvester settings, malfunctions and errors causes damage or waste

CAUSES OF POST-HARVEST WASTE EXAMPLES

- Damaged during transport
- Becoming over-ripe or spoiling on-farm packaging houses or in storage
- Last-minute order cancellation or changes to order
- Out-graded in packhouse

This food is then determined as either Surplus or Waste depending on its destination

FOOD SURPLUS

Food is counted as surplus when it is sent to one of the following destinations:

- Re-distibuted for human consumption
- Animal feed
- Biobased materials and biochemicals processing

FOOD WASTE

Food is counted as waste when it is sent to one of the following destinations/treatments:

- Composting
- Ploughed-in/ not harvested
- Anaerobic digestion
- Landfill
- Incineration
- Discarded (fish) + unmanaged disposal
- Sewer
- Land application post-harvest

Figure 1 – Definitions and examples of food waste on farm

Examples are given for illustration purposes and not intended as an exhaustive list

3. INTRODUCTION

In the UK food loss and waste (FLW) volumes are reported to be 9.5million tonnes with a 15% reduction in UK food waste achieved between 2007-2018. However, these figures exclude farm stage food loss and waste and the huge environmental and societal impacts it carries. Despite the 2021 study *Drive to Waste* (DTW) findings which estimate that 15% of food produced never makes it passed the farm gate and the huge environmental impact this carries, food loss and waste on farms continues to be omitted from official estimates, discussions and planning in FLW.

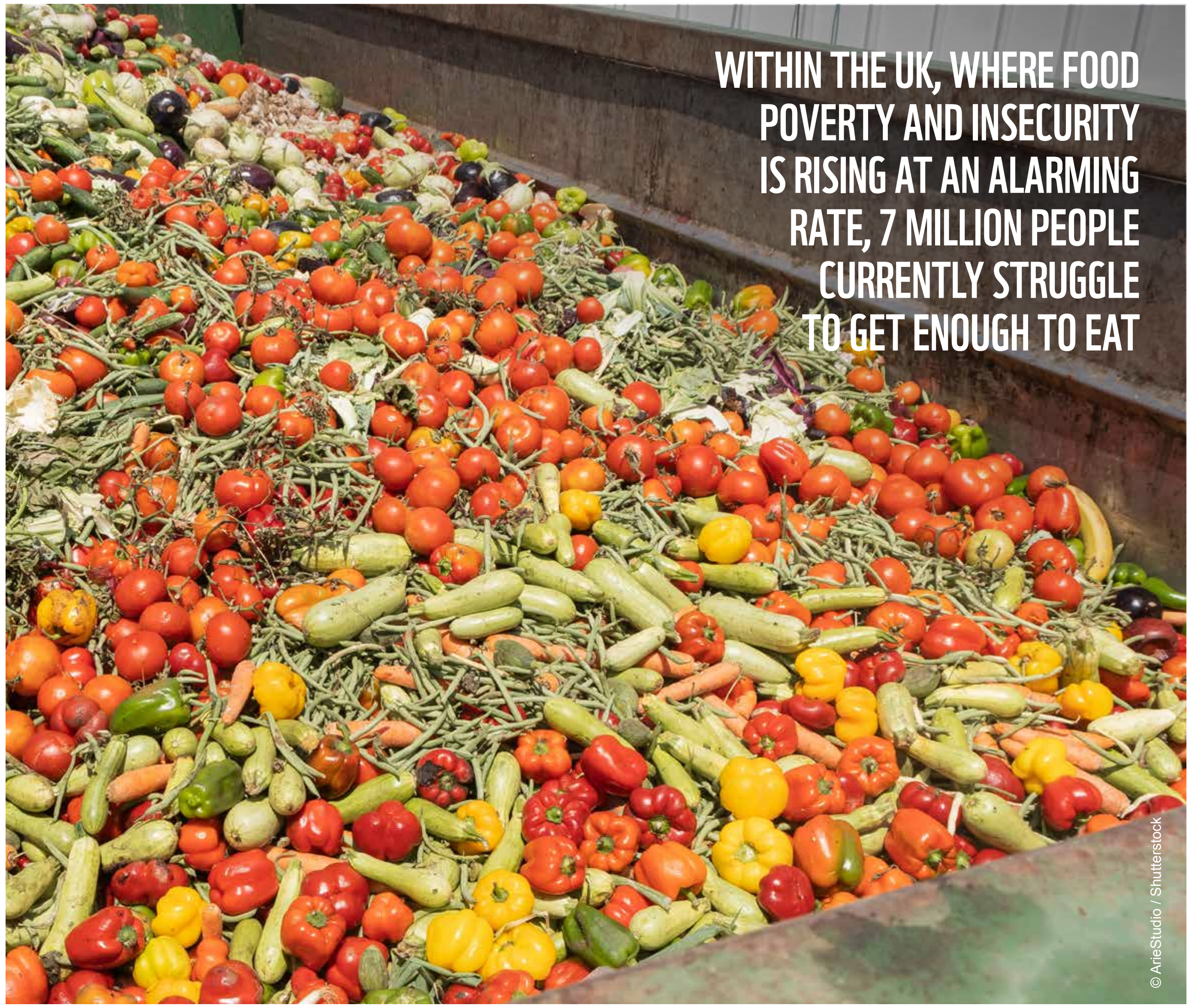
Within the UK, where food poverty and insecurity is rising at an alarming rate, 7 million people currently struggle to get enough to eat, 2 million of which are children. We are increasingly aware of the fragility of our food system and the need to increase its resilience, and yet simultaneously millions of tonnes of edible food are left on fields to rot. Research has suggested that reducing post-harvest waste by 50% in supply chains of high-income countries alone could decrease the number of undernourished people in low-income countries by up to 63 million, as well as contributing to reductions in harvested area, GHG emissions and water consumption associated with food production. It is clear that reducing food loss and waste will play a significant role in improving global and potentially domestic, food security.

The lack of established baseline for farm stage food loss is often given as a reason for the focus on post farm gate food waste reduction in the UK, with the lack of measurement and baseline preventing the setting and tracking of progress towards reduction targets. Uptake of on farm measurement is extremely low, preventing access to the data needed for this, but also, preventing farmers from fully appreciating the scale and impact of food loss to their individual businesses. Previous research has shown that when estimating food loss without measurement, farmers typically undervalue the level of food loss occurring. Furthermore, WRAP's work has illustrated that when farmers begin to engage with measurement, there are better able to identify and target the causes of food loss, reducing it and achieving an average 20% increase in profitability. Measurement of food loss and waste on farms is an imperative on many levels: to achieving a basic understanding of national FLW levels, to bring improvements to agricultural sustainability and resilience and to support farm incomes, without increasing food production unnecessarily.

The focus on post-farmgate FLW dictates policy and business action and, as a result, activity has focused almost entirely on the larger retail market and citizen food waste reduction. This is illustrated by the National Food Strategy and Government response which fail to reference farm stage food losses. Following this, DEFRA's recently released consultation on mandatory FLW measurement misses a valuable opportunity to gather the data needed to establish a UK baseline for farm stage food loss. Another missed opportunity here is the collection of data on the key drivers of loss on farms, which could enable the establishment of action and policy to support reductions of losses.

WWF-UK's *Driven to Waste* report highlighted the role of market conditions, governance, fair trade and other post-farmgate factors in driving food loss levels and diminishing farmers' ability to reduce it. Efforts to reduce food loss are significantly less likely to have lasting and meaningful impacts on food waste levels without simultaneous adjustments to underlying factors further along the food supply chain. For instance, farmers' ability to afford training or on-farm technologies to reduce waste is limited by the asymmetric power balance in the food supply chain, which leaves farmers unable to negotiate fair prices and subject to last minute cancellations which may mean farmers cannot afford to harvest surplus food. These wider influences involve actors and agencies beyond the farm gate which farmers and farm-stage interventions have little influence over, and yet impact the levels of food loss on farm significantly. As such, work to measure, report and reduce food loss on farm must be a collaborative effort. Support for farmers must be provided from across the food system and a willingness from the actors to engage with the issue and alter practices and policy in order to achieve reductions is imperative. Within WWF-UK's *Hidden Waste: the Roadmap to tracking and reducing food loss and waste on UK farms,* a series of barriers to farm stage FLW measurement are uncovered, a set of actions for supply chain members set out in order to increase the number of farmers measuring and reporting FLW.

This report sets out the scale and impact of the problem, exploring the levels of food loss occurring on farms both directly within the UK and on international farms we import from. This makes apparent the necessity of supporting farmers in measuring and reducing food loss on farm and the role these actions could play in reducing food poverty and improving farm incomes. It also examines the environmental impacts of these losses, highlighting the significant role reducing food loss on farms can play in reaching environmental targets such as reducing the carbon footprint of the UK's food system. If in the UK increasing sustainable agriculture, reducing food insecurity, reaching net zero and achieving a circular food economy are our targets, we can no longer afford to ignore farm stage food loss.



4. METHODOLOGY

The method used to estimate the scale of food waste in UK primary production and the production of imported foods followed that used for the Driven to Waste study. The best selection of relevant food waste factors were collated for crops, livestock and fisheries and for UK food production and imports, before combining the collated data to compute total estimates. The results were then compared with previous estimates and the reasons for difference and data uncertainties were explored.

Data on food waste compiled for WWF-UK's *Driven to Waste* study were designed to report at the level of global regions for each commodity group. In total, 75 datasets were available within the European region (an area extending from Western Europe eastwards to include Russia, Belarus and Ukraine). Eighty-five percent of the data related to three commodity groups, of which 'fruit and vegetables' was the most studied category. Although UK data were available across all food categories, the best approach to producing UK estimates was the use of waste factors specific to particular crops from the pool of European sources. Failing that, factors for specific crops not represented in the European data were sourced from comparable systems and growing regions elsewhere. Food waste studies were accepted for analysis if they distinguished between in-field waste and that relating to post-harvest stages. The inclusion of this parameter highlighted the fact that studies which did not differentiate between waste rates in-field and post-harvest, tended to produce lower total estimates than those which explicitly measured both components individually.

For all food items in this report, total quantities of food waste were based on the edible fraction of the crop (%) and the assumed proportion grown for use as food (%) that were consistent with those assumed for the DTW study. Food production statistics from FAOSTAT data were used for scaling-up food waste estimates for the UK, as was also the case for DTW. These related to 2020, whereas the DTW study compiled estimates from 2016 FAOSTAT production data. In order to include food waste at primary production associated with UK imports, relevant statistics were obtained from the Overseas Trade Data Table. Data were extracted for the following HMRC commodity groups for the latest reporting year (2019). Estimation of the financial value of food waste in primary production was based on output prices at farm gate (FAOSTAT Value of Agricultural Production, 2020 and Fisheries statistics 2019). Financial values of UK production were compiled from FAO data in £ Sterling, whilst values for imported foods were converted from US Dollars using the current exchange rate (July 2022).

The import data were matched to the FAO Global Regions as specified in the DTW technical report, allowing for consistency in linking with the library of food waste factors and FAO 2019 Commodity Groups. For example, where the HMRC reported an item as 'Meat, cattle', this was mapped to the FAO 2019 classification of 'Meat and Animal Products'. Import data were integrated with relevant food waste factors to determine average waste rates that could be inputted into the environmental impacts model. For all European imports (FAO region 1), the updated waste data used in the UK modelling were applied to calculate waste in primary production from those countries. For all other regions, the average waste factors compiled by DTW were applied. Once the updated commodity waste was mapped to the list of countries, the import data were applied and production waste associated with imports were calculated.

For each of 40 food commodities, the lifecycle impacts up to the farm gate (including production of capital goods and seed) have been included, based on the complete set of life cycle analyses taken from a meta-analysis study by Poore and Nemecek (2018). The same model was used in the DTW report to estimate global food waste impacts, with their impact model based on 38,700 farms and 1,600 processors, packaging types, and retailers in order to assess the environmental impacts of diverse producers over the world. The model covers 40 products that represent approximately 90% of global protein and calorie consumption. The model converts material weights across stages, with all impacts in the original model expressed as retail stage product weights ('retail state', e.g. bread), with the ability to relate these back to processing (e.g. flour) and primary commodity weights (e.g. wheat) originating at the primary production stage. In the case of wild caught fish not included in the Poore and Nemecek model, only the greenhouse gas emissions from fishing vessels were included, using other sources (Parker et al., 2018). This was necessary due to the lack of suitable Lifecycle Assessment data covering other impacts.

The results of these methods are presented within this report in two stages: the first examines food waste volume and impact within UK primary production alone. The second combines these figures with the waste volumes and impacts of production abroad for import to the UK in order to provide an illustration of the role food waste on farms plays in the UKs total food footprint.

5. THE SCALE AND IMPACTS OF HIDDEN WASTE IN UK FARMING

This section will review the findings of the research in relation to food waste in UK primary production, for details relating to UK production and imports combined please see the following section.

5.1 VOLUME AND VALUE

Estimated food waste in UK primary production amounts to 3.3 million tonnes (Mt), of which 2.9 Mt is edible food[1], representing between 6 and 7% of total production intended for human consumption. Of this waste, 1.6 Mt, including inedible, occurred in-field (48%) and 1.7 Mt occurred post-harvest but pre-farm gate (52%).

As illustrated in Figures 2 and 3, whilst tonnages of food waste in the later stages of the supply chain and citizen homes have not been altered, the addition of farm-stage food waste demonstrates the significant proportion of food waste in the UK currently being overlooked. Within the Governments response to the National Food Strategy, the focus remains predominantly on minimising consumer food waste by continuing to work with WRAP and implementing separate food waste collections nationally. The only action relating to the supply chain is the consultation on mandatory food waste measurement, which focuses solely on large businesses and excludes farm stage all together. Whilst work to reduce food waste in the supply chain and citizen homes remains important, efforts should target all stages of the supply chain, from farm to fork. Currently, farm stage food waste is largely excluded within discussions surrounding food waste, food insecurity and climate change despite being an integral part of all three agendas, as well as sustainable agriculture. The 2.9 million tonnes of edible food waste occurring at farm stage equates to approximately 6.9 billion meals[2], this is enough to feed 6.4 million people three meals a day each year and yet 7 million people in the UK live in food poverty or food insecurity (Fareshare, 2022).

The value of estimated waste within UK primary production was £1.8 billion, equivalent to 6.5% of the total value of food produced within the UK. UK farming generated a gross value of £9.4 billion in 2020, of which farmers received £4.1 billion as profit (Defra, 2021a), which suggests food waste drains 30% of profit from farming. Although not all waste occurring will be avoidable this finding contributes to the growing body of evidence which suggests targeting food waste reduction on-farm can improve farm profitability. WRAP's work illustrates that farmers can achieve increase in profitability averaging 20% by reducing on-farm food waste (WRAP, 2021b), but emphasises that measurement and reporting is the first step in reducing food waste.

It is important to note that these estimates differ from those previously reported, in particular WRAP's 2019 study, due to several key differences. The current study's estimates of 3.3 million tonnes of food waste occurring within UK production are significantly higher than WRAP's estimate of 1.6 million tonnes (WRAP, 2019). This is, in part, due to the difference in production volumes; where WRAP's 2019 study uses 2017 Defra agricultural statistics, the current study uses 2020 FAOSTAT in order to use up-to-date production statistics. Moreover, the approach used in this study adopted the food waste definition applied by each study that supplied data, even where the detail of the disposal route was lacking, whereas in similar cases WRAP applied higher-level assumptions to their estimates in differentiating food waste and food surplus for certain food categories. For instance, in studies reporting post-harvest waste from apples resulting from quality out-grades, where the destination was not specified, this is registered as waste in the current study, rather than as surplus as in WRAP's study. Additionally, WRAP's 2019 report included estimates for both food waste and food surplus, the combined estimate for which was 3.6 million tonnes. The 3.3million tonnes reported here excludes food reported in the study to have been sent to one of the destinations referred to as 'surplus' (see Figure 1). These assumptions account for the majority of differences between the two sets of estimates. Finally, WRAP's estimates do not include fish and seafood, where this study does.

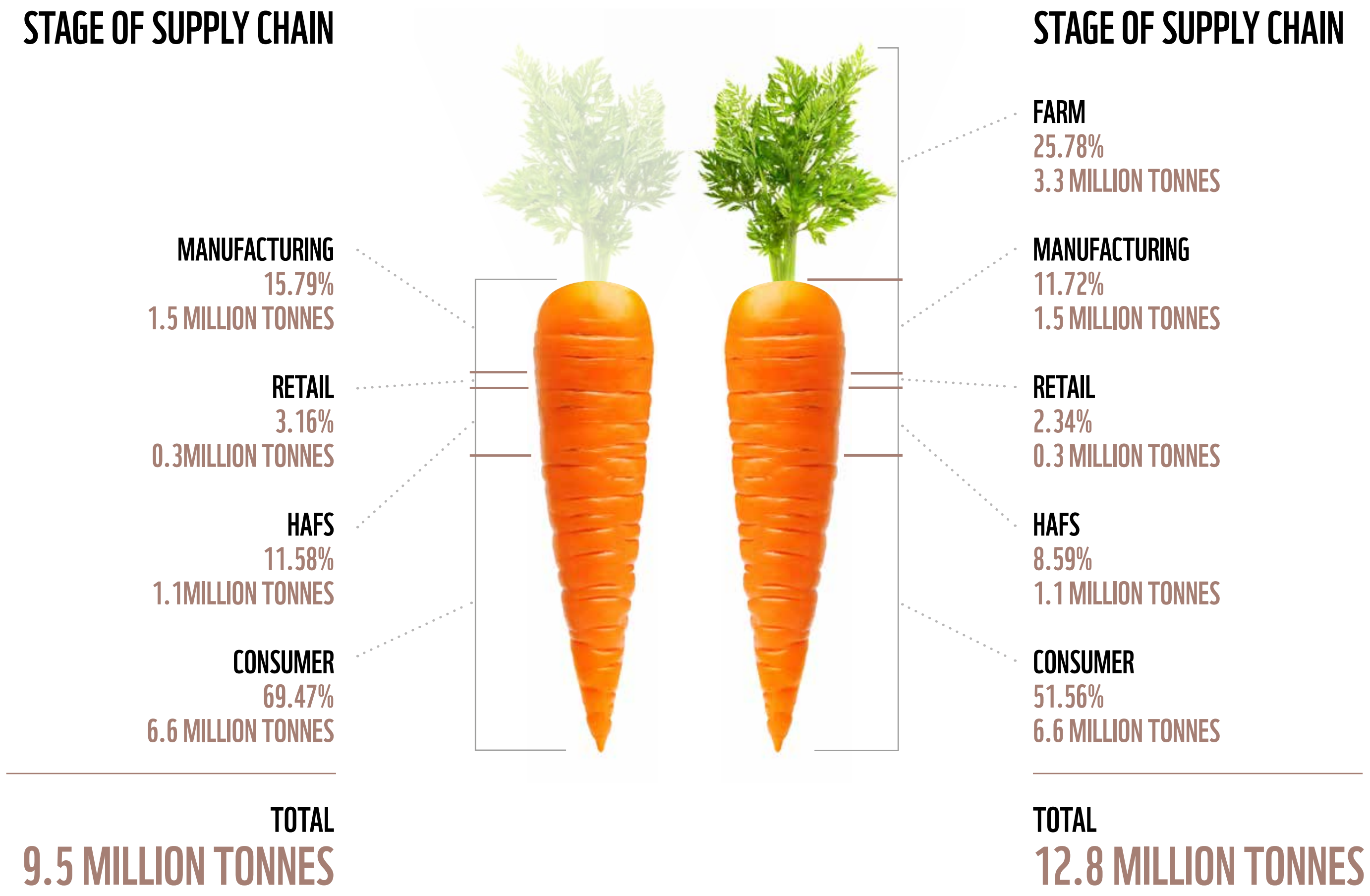


Figure 2 – Current view of food waste occurring in UK as demonstrated in the National Food Strategy (Data from WRAP, 2021a)

Figure 3 – UK food waste figures when farm stage is included (Data from WRAP, 2021a, combined with findings of current study)

1 Excluding 'inedible components'. See glossary for more details.

2 Based on WRAP's methodology using the average meal weight of 420 g. This estimate does not take into consideration nutritional balance of meals and is only meant to be indicative of what the volume of food wasted could equate to. WRAP (nd) Reporting on the amounts of food surplus redistributed.

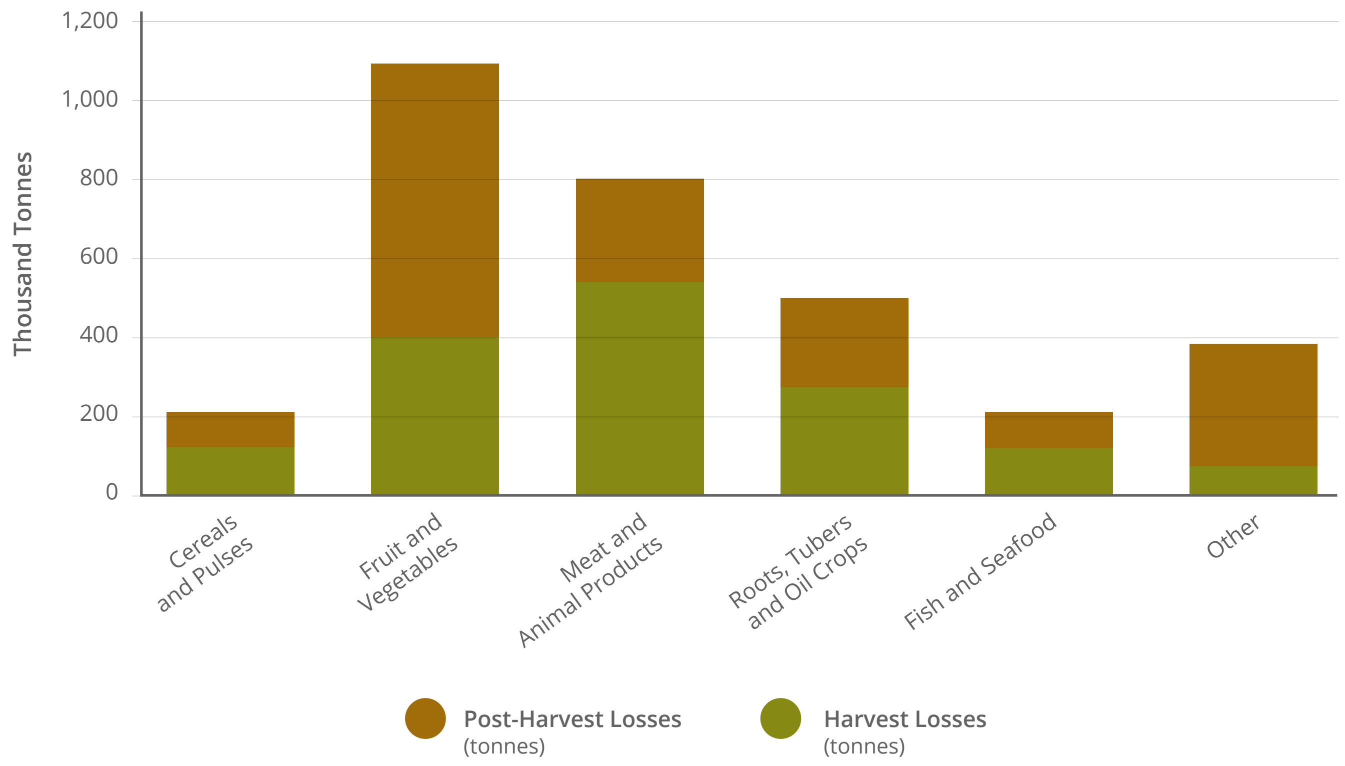


Figure 4 - UK primary production food waste by commodity group, (thousand tonnes)

As was the case with global estimates from the Driven to Waste report, primary production waste was almost evenly split between harvest (48%) and post-harvest (52%) stages (see Figure 4). An additional finding of this research was that studies reporting waste for the entire primary production stage, without differentiating in-field waste and post-harvest waste, tended to produce lower estimates than those explicitly measuring both components. Previous studies have shown that farmers tend to underestimate in-field waste rates; for example, WRAP's research showed lettuce waste rates at 33% using field samples, but were previously estimated to be 17% when farmers self-reported (WRAP, 2017). Consequently, farmers may perceive in-field waste to be insignificant in tonnage and value, and therefore see no value to conducting field measurement (Johnson et al., 2019; WRAP, 2017).This highlights not only this importance of farm stage measurement, but also of measuring both in-field and post-harvest waste in order to ensure farmers are given every opportunity to identify the causes of food waste, reduce such waste, and market edible foods where possible.

As key drivers of food waste on-farm stem from beyond farm gate, reducing them will require policy and practice changes from Government and the members of the supply chain. For example, a recent NFU survey suggested that 40% of UK farms are experiencing crop waste due to labour shortages (NFU, 2022) which are suggested to be driven largely by Brexit and the COVID-19 pandemic (House of Commons, 2022). Farms are, on average, 14% short of the required labour, which has resulted in an estimated £60 million worth of food waste from fruit and vegetables alone (NFU, 2022). The extent to which specific supply chain issues drive waste rates is unclear due to a lack of data.

In instances such as these, utilising field sampling to obtain accurate estimates of in-field waste and reporting its volume and causes provides valuable information to clarify any key drivers and to enable food system actors to develop targeted and effective action to reduce this waste.

5.2 GREENHOUSE GAS EMISSIONS

The overall carbon footprint of farm-stage food waste in UK primary production amounts to 6 MtCO2e, a substantial increase from the 4.1 MtCO2e reported in 2019 (WRAP, 2021c). WRAP's 2019 estimates of the UK's food system footprint attributes 55.6 MtCO2e to UK agriculture, with food waste contributing 4.1 MtCO2e in primary production. When updated to 6 MtCO2e, agricultural emissions increase to 57.5 MtCO2e, suggesting farm stage food waste is responsible for an estimated 10% of the UK agricultural emissions (GOV, 2021a).

Of the 3.3 million tonnes of waste, fruit and vegetable waste contributed over a third of the tonnage (1.1 million tonnes), but only 7% of Greenhouse gas (GHG) emissions. Comparatively, meat and animal products totalled 803,000 tonnes but contributed 78% of the GHG emissions of farm-stage food waste. A significant proportion of these emissions were from waste in beef production (accounting for 38% of UK food waste emissions), followed by milk (13%), and poultry production (11%). As reflected in Table 1, the higher production volume of meat and animal products within the UK, coupled with the larger impact of animal agricultural results in a greater proportion of GHG emissions being carried by meat and animal products, despite a relatively lower waste rate (4% of production).

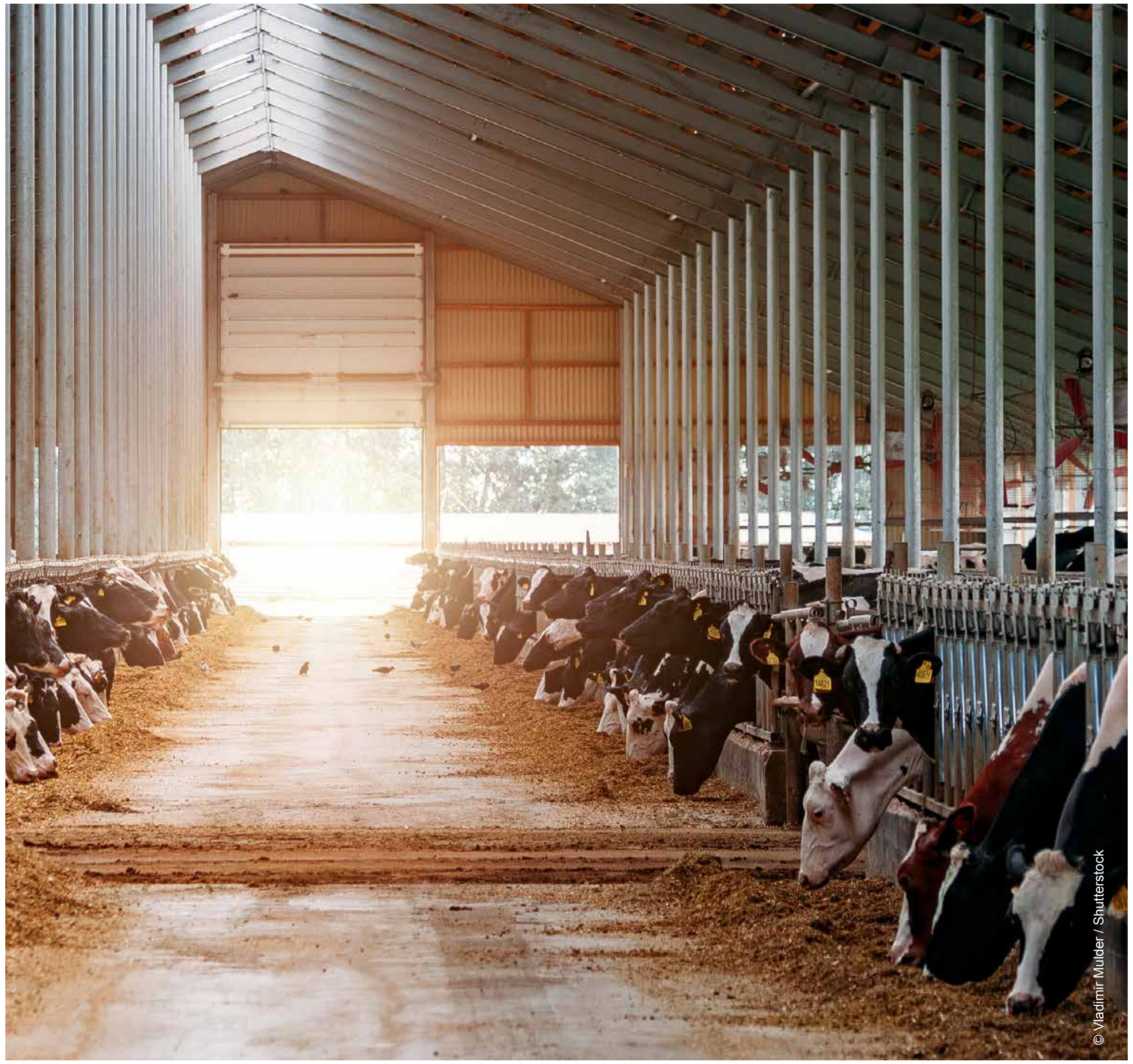
This suggests that if food waste reduction efforts focused on this more impactful area may achieve a greater amount of GHG reduction with a smaller reduction in waste tonnage and identifies this as a priority area in work seeking to reduce the carbon footprint of UK agriculture.

Table 1 – GHG contribution of UK farm stage waste by commodity type against total production volume, tonnage wasted and wasted percentage

Commodity	UK Production Volume (thousand tonnes)	In-field waste (thousand tonnes)	Post-harvest waste (thousand tonnes)	Total losses (thousand tonnes)	Waste as a % of production	GHG emissions (% of total UK farm FLW GHGS)
Meat and animal products	20,514	560	243	803	4%	78%
Fish and seafood	737	120	105	225	31%	7%
Fruit and vegetables	3,264	395	703	1,098	34%	7%
Roots, tubers and oil crops	6,451	268	258	526	8%	5%
Cereals and pulses	8,073	127	109	236	3%	2%
Other	5,989	88	299	387	6%	2%

Driven to Waste highlighted the role current animal agriculture standards and practices play in waste rates (WWF-UK, 2021). In 2020, the UK produced 61 kg of meat, 227 litres of milk and 172 eggs per person (GOV, 2021b), this level of consumption relies on in rapid farming techniques which drive up food waste. A case study within Driven to Waste suggests that the rate at which meat is being produced and the animal agricultural practices required to meet this demand impact loss of livestock (included in food wase measurements if the animal is of a mature weight), as a result of health issues or injury linked to welfare standards (WWF-UK, 2021). Improved standards in relation to the number of livestock reared in small areas and improved transportation methods are suggested to have potential in reducing the volume of farm-stage waste experienced; however, a reduction in meat and dairy consumption alongside this could support these goals further.

Also important to note in regards to GHG emissions is that an additional driver of food waste is extreme weather events, which can damage food beyond use and result in higher waste rates in animal agriculture. Here, we face a downward spiral where over-production and food waste contribute to climate change through increased GHG emissions, which in turn risks increasing food wasted due to extreme weather events and subsequently threatens food security.



5.3 LAND USE

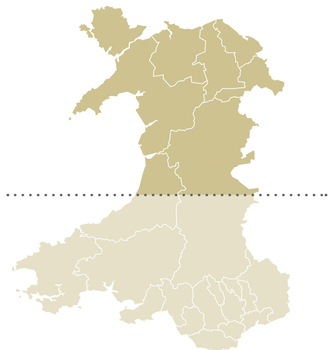
In the UK where 71% of land is used for agriculture (Defra, 2021b) it is imperative that we not increase our land footprint further in order to increase food security, instead aiming to ensure efficiency in our food system by reducing the amount of land used to produce food which is subsequently wasted. The Government Food Security report states **"Global agricultural production can not only be increased by improved yields, but also by converting more land to farmland"** *(GOV, 2021c)*, however this overlooks the significant role of reducing food waste in improving food availability and food security in a growing population. This is crucial in order to prevent further expansion into nature to improve food security.

The overall land use associated with food wasted on UK farms amounts to 9,600 km2 per year [3], the equivalent of almost half the land in Wales. Of this waste, 80% came from Meat and Animal Products, 8% came from Roots, Tubers and Oil Crops, 8% came from Fruit and Vegetables, and 4% came from Cereals and Pulses.

The inefficiency surrounding animal agriculture is a significant contributor to this figure, due to the area of land used to grow feed, which is fed to animals that are subsequently lost at farm stage. In the UK, 40% of arable land is used to grow food that is fed to animals instead of humans with 19,700,000 tonnes of crop grown for animal feed in the UK *(WWF-UK, 2022b)*. Of this, feed grown for livestock that are subsequently lost on farm is also wasted.

Recent estimates suggest that 64 million chickens are culled or die ahead of slaughter each year in the UK *(The Guardian, 2022)*. Case study research in Driven to Waste suggests that waste rates in poultry are impacted by health issues and injury related to the selection of fast-growing breeds and overstocking *(WWF-UK, 2021)*. As highlighted above, improving animal agricultural standards and practices in order to reduce waste could contribute greatly to reducing the number of livestock reared, and the environmental burden they carry, to produce the same end amount of meat.

WWF's Future of Feed also highlights the potential role in reducing the land used to grow crops for feed by better utilising food waste from across the food system (WWF-UK, 2022b). Whilst the data quality available to this study doesn't allow for estimates of tonnage, an additional volume of food meant for human consumption is directed away from the human food supply chain due to changeable issues such as last-minute order cancellations, arbitrary standards and a lack of access to secondary markets for surplus. Utilising unavoidable waste in animal feed can play a role in reducing the environmental impact of food waste by avoiding its disposal in other, more harmful, methods, such as landfill. However, as laid out in the food waste hierarchy, this should be deprioritised in favour of, first, reducing systemic issues which drive overproduction, surplus and waste and, second, redistribution of edible food to humans. Beyond this, only waste that is unavoidable or inedible to humans should be diverted to animal feed. Even then, there is a balance to be struck between reducing our consumption of meat and animal products in order to slow demand in the first place and using such waste in a circular economy to minimise the impacts of animal agriculture in addition.



THE OVERALL LAND USED TO PRODUCE FOOD WASTED ON UK FARMS AMOUNTS TO 9,600 KM^2 PER YEAR, THE EQUIVALENT OF ALMOST HALF THE LAND IN WALES

3 Land use includes the land used during the occupation time from seed, on- and off-farm arable and permanent crops, fallow land, temporary as well as permanent pasture. Following the same approach as for other impacts, land use associated with food waste is the total land area that would be used to produce an amount of food equivalent to waste.

5.4 WASTE WATER

Globally, agriculture is responsible for 70% of freshwater withdrawals (FAO, 2017). The Environment Agency (2020) has warned that without action to improve water usage between 2025 and 2050 an additional 3,400 million extra litres of water could be required each day. This report focuses on freshwater withdrawals (billion litre eq.) that include water abstracted for irrigation of agricultural land, irrigation withdrawals embedded in feed, drinking water for livestock, water abstracted for aquaculture ponds as well as processing water used on-farm. Activities such as these alter water availability and flows, which can reduce space for wildlife to live, feed and reproduce, affect migration and life-stage cues and, as water levels are reduced, pollutants entering the water environment also become more concentrated. The result of which is that water bodies cannot provide a healthy environment for fish, insects and plants, reducing biodiversity. In order to prevent this, limits must be observed with regards to water abstraction in agriculture, ensuring the withdrawals in local catchments do not approach or exceed levels that begin to negatively impact nature (Linstead, 2018).

The overall freshwater withdrawal associate with UK farm stage food waste amounts to 732 billion litre eq., which is the equivalent of 292,800 Olympic sized swimming pools. Of this withdrawal, 62% came from Meat and Animal Products (largely from embedded feed and drinking water), 23% came from Roots, Tubers, and Oil Crops, 7% came from Fruit and Vegetables, 4% came from Cereals and Pulses, and 3% came from Fish and Seafood. In 2015 the Environmental Agency (2015) reported that many abstractors exceed available supplies in their catchment areas. In areas where abstraction amounts are leading to environmental flow requirements not being met, improved farming efficiency, such as reducing food waste, could be a significant way of bringing down water withdrawal levels without significant effects on farm income.

5.5 EUTROPHICATION AND ACIDIFICATION

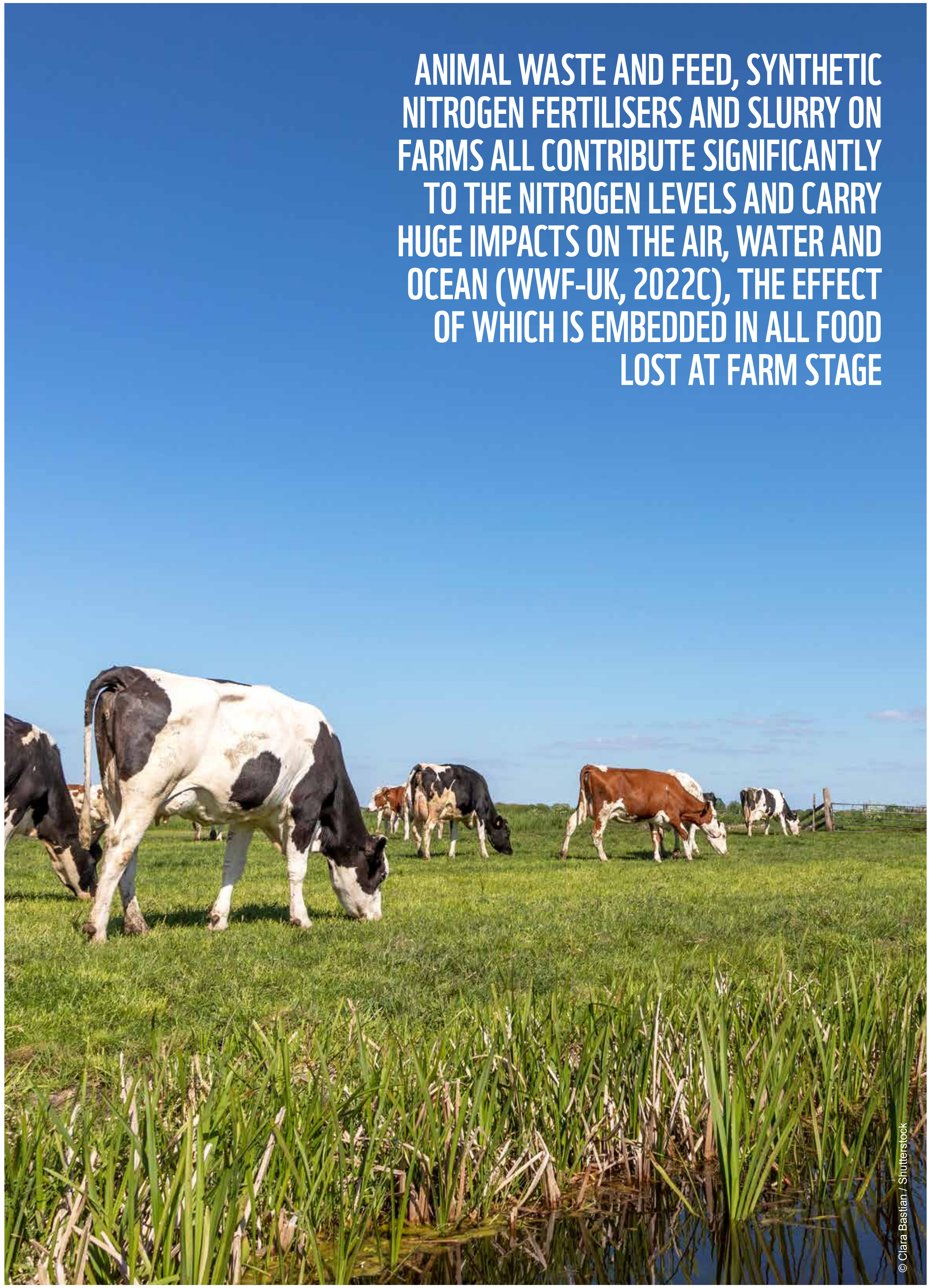
Animal waste and feed, synthetic nitrogen fertilisers and slurry on farms all contribute significantly to the nitrogen levels and carry huge impacts on the air, water and ocean (WWF-UK, 2022c), the effect of which is embedded in all food lost at farm stage. The impacts of agricultural practices on water pollution, a significant problem in the UK, is further exacerbated by releases of phosphorus. Under the Water Framework Directive, only 36% of UK water bodies were reported in 2019 as having achieved a high or good status. Over half of rivers fail to meet standards for phosphorus, making it the most significant pollutant in terms of UK water bodies failing to achieve good ecological status. Both phosphorus and nitrogen cause eutrophication, which is the process whereby aquatic systems become over-enriched by nutrients, such as nitrogen and phosphorus, released through run-off from agricultural activities into lakes and rivers. This alters the aquatic environment, placing local biodiversity at risk and has adverse impacts on water quality and water uses.

Eutrophication potential encompasses multiple emissions to water as well as to air, including SO_2 and nitrogen oxides (NO_x) to air, and nitrates (NO_3^-), ammonium (NH_4^+), phosphorous and nitrogen to water. These different emissions are reported in a standardised way in this study as phosphate equivalents (PO_4^{3-} eq.). The overall eutrophication potential of UK farm-stage food waste amounts to 24 kt of PO_4^{3-} eq., of which 82% came from Meat and Animal products.

Acidification is the process in which the pH of the soil or water environment becomes more acidic. As with eutrophication, the main sources for high acidification potential can be linked back to farming activities and their production and use of nitrogen. Acidification has been described as the largest threat and stress to continental water resources and the ecosystems of lakes and rivers after eutrophication (Geller & Schultze, 2009). Acidification in soil can also reduce the soils' fertility, reducing yields or stunting plant growth (Ghimire, Machado & Bista, 2017), and potentially resulting in additional food waste or a need to expand farming land in order to maintain current production levels. Meat and animal products are associated with high eutrophication and acidification potential due to the nature of their production processes, which can result in run-off from activities such as emissions from livestock, fertilizer application and slurry management.

To calculate the acidification potential from food waste, the emissions of SO_2, NH_3, NO_x to air are analysed and represented as sulphur dioxide equivalents (SO_2 eq.). The main sources for high acidification potential can be linked back to farming activities and to the production of key inputs, such as fertilisers and pesticides. The overall acidification potential of UK farm-stage food waste amounts to 39 kt of SO_2 eq., 90% of which came from Meat and Animal Products.

ANIMAL WASTE AND FEED, SYNTHETIC NITROGEN FERTILISERS AND SLURRY ON FARMS ALL CONTRIBUTE SIGNIFICANTLY TO THE NITROGEN LEVELS AND CARRY HUGE IMPACTS ON THE AIR, WATER AND OCEAN (WWF-UK, 2022C), THE EFFECT OF WHICH IS EMBEDDED IN ALL FOOD LOST AT FARM STAGE



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6. UK FOOD FOOTPRINT - FOOD WASTE IN UK PRIMARY PRODUCTION AND IMPORTS

In 2020, 46% of food consumed in the UK was imported (GOV, 2021b), as such, when considering the impact of the UK food system and consumption patterns, we must consider not just food grown in this country but the food and feed we import and the impacts these have on their local environments. As highlighted in Driven to Waste, the drivers of on-farm food loss often stem from decisions taken by actors and agencies beyond the farm gate which farmers and farm-stage interventions have little influence over. Behaviours and decisions taken within the UK food system can drive up food waste on global farms, exporting the environmental impacts of our food choices to countries which may have fewer resources to manage the climate, nature and water stresses they face as a result. Within this study it was found that for key commodities imported to the UK, the scale and impact of food waste occurring on farms and the environmental harm it causes was higher in overseas production (see Table 2).

Table 2: Summary of combined environmental impacts of farm stage food waste of UK production and imports

Impact category	UK production	Imports	Total footprint
GHG emissions	6MtCO_2e.	9.3 MtCO_2e.	15.3 MtCO_2e.
Land use	9,600 km^2	16,600 km^2	26,100 km^2 per year
Freshwater withdrawal	732 billion litre eq.,	1,800 Billion litre eq.	2,600 Billion litre eq.
Eutrophication potential	23.4 kt of PO_4^{3-} eq.	46 kt of PO_4^{3-} eq.	70.3 kt PO_4^{3-} eq.
Acidification potential	39 kt of SO_2 eq	55 kt of SO_2 eq	94.0 kt SO_2 eq.

Waste associated with primary production abroad linked to UK food imports is nearly double that associated with UK production (see Table 3). In total, over 6 million tonnes of food waste occur, mostly through food sourced from the rest of Europe, with in-field waste accounting for 41% (2.4 million tonnes), and post-harvest waste 59% (3.6 million tonnes). The higher proportion of post-harvest waste associated with imports compared with UK production waste is accounted for by the high volume of fruit and vegetables that the UK imports. Overall, food waste in primary production associated with UK food supply (home production and imports) amounts to 9.3 million tonnes, roughly equivalent to the total amount of post-farm gate food waste in the UK, including from household sources.

Table 3 – Total food waste on farm from UK food system: UK production and farms producing for UK import

Commodity	UK Production Volume (thousand tonnes)	Farm stage waste in UK production (thousand tonnes)	Import volume (thousand tonnes)	Farm stage waste from imports (thousand tonnes)	Total food waste on farm from UK food system (thousand tonnes)
Meat and animal products	20,514	803	2,900	346	1,149
Fish and seafood	737	225	450	486	710
Fruit and vegetables	3,264	1,098	8,100	3,918	5,016
Roots, tubers and oil crops	6,451	526	1,200	148	674
Cereals and pulses	8,073	236	5,600	943	1,179
Other	5,989	387	3,110	164	552

Farms from which we import Fish and Seafood represented 8% of food waste on farms (fisheries) the UK imports from, equivalent to 486,000 tonnes. In the UK, we are eating an increasing volume of fish, with 887,000 tonnes consumed in 2019, 81% of which is imported from overseas (WWF-UK, 2022d). This suggests that over half the volume consumed is wasted before it gets past the 'farm gate', contributing an additional third to our marine and seafood impacts.

CARBON FOOTPRINT

For imports to the UK, primary production food waste amounted to 9.3 MtCO2e, a level 53% higher than GHG emissions arising from UK production. Of these, 47% came from Fruit and Vegetables, 24% came from Meat and Animal Products and 12% came from Cereals and Pulses. The unusually high contribution to GHGs from fruit and vegetable waste is a result of the significantly higher volumes of fruit and veg imported and wasted in the UK food system, than that grown domestically (see Table 3). The combined GHG emissions associated with food waste on farms in UK production and imports are around 15.3 MtCO2e. 61% of these emissions are associated with UK imports, with the remaining 39% associated with UK production, highlighting the importance of addressing food waste in our food system as a whole.

WRAP's GHG emission estimate for the total UK food system was 158 Mt CO2e (2019), or equivalent to 35% of the UK's territorial emissions. These estimates put GHG emissions from whole supply chain food waste at 22% of the UK's overall food system emissions. As illustrated in Table 4, the current study's estimate of GHG emissions associated with primary production waste from UK imports fills a gap in WRAP's analysis, as this element was excluded from WRAP's calculations. A revised estimate for food waste's contribution puts total supply chain food waste emissions at 46.2 MtCo2e., making it responsible for 27% of food system GHG emissions, if emission values from the current study for import and home production are used for primary production waste[4].

Table 4: Embodied emissions CO2 eq. associated with UK food waste (adapted from WRAP 2021)

Sector	WRAP 2019 estimate (Mt $CO^{2}e$)	Current study (Mt $CO^{2}e$)
Primary production (UK production)	4.1	6.0
Primary production (UK imports)	–	9.2
Manufacturing	3.9	
Retail	0.9	
Hospitality and food service	3.6	
Household	22.6	
Total embodied emissions associated with producing food that is wasted	35.1	Revised total (46.2)

GHG emissions associated with UK Meat and Animal Product production waste is over double those associated with imports, whilst emissions associated with home production of Roots, Tubers and Oil Crops are similar to imports (see Figure 5). However, GHG emissions associated with imports are larger for Cereals and Pulses, Fruit and Vegetables, Fish and Seafood, and Other.

4 If the additional 1.9 $MtC0_2e$. from UK production and 9.2 $MtC0_2e$. from imports are added to WRAPs 2019 estimate of 158 $MtC0_2e$.

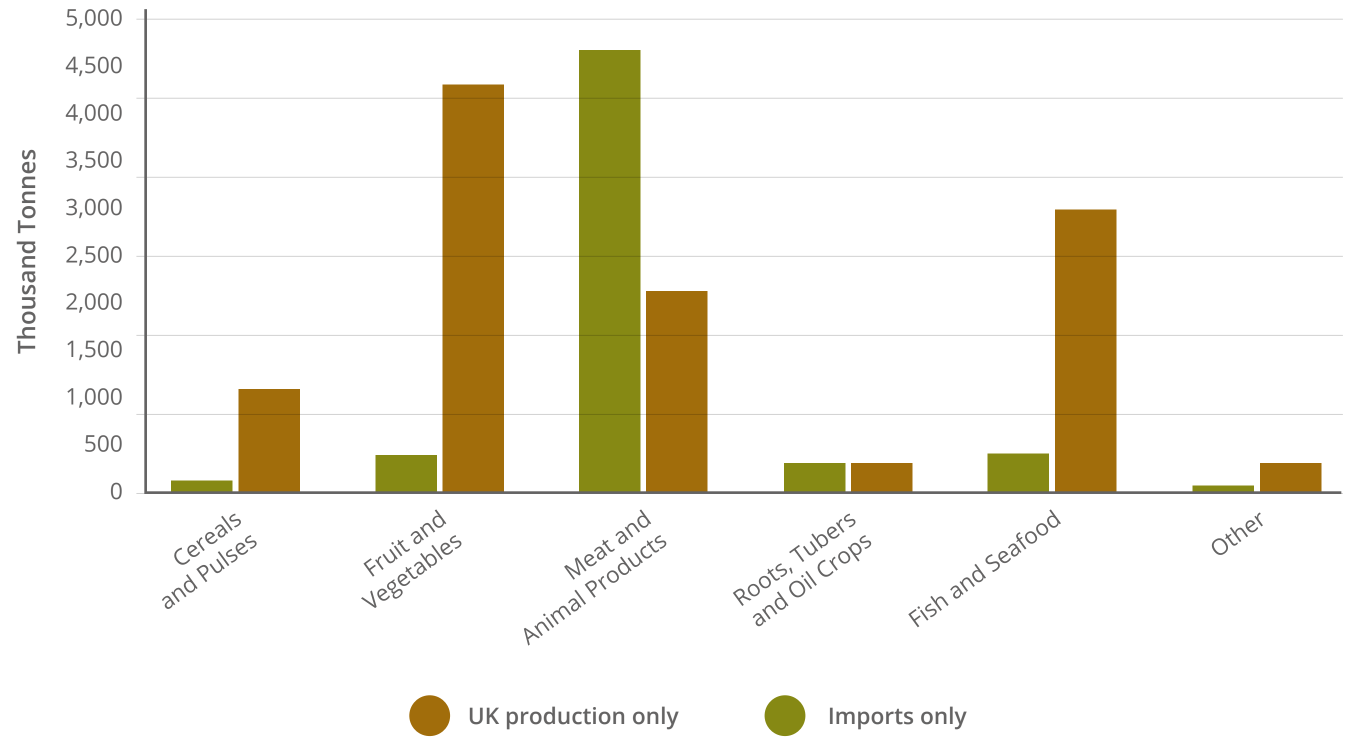


Figure 5: UK Production and Imports GHG emissions from food waste in primary production by FAO commodity group (thousand tonnes CO2e), 2020

LAND USE FOOTPRINT

Embedded within the food waste occurring on farms in countries we import from is the land use and deforestation that farming practices incur. For imports into the UK, primary production waste was accountable for 16,600 km2 per year. Of these, 44% came from Fruit and Vegetables, 27% came from Meat and Animal Products, 20% came from Cereals and Pulses, and 8% came from Roots, Tubers and Oil Crops. For the combined UK production and imports, the total land use associated with waste in primary production are 26,000 km2 per year. 63% of this impact is associated with UK imports, with the remaining 37% associated with UK production.

Figure 6 compares the Land Use associated with UK production and with imports. Land use associated with the food waste in primary production of imports is greater than that associated with UK production for all commodity groups apart from Meat and Animal. This is due to the lower volume of meat and animal products imported compared to that produced in the UK and subsequent greater tonnage of waste occurring in animal agriculture in UK production.

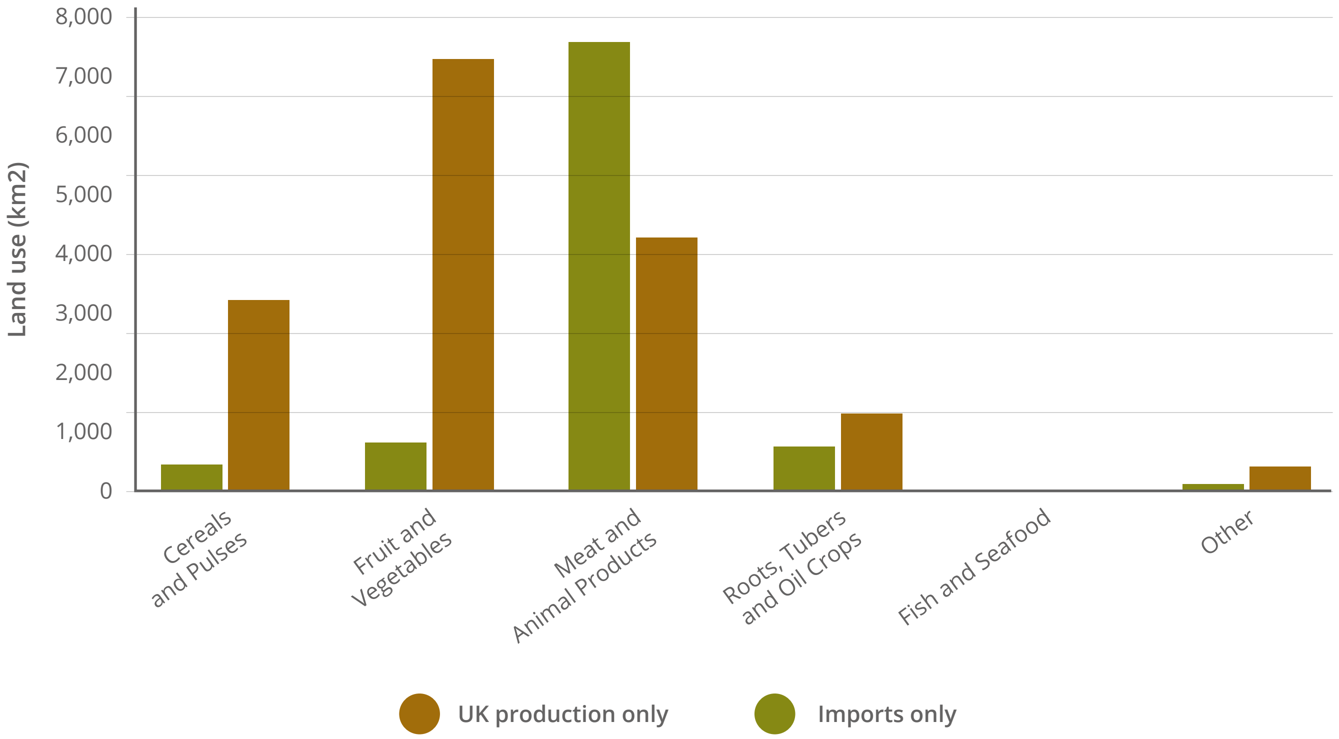


Figure 6: UK production and imports: land use associated with food waste at primary production (km²), 2020

WATER FOOTPRINT

The FAO has estimated that global demand for water will increase by 50% by 2030 (FAO, 2019) and the UN projects a 40% global water shortfall by 2030 (United Nations, 2016). As previously noted, agriculture is responsible for 70% if global freshwater abstraction, making efficiency in this area essential to bringing water consumption back within environmental limits. For the combined UK production and imports, the total freshwater withdrawal potential associated with food which is wasted in primary production is 2,600 (billion litre eq.). 72% of this impact is associated with UK imports.

According to the Government Food Security report, 50% of vegetable production occurs domestically and 43% of vegetables consumed in the UK are produced in Europe. However, fruit production, of which only 16% is produced domestically, is more widely spread across the EU, Africa and the Americas (GOV, 2021a). Water demand becomes an issue when abstractions and consumption of water reduce flows and levels below the thresholds required for sustaining ecosystems, thereby negatively effective local biodiversity. This is particularly an issue in arid and semi-arid regions where irrigated agriculture is widespread, including regions we import products from such as North Africa and Southern Europe.

For food waste in primary production for imports into the UK, freshwater withdrawal amounts to 1,800 billion litre eq. This is 152% higher than the freshwater withdrawal associated with UK production waste. Of this, 36% of the withdrawal can be attributed to Fruits and Vegetables, 30% came from Cereals and Pulses, and 13% came from Fish and Seafood (aquaculture). The highest impacts in relation to total waste were found in countries where crop production is more reliant on irrigation rather than rain-fed systems (e.g. Ukrainian cereals, Spanish vegetable production). Such practices have significant impacts on water resources in producer countries, leading to reduced river flows, depleted groundwater sources and deteriorating water quality.

ACIDIFICATION AND EUTROPHICATION

For imports into the UK, primary production waste amounted to 55 kt of SO_2 eq. This is 39% higher than acidification potential resulting from UK production. Of this, 52% came from Fruit and Vegetables, 28% came from Meat and Animal Products, and 11% came from Cereals and Pulses.

Within the eutrophication potential, primary production waste for imports into the UK amount to 46 kt of PO_4^{3-} eq. This was 94% above the level of eutrophication potential resulting from waste in UK production. Of this eutrophication potential, 50% came from Fruit and Vegetables, 23% came from Meat and Animal Products, and 13% came from Cereals and Pulses.

7. RECOMMENDATIONS

There is a need for greater policy intervention in farm-stage food waste in order to reduce its impact on farmers, the climate and nature crises and food security within the UK. This reports sister, **Hidden waste: The Roadmap**, lays out step-by-step actions which must be taken by actors within the UK food system to support farmers in beginning to measure, report and reduce waste. Hidden Waste: The Roadmap complements Courtauld 2030, the IGD-WRAP Food Waste Reduction Roadmap, and the Champions 12.3 10×20×30 initiative by providing guidance for food system actors to engage with this stage of the supply chain and support farmers in making positive strides against food waste. This report provides an overview of action needed across the food system to ensure on-farm food waste receives increased levels of attention and support.

1 SET BINDING TARGETS FOR A 50% REDUCTION IN FOOD WASTE FROM FARM TO FORK

There is a need to accelerate action and commitment in this area. Commitment through legally binding targets set by UK Governments will enable monitoring and review of progress, and drive action in the food waste agenda both in policy and by guiding businesses through the provision of certainty that this is an area where time and investment are required. Businesses should seek to align with this target and commit to supporting their supply chains in achieving a 50% reduction in food waste.

2 IMPLEMENT MANDATORY REPORTING OF FOOD SURPLUS AND WASTE:

a. **For all post-farm gate medium and large businesses, to begin in 2023.**

b. **For all medium and large farm businesses, to begin in 2024.**

This study estimates that from farm to fork, food waste is responsible for 27% of the UK's food system GHG emissions. It is imperative that we track where this waste is occurring and to what extent, so we can ensure progress towards the 50% reduction target and associated environmental impacts. As such, Defra should aim to implement mandatory reporting for medium and large farms from 2024 onwards. The sister report to this study, *Hidden Waste: The Roadmap* to tracking and reducing food surplus and waste on UK Farms, which complements Courtauld 2030 and the IGD-WRAP Food Waste Reduction Roadmap, lays out actions that must be taken by the wider food system in order to support and engage farms for measurement and reporting. This aims to improve voluntary uptake on small farms and to provide the tools and support needed for mandatory measurement to begin in 2024 for medium and large farm businesses (based on turnover and employee numbers).

3 INTEGRATE FOOD WASTE MEASUREMENT AND REPORTING INTO SUSTAINABLE AGRICULTURE FINANCIAL INCENTIVES

Subsidies and funding mechanisms such as Future Farm payments, the Farming Transformation Fund in England, the Sustainable Farming Scheme in Wales and future farming support systems in Scotland which are currently under development, should consider food waste measurement and reporting as part of their schemes. Green initiatives from other financial institutions should seek to do the same, for example green farmer credit programmes. As illustrated in this report, reducing food waste on farms is a delivery mechanism for many of the environmental outcomes these schemes target, such as reduced agricultural emissions, bringing water consumption within environmental limits and freezing the land footprint of food production.

4 REDEVELOP ANIMAL AGRICULTURE PRACTICES AND STANDARDS BASED ON THEIR IMPACT ON FOOD WASTE LEVELS AND INTEGRATE IN FARM CERTIFICATION SCHEMES

In UK production animal agriculture, whilst having the lowest waste rate, carries the highest environmental impact across all markers. Minimising waste in livestock and animal products is imperative in reducing the environmental impact of agriculture. Thus far, the development of animal agricultural practices and standards has failed to take into consideration standards that will reduce waste. The UK Government and farm certification scheme should seek to review existing policies in order to determine their impact on waste rates.

5 SHIFT SUBSIDIES IN FAVOUR OF REDISTRIBUTION AND REUSE OF FOOD, RATHER THAN ENERGY RECOVERY

A reported £750 million is available to anaerobic digestion (AD) organisations in government subsidies (The Independent,2021), which supports organisations in collection and valorisation of food waste and agricultural bi-products. Whilst AD is a viable option for the disposal of food waste not suited for redistribution (e.g. food that is unsafe for consumption) and for agriculture bi-products and non-food waste (e.g. manure management), the priority should always be given to reducing food waste and redistributing surplus. The UK Government should seek to bring subsidisation back in line with the food waste hierarchy, prioritising funding and subsidising redistribution efforts, such as gleaning initiatives and organisations that increase the redistribution of surplus food, ahead of repurposing. Second to this should be the re-use of food waste in the animal feed system in order to reduce our reliance on crops grown for animal feed and improve the circularity of our food system.

6 IMPLEMENT POLICY TO IMPROVE SUPPLY CHAIN PRACTICES WHICH DRIVE ON-FARM FOOD WASTE

Despite evidence that some supply chain practices/ policy play a role in driving food waste on farms (Soma et al., 2021), the limited level of data available is inadequate to assess the impact of this in full, as discussed in this report. This report's sister, Hidden Waste: The Roadmap, lays out a process by which reporting of on-farm food waste levels and drivers can be increased to a sufficient level for the identification of policy or practice shifts that would support a reduction of farm-stage food waste. Data gathered should be used to inform policy shifts that will empower farmers and protect their livelihoods, for example through the prohibition of actions that are shown to drive on farm food waste. This could be, for example, short-notice cancellations of perishable agri-food products or unilateral contract changes by the buyer (WWF-UK, 2021). As part of this process, WWF recommends DEFRA commission a review of existing policy, in order to understand what measures have the most impact in strengthening farmers' positions and minimising food waste on farms.

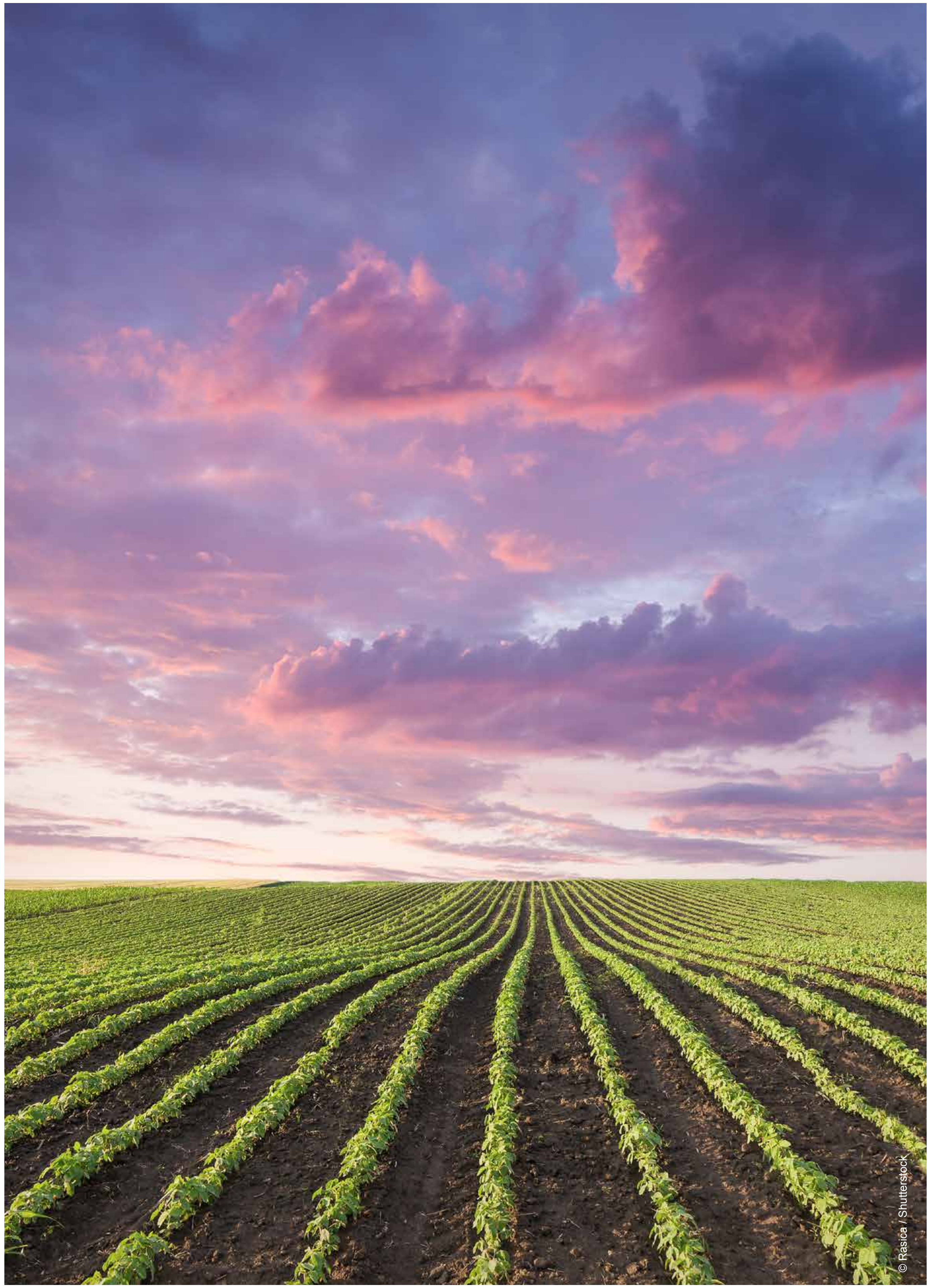
8. CONCLUSIONS

Within the UK, farm-stage food waste is almost entirely omitted from discussions surrounding FLW, food insecurity, sustainable agriculture and climate change, despite carrying 25% of the UK's FLW volume, 10% of agricultural emissions and the potential for 6.9 billion meals. Targeting a reduction in food waste at this stage of the supply chain holds a host of potential benefits, including freezing or possibly reducing our land footprint and offering protection to landscapes and biodiversity through improved food production efficiency.

It has been a long-held belief that on-farm food waste is only an issue in low-income countries (WWF-UK, 2021), which has slowed progress on this agenda in high-income countries such as the UK. This study illustrates the significant scale and impact of food waste in UK primary production and imports, highlighting the role reducing it could play in driving progress towards numerous environmental targets, such as carbon budgets and water consumption and the critical importance to improving our international supply chains. However, in order to achieve this progress, we must first see two core changes.

First, an increase in the uptake of on-farm measurement and reporting of food waste is necessary in order to help identify the core drivers of waste and create data driven solutions to them, and also to set a baseline, reduction targets and to track progress towards them. This, and numerous other studies, reflect the need for farm-stage measurement and reporting of food waste, both post-harvest and through the use of in-field sampling to calculate in-field waste, in order to provide an accurate understanding of food waste. Farmers tend to underestimate both the scale and value of food waste occurring when relying on traditional estimation and self-reporting, which contributes to missing valuable opportunities to increase on-farm profitability and simultaneously reduce food waste.

Second, we must see greater commitment from UK Governments and Businesses to support farmers and efforts to reduce farm-stage food waste. In order to achieve this, supporting farmers to measure and report food waste is the first step to collecting and utilising the data to make policy and practice changes to help reduce food waste. The actions that must be taken by food system actors in order to enable this are outlined step by step in WWF-UK's report, Hidden Waste: The Roadmap to tracking and reporting food surplus and waste on UK farms, which complements Courtauld 2030 and the IGD-WRAP Food Waste Reduction Roadmap.



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9. REFERENCES

Defra (2021a) Total Income from Farming in the United Kingdom, first estimate for 2020

DEFRA (2021b) Agriculture in the UK evidence pack

Environment Agency (2015) Water supply and resilience and infrastructure

Environment Agency (2020) Meeting our future water needs: a national framework for water resources

FAO (2019) Fishery and Aquaculture Statistics Yearbook

FAO (2017) Water for sustainable food and agriculture

FAO (2019) Water Scarcity

FAOSTAT (2020) Producer prices

Fareshare (2022) Food waste and hunger in the UK

Geller, W., Koschorreck, M., Schultze, M., Wendt-Potthoff, K., & Gene, E. L. (2009). Restoration of acid drainage. Encyclopedia of Inland Waters, Academic Press, Oxford, UK, 342-358

Ghimire, R., Machado, S., and Bista, P. (2017) Soil pH, soil organic matter, and crop yields in winter wheat–summer fallow systems. Agronomy Journal, 109(2), 706–717

GOV (2021a) Agri-climate Report

GOV (2021b) Food Security Report: Theme 2

GOV (2021c) Food Security Report: Theme 1

House of Commons (2022) Labour shortages in the food and farming sector

Johnson, L.K., Bloom, J.D., Dunning, R.D., Gunter, C.C., Boyette, M.D., and Creamer, N.G. (2019) Farmer harvest decisions and vegetable loss in primary production. Agricultural Systems, 176, 102672

Johnson, L.K., Dunning, R.D., Bloom, J.D., Gunter, C.C., Boyette, M.D., Creamer, N.G. (2018) Estimating on-farm food loss at the field level: A methodology and applied case study on a North Carolina farm. Resources, Conservation & Recycling, 137, 243–250

Linstead, C. (2018) The contribution of improvements in irrigation efficiency to environmental flows. Frontiers in Environmental Science, 6, 48

NFU (2022) Labour shortages cost millions in fruit and veg waste

Parker et al. (2018) Fuel use and greenhouse gas emissions of world fisheries. Nature Climate Change, 8, 333–337

Poore. J. and Nemecek, T (2018) Reducing food's environmental impacts through producers and consumers, Science, 360(6392), 987–992

Soma, T., Kozhikode, R., and Krishnan, R. (2021) Tilling food under: Barriers and opportunities to address the loss of edible food at the farm-level in British Columbia, Canada. Resources, Conservation and Recycling, 170, 105571

The Guardian (2022) A million UK chickens die needlessly each week to keep prices low

The Independent (2021) 150 million meals a year thrown away rather than given to hungry because of £600m government subsidies

United Nations (2016) Half the world face severe water stress by 2030

WRAP & IGD (2020) The Food Waste Reduction Roadmap Toolkit

WRAP (2017) Food Waste in Primary Production – A Preliminary Study on Strawberries and Lettuces. Banbury: WRAP

WRAP (2018) Food Surplus and Waste Measurement and Reporting Guidelines: Meat Sector

WRAP (2019) Food waste in UK Primary Production

WRAP (2020) Food Surplus and Waste Measurement and Reporting Guidelines: Fresh Produce

WRAP (2021a) Food Surplus and Waste in the UK: Key facts

WRAP (2021b) Financial Implications for Farm Enterprises of Reducing Food Surplus and Waste

WRAP (2021c) UK Food System GHG Emissions. Banbury: WRAP

WWF-UK (2021) Driven to Waste: The Global Impact of Food Loss and Waste on Farms

WWF-UK (2022a) Hidden Waste: The Roadmap to tracking and reducing food surplus and waste on UK farms. Woking: WWF-UK

WWF-UK (2022b) Future of Feed: How Low Opportunity Cost Livestock Feed could Support a More Regenerative UK Food System

WWF-UK (2022c) A Comprehensive Approach to Nitrogen in the UK

WWF-UK (2022d) Risky Seafood Business

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