FoodPrint: Low Carbon Food Report

Understanding and reducing greenhouse gas emissions from food consumption and production

Cheshire and Warrington

ESTA

Environmental Sustainability
Technical Assistance

This report has been commissioned in order to set out what is known about greenhouse gas (GHG) emissions arising from the production and consumption of food and drink in Cheshire and Warrington, and to explore the options for mitigation. In addition, it sets out a framework and an evidence base to assist in making decisions about what mitigation options will be effective and practical in the local or regional context.[1]

Data and evidence for the report has been gathered specifically for these strategic purposes and therefore needs to be read as a whole. Care should be taken not to over-extrapolate outputs and metrics; for example by using them for specific technical applications, or taking elements of the work to draw conclusions in other contexts.

The area covered by the report corresponds with the Cheshire and Warrington Local Enterprise Partnership (LEP) – comprising the boroughs of Warrington, Cheshire West and Chester, and Cheshire East. In terms of food systems and greenhouse gas emissions, the LEP is important both because of the impacts of consumption from its relatively significant population, and because of the importance of its agricultural – in particular dairy – sector. 76% of the Cheshire and Warrington's area is farmed, with agricultural activity concentrated in Cheshire East, where 3.1% of the workforce is employed in agriculture – double the national average.

The technical approach taken in this report is a rich source of information about how the FoodPrinting model works and, whilst it is listed in Appendix 2 at the rear of the report, it should not be looked upon as something ancillary to the report – it is essential reading.

Click here to go straight to Appendix 2

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Focusing on food system greenhouse gas emissions

The food system is a complex topic linked not only to environmental impacts but also health and wellbeing, economic development, history and culture. Amongst these issues, the question of GHG emissions takes on particular importance when it is considered that globally, 20-30% of all GHG emissions are caused by the food system. The findings of this report show that the consumption of food and drink in Cheshire and Warrington is responsible for 2.3 million tonnes of CO_2e every year – an amount equivalent of the annual emissions produced by around 600,000 cars (based on UK average mileage). Agricultural activities within Cheshire and Warrington are linked to a further 1.2 million tonnes CO_2e every year from sources such as methane emissions from livestock and emissions associated with the application of fertiliser.

Identifying the hotspots

Using a life cycle approach, this report sets out to help readers to understand in more detail the causes of these emissions. While all mitigation actions are beneficial, it is hoped that quantifying the greatest areas of impact will help to focus resources where they can count most. In terms of absolute emissions, primary production, energy use by consumers, avoidable food waste, and refrigeration are the biggest single factors in food and drink related GHG emissions. By contrast, some factors that might be expected to be critical, for example packaging, local sourcing and organic production, have relatively minor impact. Overall, the decisions made by consumers about the kind of food we choose to eat, and in particular how much meat and dairy we consume, has a major impact across the system.

Taking actions that count

The report then explores the kinds of actions that can be taken to mitigate these GHG impacts. There are no silver bullets or one-size-fits-all solutions. In addition to having demonstrable impact, actions to reduce emissions must above all work with, rather than against, local stakeholders such as farmers, food businesses and consumers, optimising economic, social and environmental benefits. Where possible, potential emissions reductions have been quantified, using both hypothetical and realistic scenarios. A process and evaluation matrix for helping LEPs and their partners to select mitigation measures is outlined, and two 'think pieces' are offered to initiate discussion.

Stakeholder workshops

Our initial findings were presented at a Cheshire and Warrington stakeholder workshop. This provided valuable local insights on the potential practical implications of the work, and feedback and comments were incorporated into this report.

The LEP and its partners have an important part to play in promoting food and agriculture initiatives that have significant potential to cut greenhouse gas emissions as well as supporting local job creation, generating value and enhancing competitiveness.

1 INTRODUCTION

1.1 Food system emissions are a global priority

Every year the UK population of 63 million people consumes around 34 million tonnes of food and drink. An additional 9.3 million tonnes is purchased but wasted. Around 53% of this food is grown in the UK, 28% comes from the EU, and 19% from the rest of the world.[2]

If we are serious about reducing GHG emissions, we need to manage emissions from the food system. Emissions from food are responsible for between 20-30% of all anthropogenic GHGs.[3] The research for this report shows that consumption of food by the UK population is responsible for emissions of 150 million tonnes CO_2e every year.[4] In order to meet global and national targets for emissions reductions, there is much work to be done at all levels – global, national, regional and local – to reduce emissions from food. LEPs are uniquely positioned to be able to catalyse relevant action at a scale large enough to have significant impact. The aim of this research is to help the LEP and its partners in Cheshire and Warrington to understand the causes of GHG emissions related to food consumption and production, and to provide a framework for selecting effective and locally resonant mitigation options.

1.2 How to use the report

The information and findings in this report are intended to provide an authoritative foundation for future discussions and decisions about action to reduce GHG emissions from the food consumed and produced in Cheshire and Warrington.

The report is split into two main parts; first a general analysis of GHGs, food systems, and how to influence them (Sections 2-3), and second a geographically specific analysis of the emissions relating to Cheshire and Warrington, along with an initial evaluation of options for reducing emissions (Section 4).

The intention is to provide comprehensive briefing materials and tools for the LEP and its partners involved in the food system and to assist them in making decisions about how to act to reduce GHG emissions. The report outlines potential actions and interventions, and illustrates what might be achievable. The decision about what to do should rest finally with the people who will take action.

'In order to limit global temperature increase to less than 2°c after 2050, greenhouse gas emissions must be reduced by 40-70% compared to 2010 levels, and drop to near zero by 2100 (IPCC 2014)'.

[2] Defra 2014

[3] Emissions caused by human activity - Audsley et al (2009)

[4] Based on emissions entailed in the whole lifecycle of food that is consumed in the UK, wherever in the world those emissions occur. This figure includes direct and indirect emissions but excludes any contribution to emissions from land use change. For fuller discussion see Section 2.3.

'Food sustainability is a complex topic and the subject of much debate, not least because food is so intimately connected to many areas of our lives'

1.3 The approach taken

Food sustainability is a complex topic and the subject of much debate, not least because food is so intimately connected to many areas of our lives. This has generated multiple 'views' and positions on what sustainable food is, or ought to be. Sometimes these views are opposing, sometimes they are reflective of differing worldviews, and sometimes they may come as a result of vested interests. In all cases there is a need to find ways to cut through complexity in order to be able to make effective decisions.

This report was commissioned in order to focus on environmental impacts, and specifically on GHG emissions. The intention is that it provides insight into this topic that can be used by the LEP and its partners to develop a balanced view on the action that needs to be taken, in the light of full consideration of all of the issues. The approach used attempts to generate some clarity by applying three disciplines:

1. **Numbers, not adjectives**
2. **Simplicity**
3. **Practicality**

These disciplines are explained in more detail as follows:

1 Numbers, not adjectives

In his book 'Sustainable Energy Without the Hot Air' David MacKay (2008) promotes 'numbers, not adjectives' as a means of evaluating and comparing different solutions to reducing GHG emissions from the energy sector. Part of what he is alluding to is that even when arguments for sustainable solutions are compelling and well-positioned, they may not always be very useful in terms of actually reducing emissions. But, if you can show numerically that something counts, then regardless of how attractive a proposition sounds, you know it's probably a good idea.

The aim is to apply the same principle to food system analyses. The approach taken for this, using **Life Cycle Analysis**, is now fairly tried and tested and uncontroversial. It simply takes the current state of the knowledge in terms of published data on the GHG impacts of all the different activities along the food supply chain, and uses these to estimate overall emissions. The results can then speak for themselves, even if sometimes they are counter-intuitive.

'This report aims to narrow the focus of broader sustainable food discussions to concentrate specifically on GHG emissions related to the food system.'

2 Simplicity

Seen holistically, the food system embraces issues concerning not just the environmental impact of GHG emissions but also:

Water
Energy and land use
Habitat loss and biodiversity
Soils
Local and regional economies
Working conditions
Landscape aesthetics
Animal welfare
Food poverty
Public health
Food culture and knowledge
Transportation

However, the threat of climate change cuts across all of these aspects as the most pressing issue of our time. Partly for this reason, and partly for clarity to facilitate decision-making, this report aims to narrow the focus of these broader sustainable food discussions to concentrate specifically on GHG emissions related to the food system, and to provide an evidence-base and targeted recommendations for making reductions. One of the key tools in this approach is to identify 'hotspots' in the food system. These are stages, processes, or factors in the food system that influence large portions of its overall impact. These hotspots make good places to start when thinking of where to focus effort.

3 Practicality

As with any 'big issue' there is an attraction to idealistic 'if only' solutions. They are attractive because they can point optimistically to a perfect world, where for example, people aren't obese anymore and food is sustainable because everyone eats a gourmet artisanal diet and works on the allotment at weekends. The problem is, even if the case stacked up numerically, it would never actually happen. The world is too messy and imperfect.

The final discipline is therefore to evaluate the practicality of any proposed solution or intervention. If it isn't likely to work, then it doesn't count. This is done by considering two factors: (1) does the idea have 'resonance' locally – i.e. is it the sort of thing that people or businesses actually seem to do, will it fit with other social and economic priorities, and (2) are there any 'champions' for the idea – people or organisations who are motivated to take it on. Without these factors, the best solution in the world is actually worth very little.

'Seen holistically, the food system embraces issues concerning not just the environmental impact of GHG emissions.'

1.4 Methodology

Three distinct research approaches were used. These are summarised below, and explained in more technical detail, where necessary, in the relevant parts of the report.

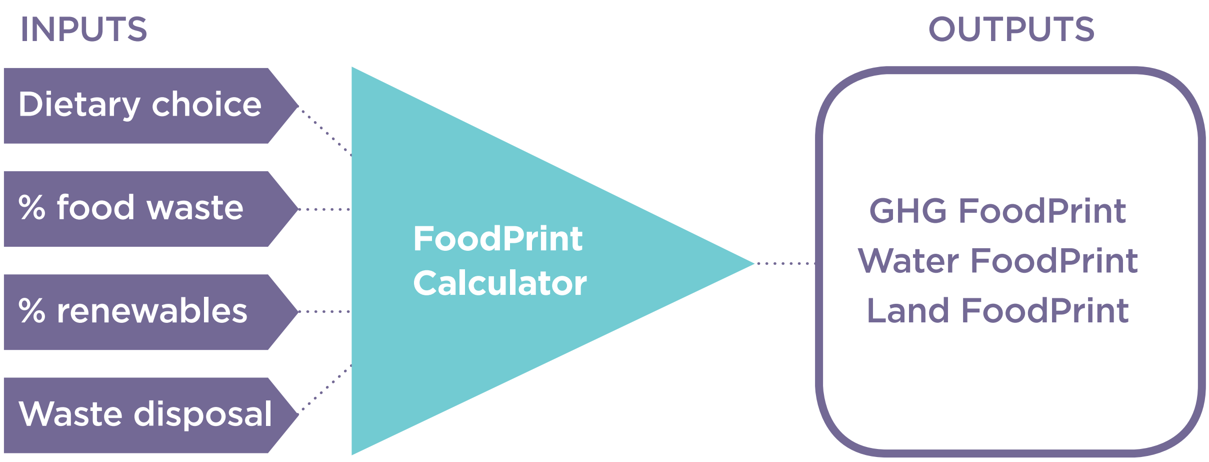
1.41 State of the knowledge

The investigations and analysis for this report were explored through, and backed up by, comprehensive reference to the literature – both grey literature (government and institutional publications) and published scientific work. This means that the result of each of the analyses and questions addressed is based on the current 'state of the knowledge'. It is important to realise that this knowledge is not comprehensive, not always consistent, and is always evolving. Wherever possible references and findings have been checked against several sources, and in some cases a qualified judgment call has been made. Whilst the report aims to present a clear picture, it should not be seen as 'the last word' – the science of food systems sustainability continues to emerge.

1.42 FoodPrinting

As well as addressing a wide range of specific and technical questions through reference to the literature, a scenarios testing tool developed by 3Keel Ltd is also employed.[5] The 'FoodPrint' calculator pulls together data and information from a range of published sources into a model to calculate GHG (and other) footprints based on different input variables, shown in Figure 1 below. Specific aspects of the methodology used are explained in more detail throughout the report.

Figure 1: FoodPrint calculator inputs and outputs



[5] The initial version of this tool was developed for the FoodPrinting Oxford project commissioned by Oxford City Council and Low Carbon Oxford, the findings of which were published in 2013 (Curtis, 2013).

1.43 Understanding the situation on the ground

The geographically specific analysis is based on initial gathering of both data and intelligence on the LEP area. This is done in two ways:

1. Using published data such as Defra agricultural statistics and local socio-economic profile to 'localise' input variables for the FoodPrint calculations.
2. Using reports, contact with stakeholders[6] and comprehensive web-searches to understand the structure of the local economy, the local food system, existing local initiatives, and crucially, potential local people and organisations who might be interested in working on reducing emissions from the food system.

It should be noted that the agricultural statistics represent county/unitary authority level information, which give an understanding of the scale and type of activities, for example the field area of different crop types and the number of head of livestock. They do not include data on the specific farm systems in use (e.g. extensive, intensive, free range, organic etc). Assumptions on farm systems and their impacts are based on national averages, and as such local differences in production techniques may impact the figures produced for this report. There is scope for future work to explore this.

Ultimately, it is users of this report who will have the best on the ground knowledge of the context for work on food sustainability, and they are encouraged to deploy the findings of this report in ways that resonate with conditions and stakeholders in the local area.

'The 'FoodPrint' calculator pulls together data and information from a range of published sources into a model to calculate GHG (and other) footprints'.

[6] A workshop involving stakeholders from the local LEP was held in September 2014.

2 UNDERSTANDING THE FOOD SYSTEM

This section pulls together the state of the knowledge about the UK's food system to present a simple outline of where within the system GHG emissions occur, and the relative volumes of those emissions. This is done in two ways: first, by taking a journey along the food life cycle from field to fork to explore the impacts at each stage; and second, by identifying system-wide factors that might not be identified by looking just at life cycle stages, but that are causally significant and will be useful later on when identifying levers for change.

2.1 Life Cycle Analysis

Historically, policymakers, businesses and civil society groups have not always been good at recognising where the biggest hotspots in the food system are, tending to pick one particular facet or one particular solution as the single most important consideration, to the detriment of others. In reality, in order to achieve the necessary reductions in food system GHGs, multiple different approaches will be needed. Life Cycle Analysis (LCA) tools help to avoid a narrow perspective by showing the full range of impacts during a product's life – from the fertiliser inputs required in crop production, for example, to the leakage of refrigerants required to keep fresh produce cool in storage, right through to the generation of methane when uneaten food waste decomposes on a landfill site. By taking this holistic view of all the system inputs and outputs during the journey of a final product, the LCA perspective also allows us to put different lifecycle stages side-by-side to quantitatively compare their relative impacts and mitigation potentials.

2.2 How these figures were produced

There is no single approach to measuring GHG emissions from the food lifecycle and, often, different studies have produced significantly divergent results. Studies tend to look at only one or a few different products, product groups or agricultural commodities, and may still then only look at a fragment of the entire food chain. Methods and assumptions used for one product group or one section of the food chain may be different from those used in others. In order to try to understand this array of mismatching information, the FoodPrint model was created allowing data looking at different food types and different lifecycle stages to be placed side-by-side in a single framework. Bringing the data together in this way allows for a high-level overview of the hotspots in the supply chain to show where major emissions are occurring, and what categories of food they are associated with.

The starting point for this work is food consumption, using detailed Defra data on the quantities of food that people buy on average every week in the UK. It is important to know the types of food being consumed – the production and subsequent journey of a kilogram of carrots is very different to that of a kilogram of fish. The average weekly quantity of food consumed in 17 categories is then traced back through the supply chain to assess the GHG emissions associated with each stage in the lifecycle, e.g. producing, packaging, transporting, and so on. Data for these impacts was selected from sources that fulfilled the criteria of being methodologically rigorous and consistent, as well as being able to provide information on a wide variety of different product types. For lifecycle stages where this latter condition was not possible, top-down estimates of aggregate GHG emissions were used instead.

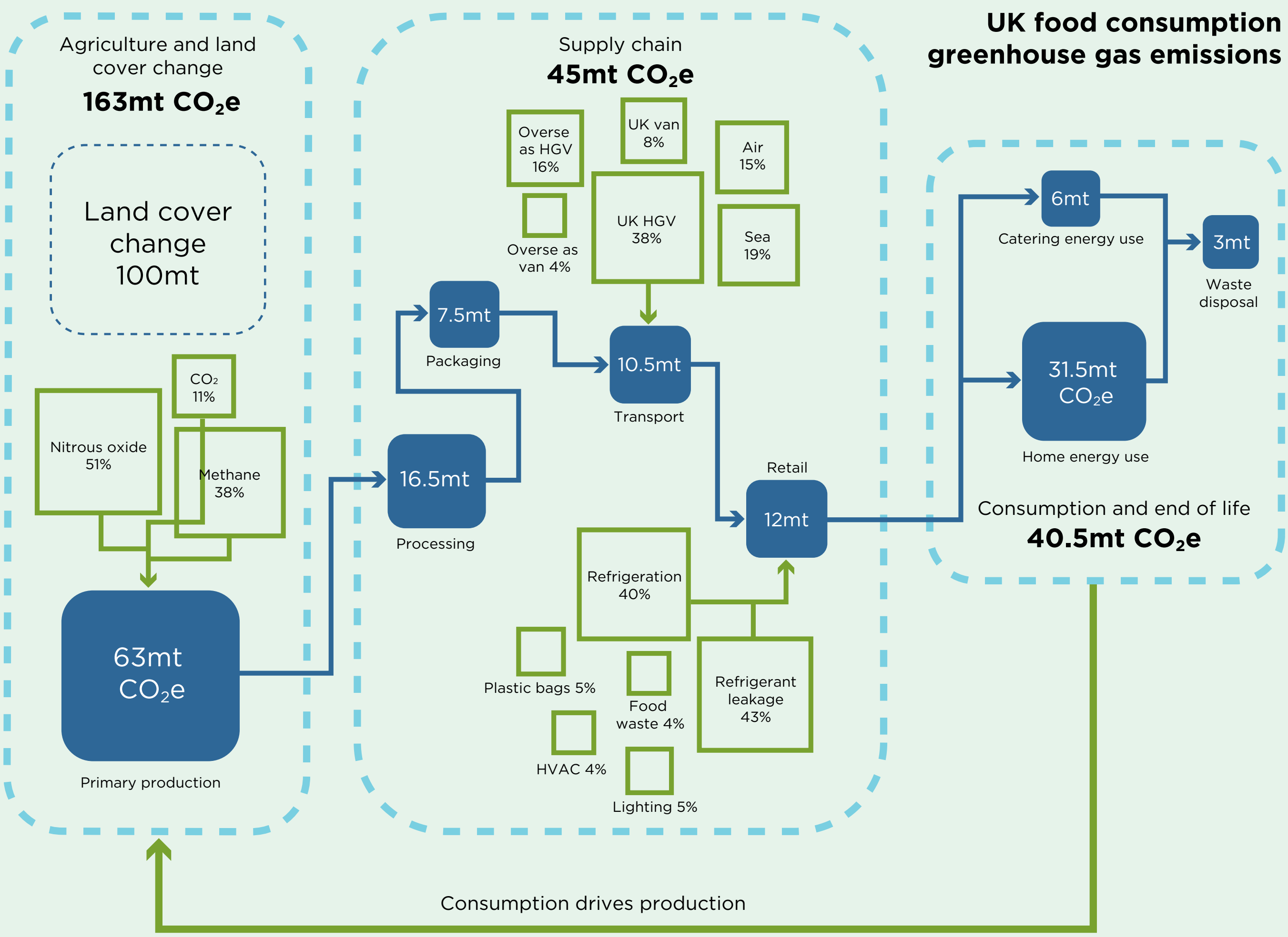
Food system lifecycle emissions are summarised in Figure 2 on page 12, followed by a more detailed investigation of each stage.

How to use these figures

The full impacts of the food system are often not included in city or regional level studies of GHG impacts. This is partly because unlike energy use and emissions from vehicles, which are relatively easy to link to a certain place, time and set of actors, food emissions have a complex, international supply chain. Indeed, excluding land cover change, 20% of the 150 million tonnes of direct emissions from UK food consumption occur outside of the UK. And if land cover change is included, bringing the total to 250 million tonnes, 50% of this total occurs overseas, mostly due to deforestation for grazing or fodder crops (Audsley et al 2009).

Some methods of accounting for emissions only count emissions that occur within the geographical or organisational unit being studied (Scope 1), or electricity produced to supply energy within that unit (Scope 2). In this report, by contrast, a consumption – based approach to food emissions is used – that is, emissions at all stages in the supply chain are accounted for wherever they occur (Scope 3). This is useful because it allows us to take a systems view of the problem, and to consider all of the levers for change available at the regional level to reduce overall GHG emissions. A more limited approach risks missing the fact that it is demand at the point of consumption that drives GHG emissions along the supply chain.

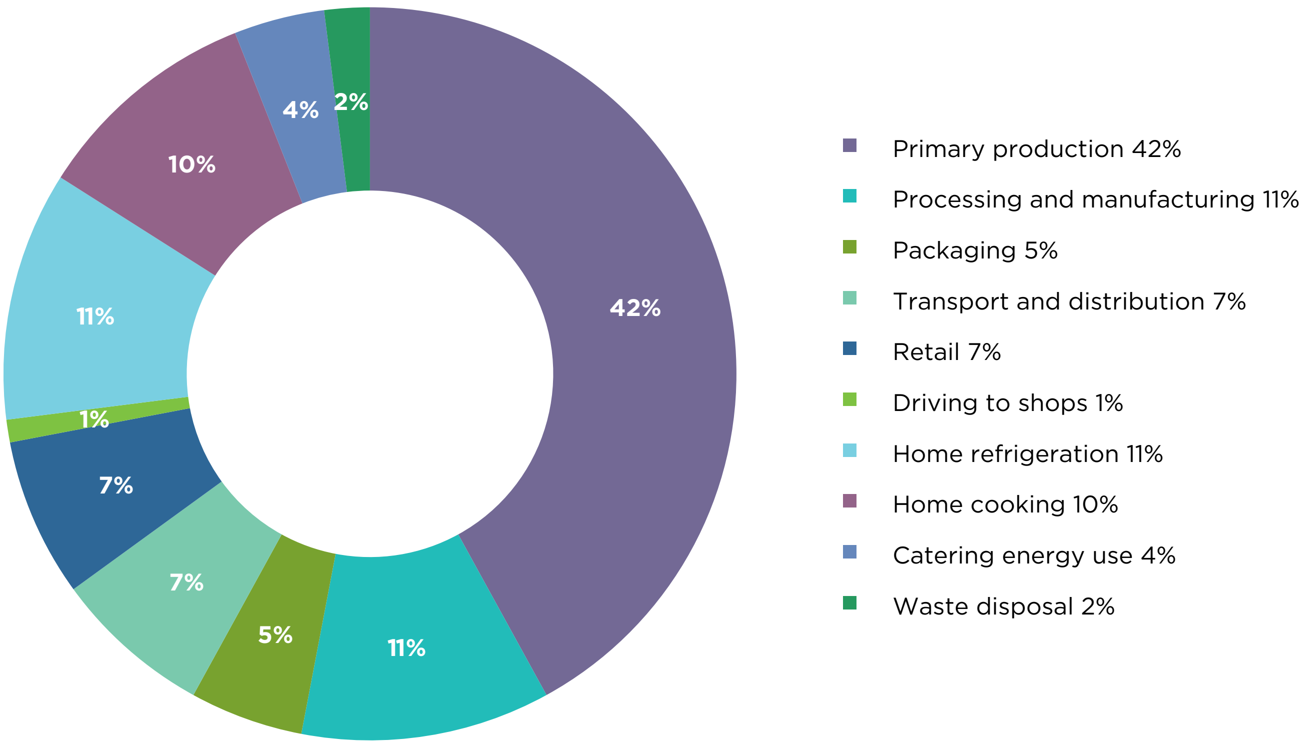
Figure 2: The Food Chain, showing stages in proportion to their emissions



2.3 What is known #1: Emissions at different stages in the food system

It is calculated that total emissions associated with food consumed by the UK population add up to 150 million tonnes of CO_2e, broken down as follows:

Figure 3: Lifecycle greenhouse gas impacts of food consumption



2.31 Primary production: 42% (63mt CO_2e)

The most significant single portion of total food system emissions arises from farming, grazing and fisheries. This is also the lifecycle stage with the biggest impact on land and water use.

In the UK, production emissions are dominated by nitrous oxide (51% of total CO_2e), followed by methane emissions (38%), with only 11% made up of CO_2 from energy for fuel and heating.[7]

- 90% of agricultural nitrous oxide emissions come from soil management, and in particular, fertiliser applications.[8]
- Around 70% of methane emissions from agriculture come from enteric fermentation by ruminant animals (cattle and sheep), with the remaining 30% coming from manure and slurry management.[9]
- Agriculture accounts for 84% of the UK's total nitrous oxide emissions, 44% of total methane emissions and 0.9% of carbon dioxide emissions.[10]

Livestock for meat and dairy make up a significant proportion of primary production GHG emissions, both through the production of crops for animal feedstock and through direct methane emissions from animals.

Additional indirect emissions from land use change are estimated at as much as 100m tonnes CO_2e.[11]

Carbon dioxide equivalent

The food chain is responsible for emissions of various different GHGs, not just CO_2.

Gases have different impacts on the climatic system – for example, over a 100-year period one tonne of methane will cause as much warming as 34 tonnes of CO_2 (IPCC – Myhre et al 2013).

Here all emissions are reported as CO_2 equivalent, or CO_2e, a single unit presenting all gases in relation to CO_2.

7 DECC 2014
8 Defra 2014a
9 Defra 2014a
10 Defra 2014a
11 Audsley et al 2009

2.32 Processing and manufacturing: 11% (16.5mt CO_2e)

Primary processing involves cleaning, sorting, milling and packing.
Secondary processing includes cooking, drying, smoking and fermentation.
Emissions include CO_2 from energy use, as well as some methane and nitrous oxide from wastewater systems.
Processing emissions are increased for prepared foods such as ready meals or pre-cooked vegetables, but industrial processing is more energy efficient than household processing due to scale and cost-efficiency drivers.

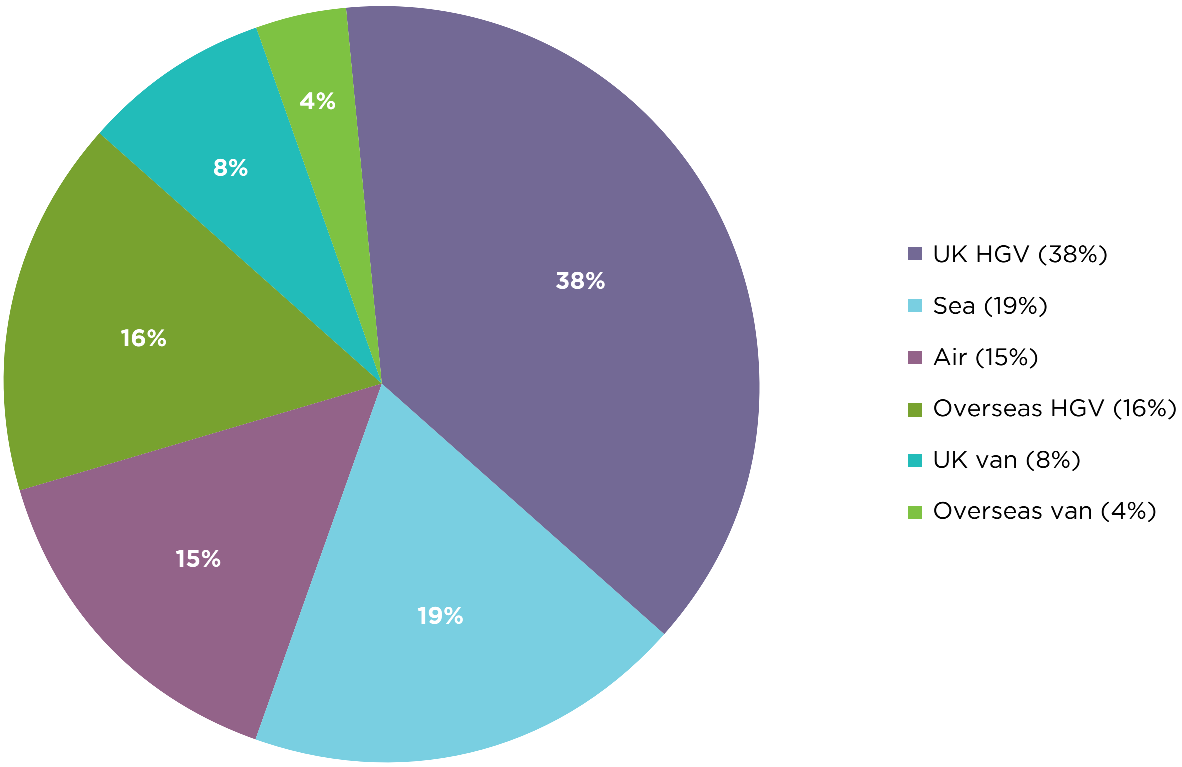
2.33 Packaging: 5% (7.5mt CO_2e)

Packaging is used at all stages in the food supply chain in order to protect products and extend transportation and shelf life – 30% of packaging waste occurs prior to the consumer stage.[12]
GHG impact of packaging is a function of quantity of packaging used, materials used in packaging, and whether packaging is recycled or reused.
There may be less need for packaging in short supply chains.

2.34 Transport: 7% (10.5mt CO_2e)

Food transport GHG impacts differ considerably depending on mode of transport. The same amount of fuel can transport 5kg of food 43km by air, 740km by truck, 2,400km by rail and 3,800km by ship.[13]
46% of transport emissions are related to UK road transport, 20% to overseas road transport, 19% to sea and 15% to air transport.[14]
Air freight has the highest impact of any commercial food transport mode, accounting for around 1% of food tonne kilometres but 15% of food transport CO_2 emissions.[15]

Figure 4: GHG emissions from transport of food consumed in UK (Defra 2012b)



[12] WRAP 2010
[13] Brodt 2007
[14] Defra 2012b
[15] Defra 2012b

2.35 Retail (including driving to shops): 8% (12mt CO_2e)

Retail GHG impacts are dominated by refrigeration, with energy for refrigerated display cabinets accounting for 40% of retail emissions, and refrigerant leakage accounting for a further 43%.[16]

Impacts vary depending on store type: refrigeration makes up 25-30% of energy consumption for hypermarkets but over 60% for convenience store formats.[17]

Other impacts include heating, ventilation and air conditioning, lighting & plastic bags.

The average distance driven per car driver per year for food shopping is 168 miles, accounting for 1% of total food system GHGs.[18]

2.36 Home energy use: 21% (31.5mt CO_2e)

Calculations for this report show that refrigeration (including both chilling and freezing) in the home accounts for 11% of food GHG emissions, while cooking accounts for 10%.

Cooking is split between gas and electric: 36% of domestic ovens and 55% of hobs are gas.[19]

In 2009, hobs accounted for 8TWh of energy use, ovens for 6.5TWh, electric kettles for 4.3TWh and microwave ovens for 2.4TWh.[20]

Habits and behaviour, energy efficiency of household products and rate of renewable energy use are all factors in GHG emissions from home energy use.

In 2012, 4.1% of UK energy consumption came from renewable sources.[21]

2.37 Hospitality and food sector cooking and refrigeration: 4% (6mt CO_2e)

Around 40% of energy use in the catering sector is attributable to cooking and refrigeration.[22]

This analysis does not include emissions from other kinds of energy use in the catering sector, which would raise the contribution of this sector substantially.

For example, space heating is responsible for 17% of energy use, water heating for 16%, and lighting for 10%.[23]

60% of energy use is electricity, with oil and natural gas providing the remainder.[24]

2.38 Landfill food waste disposal: 2% (3mt CO_2e)

Food waste sent to landfill from household and catering emits methane, a highly potent GHG.

Currently around 90% of food waste goes to the sewer or landfill.[25]

16 Defra 2008
17 Tassou et al 2011
18 Defra 2012b
19 Defra 2009
20 Defra 2009
21 DECC 2013
22 Carbon Trust 2012
23 Carbon Trust 2012
24 Carbon Trust 2012
25 WRAP 2013a

Land cover change – the hidden driver of GHG emissions

The figures in this report do not include GHG emissions from land cover change. However, deforestation, forest degradation and peat land degradation driven by agriculture are major global sources of GHG emissions, estimated to account for some 12% of total anthropogenic GHG emissions (Van der Werf et al 2009).

Three quarters of land cover change is attributable to agriculture. Although the science is still relatively uncertain, some studies suggest that including land cover change could increase the total contribution of the food system from 20% to 30% of global anthropogenic greenhouse gas emissions. UK food consumption may be responsible for up to 100mt CO_2e from land cover change (Audsley et al 2009).

Emissions from land cover change are hard to attribute to specific food categories using a FoodPrint type methodology. However, it is known that deforestation for agricultural land is driven by increasing global demand for food, and that in particular, cattle grazing and soybean cultivation for livestock feed are major factors in Latin America, while palm oil is a major factor in Asia.

The FCRN/WWF study 'How Low Can We Go?' (Audsley et al 2009) concluded, however, that transferring consumption away from products directly linked to deforestation would do little to reduce the underlying drivers of deforestation, and that there was additionally a need for market based approaches including certification and moratoria, alongside top-down governmental efforts to prevent deforestation.

2.4 What is known #2: System-wide processes

Looking at lifecycle stages helps to understand the breadth of processes and actors involved in food system GHG emissions, but is only part of the analytical toolkit available. A number of important factors in GHG emissions from the food system span multiple life cycle stages. Being able to home in on these cross-cutting issues – refrigeration, energy use, food waste and dietary choice – opens up new pathways for mitigation that might be missed from looking just at lifecycle stages.

2.41 Refrigeration

The UK food supply chain is highly dependent on refrigeration. From the point of harvest onwards, refrigeration is used during food transportation, manufacturing, and retail, as well as in domestic and catering contexts.

Refrigeration GHG emissions come from both energy use and the leakage of refrigerants gases, which can have global warming potentials thousands of times greater than CO_2.

Leakage in refrigeration systems can commonly be as high as 10-30%, but could be reduced to between 1 and 5%.[26]

Garnett (2007) estimates that refrigeration is responsible for as much as 3-3.5% of the UK's total GHG emissions.[27]

Exact data on the total contribution of refrigeration is uncertain but likely to be between 15-20% of food system GHG emissions.[28]

2.42 Energy use

Energy use in the form of transportation fuel, electricity and gas for processing and cooking, and electricity for refrigeration is a major cross-cutting factor in food system GHG emissions.

The food system is responsible for 18.75 GJ (gigajoules) (5.2MWh) of energy use per person per year in the UK, or 1.2 billion GJ (333 million MWh) for the whole country. This is between 10-20% of total UK energy use.[29]

Agriculture and fisheries are responsible for around 25% of energy use, with processing, distribution, retail, preparation and cooking taking up a larger share.[30]

It is calculated that as much as 46% of food system GHG emissions may be associated with the use of electricity and gas and 10% associated with vehicle fuel.[31]

2.43 Consumer waste

Up to one third of food produced globally is never eaten, leading to significant GHG emissions and resource use occurring for no nutritional benefit – recycling this waste through composting or anaerobic digestion only makes a small contribution to reducing this impact.[32]

Food waste occurs at all stages in the supply chain, from primary production to manufacturing, retail and household level.

In the post-production supply chain, the smallest component of total waste is within distribution and retail, at 3%. 32% of post-production waste occurs during processing and manufacturing, while around 65% occurs at consumer stage.[33]

Of this, households produce around 7 million tonnes of food waste every year,[34] while hospitality and food service produce an additional 0.9 million tonnes.[35]

The FoodPrint calculations show that avoidable food waste from households and catering is responsible for 14% of food-related GHG emissions.

[26] Defra 2012b

[27] Garnett 2007

[28] 11% from home refrigeration, 6.5% from retail, and an unknown proportion from transport, processing and primary production stages. Garnett (2008) puts the figure at 15%.

[29] Tassou 2014

[30] FAO 2011

[31] Vehicle fuel calculation assumes primary production stage accounts for 3mt emissions, transportation for 10.5mt, and driving to shops for 1.5mt. Electricity and gas calculation assumes 6.3mt from primary production, 16.5mt from processing, 5mt from packaging, 5mt from retail, 37.5mt from cooking and refrigeration.

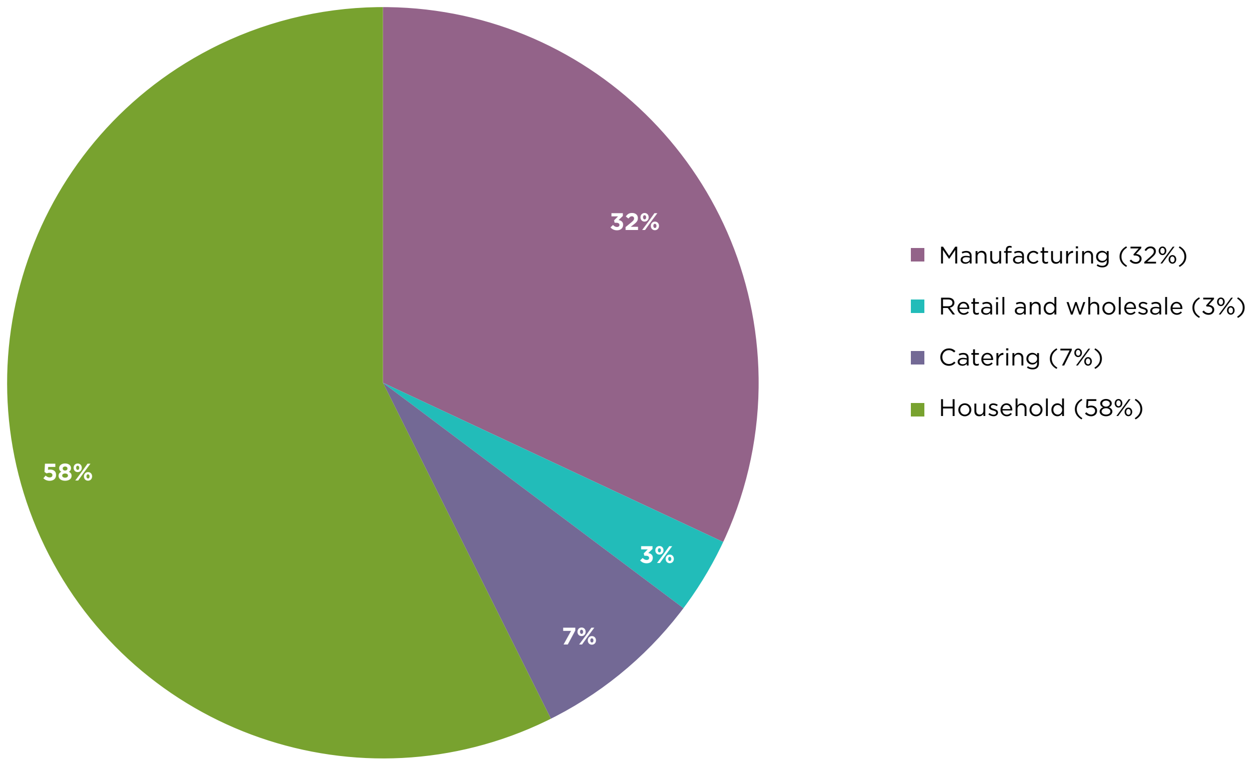
[32] Bond et al 2013

[33] Bond et al 2013

[34] WRAP 2013a

[35] WRAP 2013b

Figure 5: Sources of food waste post primary production[36]



2.44 Dietary choice

On average in the UK we each consume around 540kg of food and drink every year[37], with significant variation in individual diets.

Because different foods have very different emissions profiles, dietary choice has a huge impact on overall GHG impacts.

The choices made by individual consumers are the engine driving food system emissions – changing demand changes the whole system.

The FoodPrint tool has been used to show the contribution of different food groups to GHG emissions, compared to the percentage of diet they constitute both by weight and by calorific contribution, see Table 1 and Figure 6 overleaf.

Kilograms and calorific value are crude measures of nutritional adequacy, but are included in this comparison in order to demonstrate that a calorie of one type of food may have very different GHG impacts to another type.

Other research has investigated the links between healthy and sustainable diet. There is not always a direct correlation – high sugar products have a low GHG footprint but poor health outcomes for example.

Overall, meat products and ready meals have a disproportionately high GHG impact compared to their nutritional benefits. Diets with high levels of meat consumption have an emissions footprint almost 2.5 times higher than vegan diets. A low meat diet reduces emissions by a third compared to a high meat diet.[38]

[36] WRAP 2013a, 2013b, 2013c

[37] Based on Defra's figure for food purchases (660kg per person per year) with average wastage rates applied from WRAP 2013a and 2013b

[38] Scarborough et al (2014)

Figure 6: Comparison of kg consumed, calories and GHG

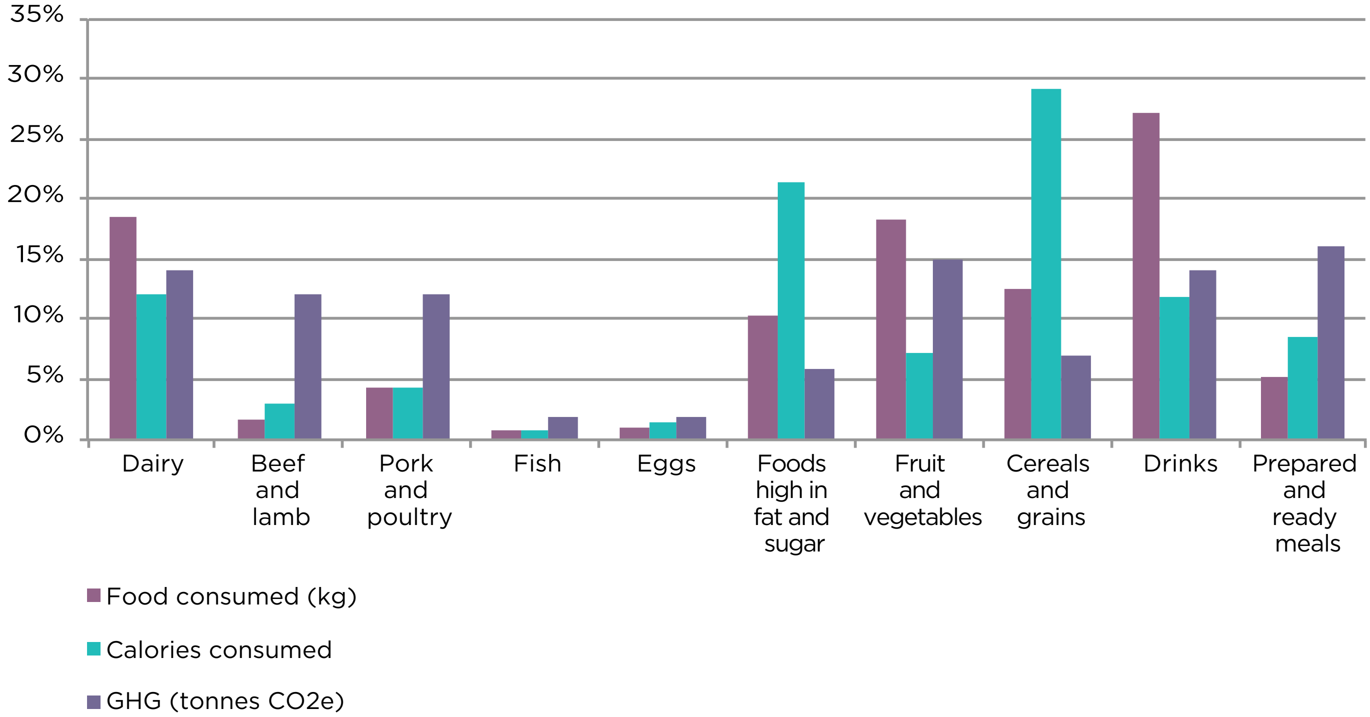


Table 1: Comparison of kg consumed, calories and GHG for selected food categories (excerpts from Figure 6)[39]

	% total food consumption (by weight)	Contribution to overall calorific intake	Contribution to greenhouse gas emissions
Beef and lamb	2%	3%	12%
Dairy products	19%	12%	14%
Ready meals and prepared food	5%	8%	16%
Foods high in fat and sugar	10%	21%	6%
Cereals and grains	18%	29%	7%

[39] Figures produced using the FoodPrint calculator

2.5 What this tells us

2.51 Some things count a lot more than others

These ways of breaking down the food system into its component pieces show just how many different factors are at play in contributing to overall food-related GHG emissions. But it also shows that some factors have a bigger impact than others:

Primary production (42%) and household energy use (21%) are the life cycle stages responsible for the biggest individual contributions to emissions. Other stages are relatively much smaller.

Land cover change is a hidden cause of food-related GHG emissions, responsible for additional emissions equating to as much as another two thirds of direct emissions.

Refrigeration, energy use, food waste and dietary choice are all responsible for significant emissions across the life cycle. Emissions from refrigeration, for example, are likely to be larger than those from packaging and transportation put together.

2.52 Some things aren't as might be expected

These figures provide an opportunity to interrogate proposed and existing mitigations of GHG emissions to examine their potential. Sometimes the results are surprising:

Although excessive **packaging** is seen as a major issue, total packaging emissions are a relatively small part of the total, and packaging is often important to protect food and prevent wastage. This does not mean that excess packaging should not be minimised, of course, but simply that the potential gains in this area might be smaller than if efforts were concentrated on other parts of the supply chain.

Transport is another example. Sourcing food locally does offer considerable benefits to the local economy and communities but in fact has very little impact on overall GHG emissions in its own right. This is partly because food transport is a relatively small contributor to the total, but also because local modes of transport, like small vans and trucks, are much less efficient than long-distance transportation like articulated lorries and container shipping.

Organic agriculture minimises the use of artificial inputs, which are energy intensive to produce. It also reduces nitrous oxide emissions associated with fertiliser applications. However, inputs are only part of the picture, and overall emissions per kg of organic produce are sometimes the same or higher than for conventional produce. Emissions from organic livestock can also be higher due to longer animal lifespan and lower feed conversion efficiency. Overall, there is significant variation within the broad categories of 'conventional' and 'organic' and there is currently no expert consensus that conversion to organic agriculture would offer net benefit in terms of reduced GHG emissions on a global scale.[40]

There are good reasons for adopting many different interventions into the food system – for example, adopting organic methods in order to increase on-farm biodiversity, protect soils, enhance animal welfare and reduce the pollution of local watercourses – but not all interventions make a significant contribution to reducing GHG emissions. Clarity is needed on why certain actions are chosen and what the aims and achievements of these actions might be.

[40] See for example the meta-analysis by Tuomisto et al 2012. As the paper makes clear, organic farming is normally shown to have positive impacts if measured per unit of area, but not necessarily when measured per product unit, the approach taken in this report.

Seasonal UK produce

Food transport emissions are an important consideration, but where we source our food from is just one factor within a complex system making up GHG impacts of products. A recent study, 'AEA (2008)', for example, found that total emissions from UK tomatoes were on average 3-5 times higher per kg than for tomatoes imported from Spain, because although there are additional transport emissions for Spanish imports, these are more than offset by the energy embodied in the construction of UK glasshouses and the energy used to heat them. The same study also found that emissions from transporting lamb from New Zealand were offset by lower emissions in the production stage of NZ compared to UK lamb.

There are many contours to the debate about where we should get our food from – how efficient is the production of lamb in different climates, how long are European apples kept in energy-intensive cold storage, are UK tomatoes produced in glasshouses using waste heat from power stations? Further questions bring in not just GHG emissions but also, for example, other environmental impacts such as the high levels of pesticide and water use in Spanish tomato production. These complexities tell us that there are no hard and fast rules – local or UK produce is not going to be better in every case. But as a general guide, it remains true that seasonal UK produce is likely to result in overall net GHG benefit. Secondly, it is shown without doubt that airfreight has the largest emissions per tonne-km of all food transport types: transporting food by air should be avoided wherever possible, and reduced over time.

This report is aimed at the LEP and its partners in Cheshire and Warrington. It is easy to think that because the bulk of food consumed is not produced in the area, that there is little leverage available to reduce food system GHGs.

In fact, when retail, travel to shops, cooking, refrigeration and waste disposal are all taken into account, as much as 35% of Scope 1 and 2 emissions are likely to occur very close to home.[41] 14% of emissions are caused by avoidable waste at consumer and catering level.[42] Dietary choice by consumers is another factor highly amenable to local influence, and a major driver of emissions throughout the supply chain: for example, minor changes like adopting a meat-free day could reduce emissions by as much as 4%.[43]

'Minor changes could reduce emissions by as much as 4%. So there is an opportunity for us to make a difference'.

[41] Figures from FoodPrint Calculator

[42] Those occurring as a direct result of activities in the region, rather than 'embodied' in products brought into the region

[43] Figures from FoodPrint Calculator

3.1 Basic principles

Turning the potential for change into reality requires a disciplined approach. It is essential that the actions chosen will actually make a material difference, and they also need to make practical sense locally – that is to say that they have a chance of being put into action. These principles can be called, respectively:

Materiality – The extent to which an action or intervention would count if it were implemented, and;

Resonance – The extent to which the action or intervention reflects the interests and concerns of the people and businesses who will be involved in taking action.

In this section the range of options that are available is identified, and their potential impacts evaluated. An evaluation matrix is then set out, based on Materiality and Resonance, which can be used for weighing up local decisions about how to act to reduce GHG emissions in the food system.

3.2 A menu of options

The menu of GHG-cutting options is based on the most significant hotspots identified in Section 2. Each hotspot has multiple points of intervention with varying degrees of impact in reducing emissions from the total. Where possible numbers have been provided to quantify the potential of mitigation measures. Some measures are more technical – like improving the timing and dosage of fertiliser applications on farms – while others require greater degrees of behavioural change – like changing the amount of meat we eat. Three themes emerge from this section:

1. **There are no silver bullets**: There are some areas where more impact can be realised than others, but achieving the scale of change necessary will require action on many fronts.
2. **Look for the synergies**: Creating change is always difficult, but there are areas where actions to reduce GHG can also help cut costs for farmers or manufacturers, for example, or improve the health of citizens. These are good starting points.
3. **All change is behavioural**: Even the most technical sounding interventions require buy-in and support from those who will implement them. Consider the local conditions and the interests of stakeholders in order to turn hypothetical improvements into real actions.[44]

Mitigation measures

Based on an assessment of the hotspots and cross-cutting factors that account for the highest proportions of GHG emissions and also have considerable potential for emissions reductions, the following five areas are considered most promising. Potential mitigations relating to these are explored further in Sections 3.21 to 3.25. For the first three areas, quantifications are provided of the potential of specific mitigations to reduce emissions relating to food consumption.

1. **Cutting food waste**
2. **Reducing consumption of animal proteins**
3. **Decarbonising the energy supply**
4. **Interventions in UK agriculture**
5. **Addressing land cover change**

3.21 Cutting food waste

Mitigation measure (100% adoption)	Food consumption GHG emissions reduction
Eliminate avoidable food waste in catering sector	2%
Eliminate avoidable food waste in households	13%
Reduce all avoidable household and catering food waste by 50%	8%

Table 2: Potential GHG reduction from cutting food waste

[44] See recent report ‘Change matters: understanding low carbon behaviours’ (ESTA 2014)

1. **Manufacturing, retail and wholesale**:[45] There is scope for food waste prevention in the supply chain, though less than in households and the catering sector. A significant proportion of manufacturing waste is from inedible parts of produce and thus classed as unavoidable. In addition to the 3.9 million tonnes of food waste from manufacturing and 0.4 million tonnes from wholesale and retail, a small amount of food (roughly 2,000 tonnes from grocers and slightly more again from manufacturers) that would otherwise be classed as waste is redistributed through charities and food banks, e.g. Fareshare.[46] An additional 2 million tonnes from manufacturing, officially classed as by-product rather than waste, goes to animal feed.[47]

2. **Catering sector**: While waste in the Hospitality and Food Service (HaFS) sector is a relatively small proportion of overall post-production food waste (7.4%), this 0.9 million tonnes has an estimated cost to the sector of £2.5 billion. 75% of this waste is avoidable and could have been eaten, with on average 21% of waste arising from spoilage, 45% from food preparation and 34% from consumer plate waste. There is considerable scope for reductions in food waste and concurrent cost savings – just a 5% reduction in food waste could save the sector £125 million a year. Menu planning, demand forecasting, food preparation, food storage best practice and staff and consumer behaviour all have potentially significant impact.[48]

3. **Household food waste**: The single largest contributor to food waste in the UK, the 7 million tonnes of food waste thrown away by households in 2012 would fill Wembley Stadium nine times over. Around 19% by weight of all food brought into the home is wasted, of which 60% is avoidable.[49] Avoidable food waste costs the average household £470 a year, around 14% of the shopping budget – this is equivalent to throwing away six meals a week per household.[50] By weight the top five largest contributions to avoidable food waste in 2012 were from:

Bread
Fresh potatoes
Milk
Home-made and ready meals
Carbonated soft drinks

In terms of mitigation, the reason given for around 50% of avoidable food and drink waste is that the product had gone off or passed the date on the packaging, and a further 30% was classified as 'cooked, prepared or served too much'. Concentrating on these issues is thus likely to yield the greatest reductions in household food waste.

Food waste is now receiving increasing attention at national level, with research efforts spearheaded by WRAP, who have also led the creation of the Hospitality and Food Service Agreement (www.wrap.org.uk/content/hospitality-and-food-service-agreement-3),[51] aiming to reduce food and associated packaging waste generated by the sector by 5% by 2015, compared to a 2012 baseline. The voluntary Courtauld Commitment (www.wrap.org.uk/category/initiatives/courtauld-commitment)[52] covers the grocery sector, and for consumers, WRAP has developed the national Love Food Hate Waste campaign.[53] Additional approaches could include publicity, infrastructure and work with retailers at a local level.

[45] It should be noted that the food waste data does not include on-farm food losses including contractual losses e.g. plough-back, grading losses etc. as no reliable data sources exist for such waste. However as of autumn 2014 WRAP have commissioned work in this area.

[46] WRAP 2013c

[47] WRAP 2013c

[48] WRAP 2013b

[49] WRAP 2013a accounts for all data under heading 3

[50] WRAP 2013a accounts for all data under heading 3

[51] www.wrap.org.uk/content/hospitality-and-food-service-agreement-3

[52] www.wrap.org.uk/category/initiatives/courtauld-commitment

[53] www.lovefoodhatewaste.com

3.22 Reducing consumption of animal proteins

Mitigation measure (100% adoption)	Food consumption GHG emissions reduction
Reduce meat and dairy consumption by 20%	4%
Reduce meat consumption by 50%	10%
Adopt vegetarian diet when eating out	3%
Adopt vegetarian diet	26%
Adopt vegan diet	36%

Table 3: Potential GHG reduction for reduction of consumption of animal proteins

The impact of dietary change on GHG emissions is a complex area to think through, as there are many possible different scenarios for adjustments to the current dietary mix, all of which must juggle multiple social and economic factors as well as ensuring that reductions in consumption of certain food categories are compensated by increases in other food types so that diets remain balanced and nutritious. There is no consensus as to exactly what alternative diets should look like, however, it is becoming clear that reduction in meat consumption is a priority across most scenarios.[54]

One of the most in-depth approaches to the modelling of a ‘healthy and sustainable’ diet is presented in the *Livewell Plate* report commissioned by the WWF,[55] which suggests that consumption of meat products be reduced to only around 4% of the average dietary intake (their estimate of current meat consumption is 16%), with a compensating increase in bread, rice, pasta, potatoes and other starchy foods, as well as an increase in fruit and vegetables. This could result in GHG reductions of 25%.

How such dietary changes might be achieved is, however, also a complex question and a live topic for research. The majority of people are unlikely to change their dietary choices for purely environmental reasons. Health and affordability offer useful synergies for promoting change – diets with lower meat consumption are also likely to be healthier and cheaper. Existing initiatives have great potential for further expansion – for example, if an entire population adopted a programme like Meat Free Mondays, GHG savings of 4% could be achieved.[56] School and other caterers are good venues to roll out this approach.

In addition to awareness raising and enabling approaches to change, it is likely that fiscal and regulatory measures will need to be considered. There is currently little evidence of effectiveness of most of these kind of measures and there is significant risk that any interventions may have unwanted side effects, for instance if interventions to raise the price of meat have the effects of encouraging people to eat the same amount of less healthy meat, rather than reduced overall consumption of higher quality healthier meats.[57]

[54] Garnett 2014a

[55] Macdiarmid et al 2011

[56] Estimate assumes 1/7 reduction in meat consumption across population www.meatfreemondays.com

[57] Garnett 2014b

3.23 Decarbonising the energy supply

Mitigation measure (100% adoption)	Food consumption GHG emissions reduction
100% renewable energy in households	21%
100% renewable energy in catering sector	4%
UK meets 2020 renewable energy target (15%)	5%

Table 4: Potential GHG reduction through energy reduction

Energy use cuts across all stages of the supply chain from primary production through manufacturing to retail and household level, though the analysis suggests that household refrigeration and cooking is amongst the biggest single contributors while the farm-level contribution is relatively small.

Energy efficiency:
In the home and in food manufacturing, catering and retail, energy efficiency of appliances, machinery and processes can reduce GHG emissions and cut costs. Energy savings of 20-50% can be made through efficiency measures to existing commercial refrigeration systems, while commercial induction hobs can use 15-50% less energy than conventional gas or electric and new specification deep fat fryers use up to 50% less energy.[58]

Behaviour change:
At the level of household and catering sector, reductions may still be achieved through behaviour changes such as avoiding over-filling pans and kettles with water and making sure equipment is turned off when not in use.

Renewable energy generation:
Renewable energy generation on farms is mentioned in Section 3.24, and food manufacturing and retail sites may also have large roof areas with potential for solar energy generation.

Decarbonisation of UK energy supply:
Ultimately the largest reductions in food system energy use can only be achieved through decarbonisation of the UK energy supply. The UK is legally committed to meeting 15% of energy demand from renewable sources by 2020, with the figure currently standing at around 5%.[59]

[56] Carbon Trust 2012
[57] DECC 2013

3.24 Interventions in UK agriculture

Between 1990 and 2011, GHG emissions from UK agriculture fell by 20% due to a reduction in animal numbers and a decrease in fertiliser use.[60] Seen from a global perspective, however, only part of this can be said to be a genuine reduction in impact, since declining livestock production in the UK will have been compensated by increases elsewhere (e.g. Latin America). Five main approaches to achieving further reductions have been identified – further work would be required to quantify the mitigation potential of each.

Increase efficiency:
The main approach advocated by the voluntary industry-led Greenhouse Gas Action Plan (GHGAP)[61] applies to both crop production and livestock so has potential to impact on both nitrous oxide and methane emissions. In addition, it implies no necessary economic burden on farmers since increased efficiency reduces input costs. The two central planks of this approach are:

- Improved timing and dosing of fertiliser application
- Improved livestock feed conversion ratio (the amount of feed needed to produce 1kg of final product) through breeding or feed reformulation.

Reduce ruminant emissions:
Reduced methane emissions from ruminant livestock can result from improved feeding practices, the use of dietary additives, and changes in management and breeding.

Reduce wastage and crop loss:
Crop losses due to weather, weeds, pests and diseases are lower in the UK, at 15-20%, than elsewhere in the world (over one third in other industrialised countries and over one half in the developing world), but are still substantial.[62] Contractual arrangements with UK supermarkets, including 'On-Time In-Full' (OTIF) contracts and high aesthetic quality standards also result in edible crops being used as animal feed or ploughed back into the ground. Mitigation measures include improved varieties and management practices, changes to supermarket contracts and the creation of alternative markets for excess produce.

Carbon sequestration:
Soil management practices including crop rotations, cover crops and conservation tillage have potential to increase the amount of carbon stored in agricultural soils, in addition to sequestration through field margins and woodland areas.

Energy generation:
While on-farm energy use is a comparatively small contributor to agricultural GHG, farms can offer potential for renewable energy generation, either through installation of small or large-scale solar and wind, or through sending manure, slurry, waste and by-products to anaerobic digestion, which may have the additional benefit of avoided emissions compared to other waste management practices.

[60] DECC 2014
[61] NFU 2010
[62] Bond et al 2013

3.25 Addressing land cover change

Direct emissions from UK food consumption come to 150 million tonnes CO_2e every year, to which land cover change could add a further 100 million tonnes, although estimates still vary. It is clear that emissions related to land cover change are a major component of total global emissions and that food production is heavily implicated. Three main drivers link UK food consumption to deforestation, forest degradation and peat land degradation:

Direct consumption of palm oil, soy and meat products produced in previously forested areas.
Soy meal used as the main protein source in most livestock feeds in the UK.
Consumption creating increased demand for land, a driver of agricultural expansion at global level.

Ultimately, measures must be put in place in producer countries to effectively monitor and protect valuable ecosystems. However, a number of UK-based measures also have potential to reduce land cover change driven by food consumption. Further work would be required to quantify the mitigation potential of each.

Certification: To ensure that no palm oil or soy potentially implicated in land cover change is included in products, UK food manufacturers should purchase only ingredients certified by Roundtable on Sustainable Palm Oil (RSPO) or Round Table on Responsible Soy (RTRS).
Product reformulation: Given limited availability of certified and traceable products UK food manufacturers could substitute risky ingredients like soy and palm oil with alternative functionally similar ingredients from trusted sources.
Alternative livestock feed ingredients: Soy is a cost-effective and nutritionally optimal protein ingredient in livestock feed, but there is potential for replacing small amounts with alternative home-grown proteins, for example legumes such as beans or lupins. Other future scenarios include insects as a component in animal feed.
UK grass-fed livestock: Extensive grass-fed livestock on pasturelands reduces demand for feed – although grass-fed livestock from abroad may be grazed on previously forested land. Buyers of imported beef should aim to ensure it is from non-deforestation source, e.g. new Rainforest Alliance certification for Brazilian beef.
Increased food production efficiency: Also known as sustainable intensification, producing more food from the same land area across all UK food production is proposed as a vital strand of policy to reduce demand for further agricultural expansion overseas.
Reducing meat consumption: See Section 3.22.

3.3 Deciding what to do

This report aims to help the LEP and its partners to identify actions that have a good chance of making a real difference to GHG emissions. This starts with a proportionate understanding of where emissions arise in the food system.

This process needs to be carried out by the people who will actually be involved in taking action. In this section, a framework is outlined that can help the decision process.

It is recommend that a simple two-step approach to options appraisal is used, based on applying the principles of **Materiality** (making sure it counts) and **Resonance** (making sure it makes practical sense to people and businesses). The two steps are illustrated in more detail in Figure 7 on page 32.

It is then important to understand the general kinds of options that might be available. Deciding how to put this into action requires a more practical analysis of options, based on local resources, issues and opportunities.

1. **Options generation**. This matches up the general menu of GHG interventions outlined in this report with local conditions in order to create a long-list of practical options. The objective is to turn broad recommendations, such as a change in diet, into something specific and actionable. For example, 'the local education authority will work in partnership with company x, its catering supplier, and local NHS clinical commissioning groups to devise and deliver school meals with more fresh vegetables and less meat, but meat of better quality.'
2. **Options evaluation**. This is about weighing up which options would be best to go with. The use of a very simple 'matrix evaluation' is recommended to systematically evaluate materiality and resonance, and then rank options based on a combination of both factors. A blank version of a matrix designed to assist in the appraisal of options is provided in Appendix 1. A completed example is also included, as a guide.

Food waste: acting where it counts

Food waste is a good example of where a focus on materiality can help us to make sure time and resources are used on action that really counts.

It is common knowledge that it's good to avoid wasting food, and also that any food that is wasted should be composted, or diverted to an anaerobic digester to generate energy, rather than going to landfill.

Both avoidance and recycling seem compelling in their way. The idea of generating energy from waste, rather than emitting methane from a landfill site, makes the composting/Anaerobic Digestion (AD) option seem an especially attractive option.

But the numbers tell a different story. Even just cutting the avoidable food waste from domestic consumption would be five times more effective than getting rid of all the GHGs associated with the process of food disposal.

The point is that the vast majority of the GHGs that arise from food have already been emitted by the time they reach our plates. So there's nothing much left to save by the time it reaches landfill.

So, while AD and composting brings some small benefits, the issue is that it can create an illusion that the issue of waste is being addressed. To reduce emissions from food waste there is a need to focus on food waste reduction.

Figure 7: Options Appraisal

Step 1: Options generation

GHG hotspots (Materiality)

Consider:

1. Generic hotspots, such as food waste, diet – things that we know in general have a significant impact on emissions.
2. Specific hotspots – things we know about the region's food system that have a more significant than usual impact on emissions.

Local conditions (Resonance)

Consider:

1. **Industry** – what sorts of businesses operate locally, what types of action are they likely to be interested in?
2. **Pubic sector** – what sort of leverage does the public sector have locally, e.g. is there scope to change public procurement policy.
3. **Population profile** – are there local cultural or economic characteristics of the population that might influence the uptake of one initiative over another?

Practical options

Generate a long-list of practical actions and solutions that coincide with GHG hotspots and with local conditions.

A good way into this is to consider the generic options covered in this report, and to consider for each:

1. Does the hotspot apply more/less locally than it would nationally?
2. How might you imagine the action translating into action in your region? Who could you imagine wanting to do something about it?

Step 2: Options evaluation

Materiality

How much difference could it make?

Consider what proportion of the food system's emissions could be influenced by this action:

1. How big is the hotspot that the action addresses?
2. How much could it be reduced by this action?
3. Is it practical?

Materiality \ Resonance	Low	Mod	High
High	OK	Good	Best
Mod	Poor	OK	Good
Low	Worst	Poor	Good

Resonance

How likely is it to work?

Consider:

1. Are there businesses or other organisations who would take this up?
2. Does it reflect local issues?
3. Is there any interest already?

The area covered by the report corresponds to the Cheshire and Warrington LEP – comprising the boroughs of Warrington, Cheshire West and Chester, and Cheshire East. In terms of food systems and greenhouse gas emissions, the LEP is important both because of the impacts of consumption from its relatively significant population, and because of the importance of its agricultural – in particular dairy – sector. 76% of the Cheshire and Warrington's area is farmed, with agricultural activity concentrated in Cheshire East where 3.1% of the workforce is employed in agriculture – double the national average.

In this section the methodologies and insights from the rest of the investigation are applied to Cheshire and Warrington.

Details of the following are presented:

1. **'FoodPrint' findings – what are the GHG emissions from Cheshire and Warrington's food system?**

2. **Analysis of the options that could be taken forward to address emissions in Cheshire and Warrington's food system, and the extent to which this could make a difference.**

'On average people in the UK purchase around 650kg of food every year. Every week the average person spends £41 on food and drink'.*

*£29 at home, £12 eating out. This includes an average £6.50 spent on alcoholic drinks per person per week. (Defra 2012)

4.1 GHG analysis

4.11 Emissions resulting from the food eaten in Cheshire and Warrington

Adjusting data to the local context

In essence, the approach is firstly to establish as a baseline the emissions that would be expected from Cheshire and Warrington if it reflected national average figures. Reasons to apply any adjustments to this figure to reflect locally specific conditions are then considered.

The first step in the FoodPrinting analysis of Cheshire and Warrington is to create a picture of food consumption. The data used is derived from the Defra Family Food Survey.[63] To adjust these figures to local conditions a number of localised factors that could make a difference to the overall FoodPrint were considered. These were:

These were:

Dietary balance, based on the socio-economic profile of the population.
Food waste, how much is wasted, and how it is dealt with.
Sources of domestic energy supply (proportion that is renewable).

The availability of sufficient and reliable local data for these factors was also taken into account. The analysis found either insufficient evidence of impact or insufficient available data at a LEP level for any factor except socio-economic variation. Research suggests that at a LEP level there are unlikely to be significant differences in food consumption patterns compared to national average, a finding borne out by the analysis of socio-economic variance.

Socio-economic variance in food consumption in Cheshire and Warrington

Per capita food consumption for each food category was adjusted to represent local socio-economic profile using differences in consumption between income deciles recorded in the Defra Family Food Survey.

Income deciles categorise the population according to how much money people earn; splitting the population into 10 equally sized groups, ordered from 1 (lowest) to 10 (highest) income. Overall, the lowest income decile purchases 5.7% less food by weight than the highest. But there are also differences in particular food categories, for example, consumption of fish, fruit and alcohol is 30-40% higher than average in the highest income decile and a corresponding percentage lower than average in the lowest income decile. Consumption of high fat and sugar products is below average in high income deciles and above average in the lower income deciles. As direct data on the percentage of local populations falling into each UK income decile is not available, local occupational group data is used to derive these proportions.

[63] Defra 2012. Family Food asks 6,000 households every year to keep detailed records of quantities and expenditure for purchased food and drink both within the household and when eating out. Family Food uses a hierarchical coding scheme of approximately 500 different food codes. We have condensed these into 17 food categories useful for assessing consumption choices and related environmental impacts. For ease of interpretation these are further condensed into 10 categories in some graphs and tables in the report.

Figure 8: Cheshire and Warrington socio-economic profile

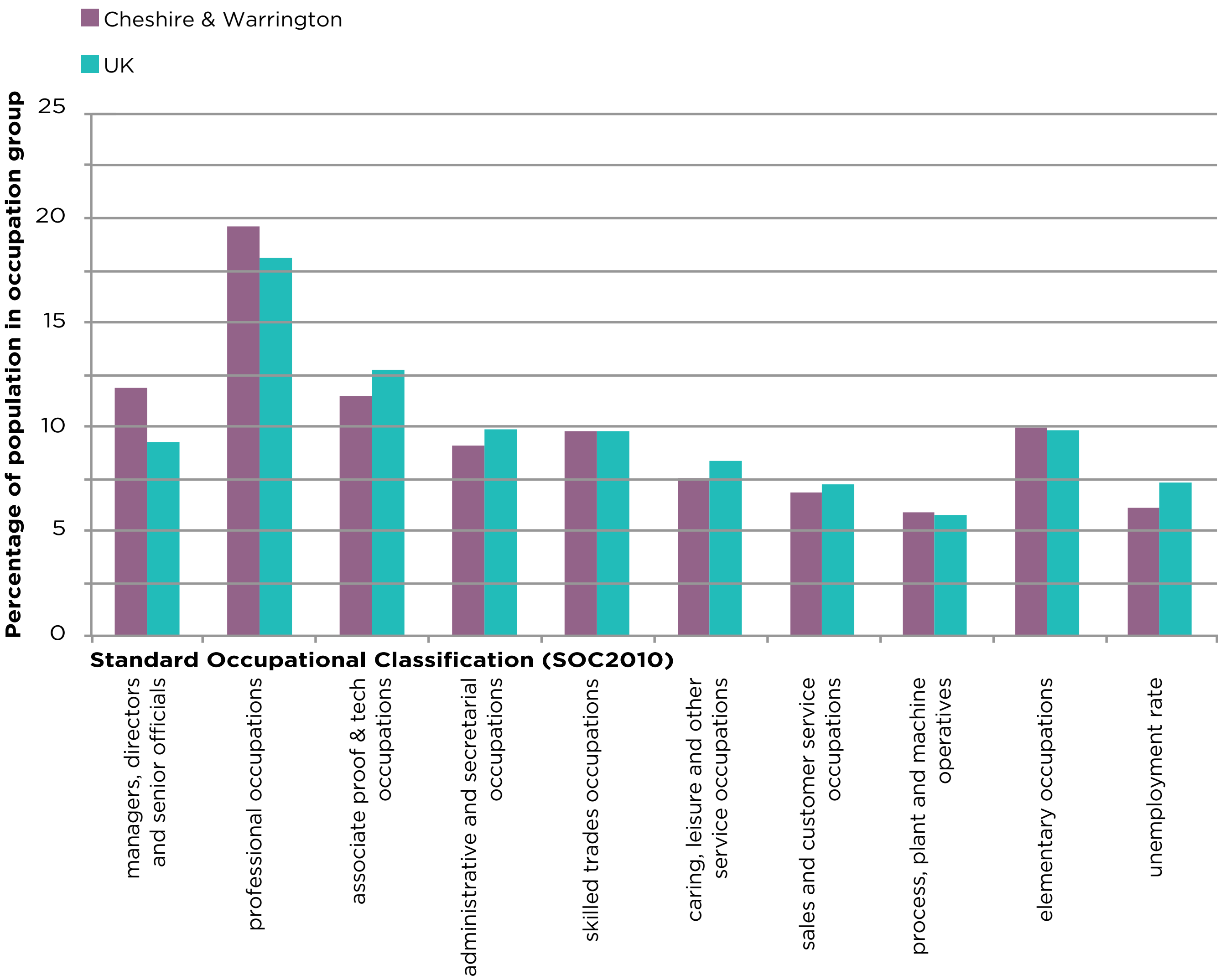
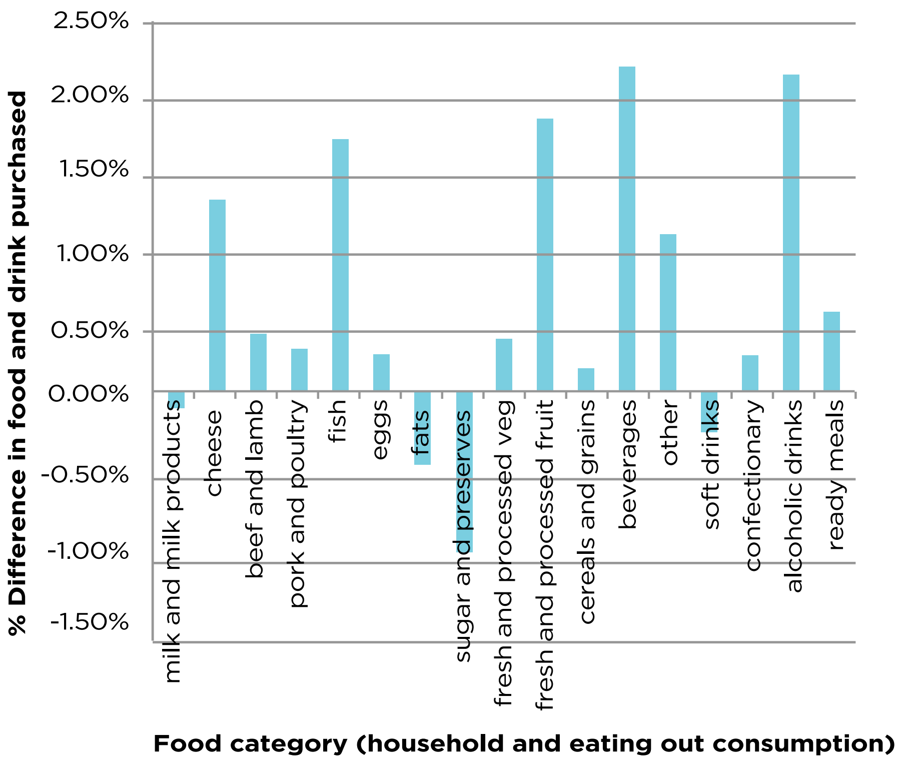


Figure 9: Cheshire and Warrington – Difference in consumption profile compared to national average



Cheshire and Warrington's socio-economic profile is skewed towards professional and managerial occupations, compared to the national average. There are comparatively fewer people in sales, service sector and administrative roles.
While there are differences in socio-economic profile in Cheshire and Warrington compared to the national average, the impact on aggregate food consumption patterns is too small to be considered significant.
Based on differences in consumption, per capita GHG emissions from Cheshire and Warrington differ from the national average by less than 1%.

Generating Cheshire and Warrington's FoodPrint

In order to calculate GHG emissions from Cheshire and Warrington's food system, average per capita food consumption figures were multiplied by conversion factors taken from studies of emissions from different stages of the supply chain.

Where possible a consistent data source was used for these conversion factors, listed in the references section.[64] Where a reliable data source for a particular life cycle stage could not be identified, figures were produced by applying a top-down generic assumption to all food categories. Since most conversion factors relate to specific products and the consumption data is based on 17 food categories, after reviewing the category contents one or more representative products for each category were selected, based on category composition and knowledge of the relative impacts component products. Where multiple products were included, a weighted average was constructed – for example the ruminant meat category includes a 3:1 ratio of beef to lamb based on consumption data.

Findings

Total annual GHG emissions related to food consumption by residents of Cheshire & Warrington are 2.4 tonnes per person or a total of 2.3 million tonnes CO_2e. This is equivalent to the annual emissions produced by around 600,000 cars (based on UK average mileage).

[64] Where available data relates to energy use rather than directly to GHG emissions, conversion factors appropriate to the energy source were taken from the Defra Greenhouse Gas Conversion Factor Repository.

Beyond GHGs…

In addition to GHG emissions, we used a similar methodology to model water and land requirements from Cheshire and Warrington's food consumption. This is important because these factors operate together in an interconnected nexus involving both synergies and trade-offs. Globally, land is becoming a scarce commodity, whilst agricultural water availability is increasingly marked by extremes, with growing incidence of flood and drought. As inputs to the farming system, management of water and land resources is essential for the commercial viability of agriculture.

Findings

It takes 152,000 hectares (587 square miles) of land to feed Cheshire and Warrington – that's around 66% of Cheshire and Warrington's land areas or 93% of Cheshire and Warrington's agricultural land.

Feeding Cheshire and Warrington requires 1,200 million cubic metres of water every year – the same as 470,000 Olympic swimming pools.

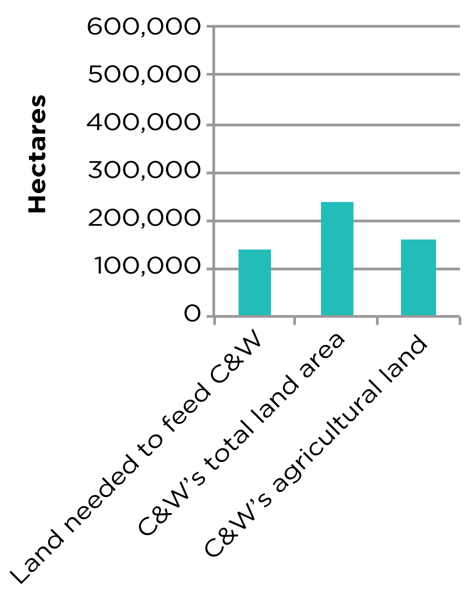
'As inputs to the farming system, management of water and land resources is essential for the commercial viability of agriculture'.

4.12 Emissions arising from farming in Cheshire and Warrington

In addition to emissions arising from food consumption, there are also significant emissions from food production in Cheshire and Warrington itself. 163,000 hectares, or around 80% of Cheshire and Warrington's land area is used for farming, and there are a total of 2,800 agricultural holdings.

Detailed data on agricultural activities at a local authority level produced by Defra[65] was used to calculate the emissions associated with food production in Cheshire and Warrington. Defra data includes figures for land area of different crop types, and number of livestock. These were used to produce greenhouse gas emissions figures by converting land areas and number of livestock into tonnage of harvested crops, meat, eggs and milk using Defra average yield figures for the UK, followed by applying GHG conversion factors from the literature.[66]

Figure 10: Cheshire and Warrington land requirements



Findings

Cheshire and Warrington's agricultural land is predominantly used for dairy and livestock, with some area of cereals, general cropping and mixed farming.

It is estimated that Cheshire and Warrington produces 5,500 tonnes of beef, 700,000 tonnes of milk, 11,000 tonnes of chicken meat, 18,000 tonnes of sheep meat, 165,000 tonnes of cereals, 169,000 tonnes of potatoes and 64,000 tonnes of maize every year.

For comparison, every year Cheshire and Warrington consumes 7,500 tonnes of beef, 93,000 tonnes of milk and 33,000 tonnes of potatoes.

Annual emissions from Cheshire and Warrington's agricultural production total 1.2 million tonnes CO_2e.

Agricultural production emissions are thus around 50% of food consumption emissions in Cheshire and Warrington.

[65] Defra 2010.

[66] Audsley et al 2009, and Sonesson 2009. NB these figures are therefore based on national average production methods and will not reflect localised differences (e.g. extensive vs intensive livestock production). This would be an interesting area for further studies to explore in more detail.

Figure 11: Cheshire and Warrington's agricultural land use profile

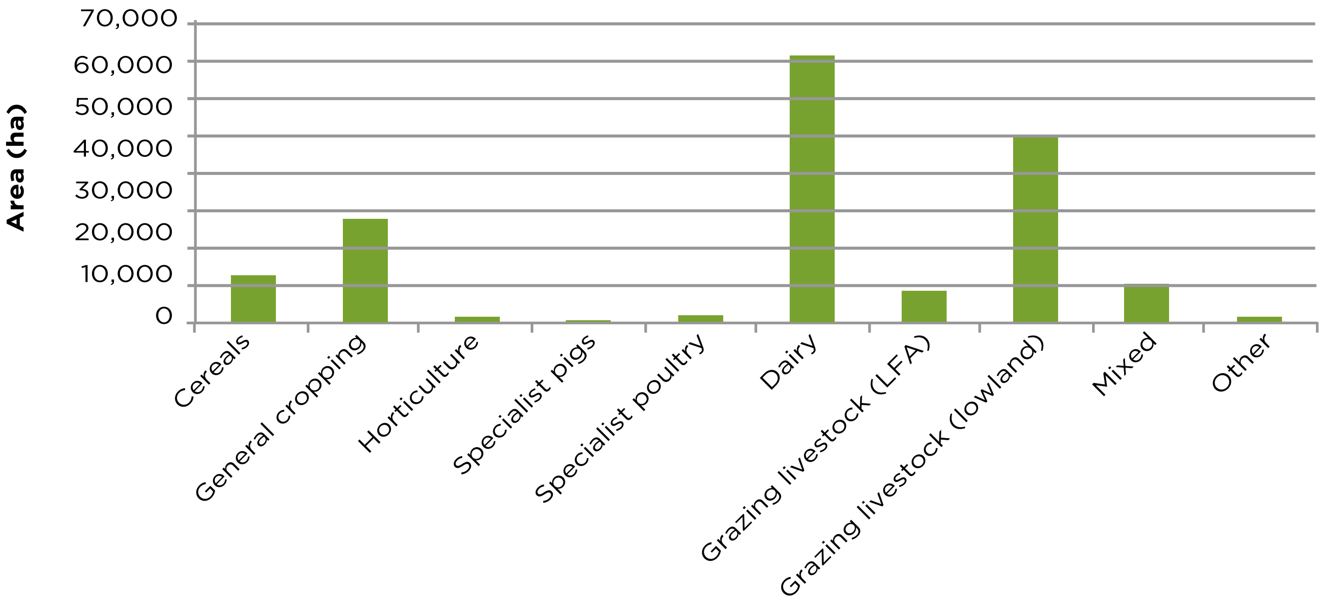
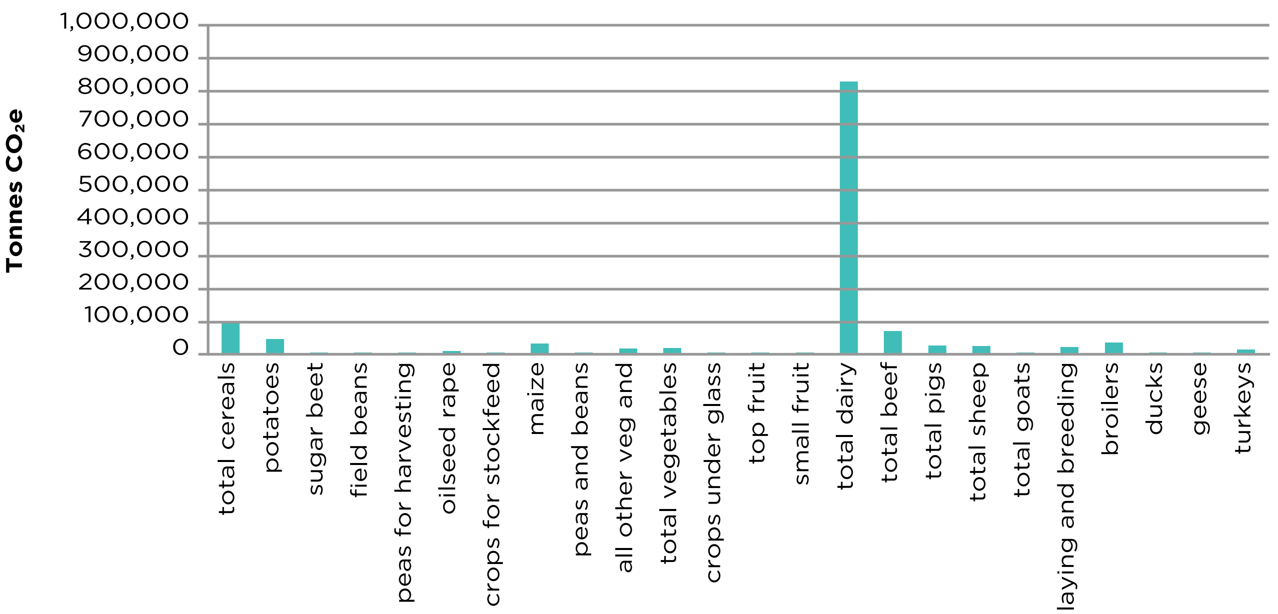


Figure 12: GHG emissions from agriculture in Cheshire and Warrington



4.2 Making a difference

There are plenty of hypothetical scenarios in discussions of how to improve the food system – the numbers tell us that if the whole of Cheshire and Warrington adopted vegan diets, 36% of emissions would be slashed, or that if only renewable energy was used for cooking and refrigeration, a further cut of 25% could be made.

'If these targets were met, they would cumulatively reduce food consumption GHG emissions by 15%, and food production GHG emissions by 8% or just over 400,000 tonnes CO_2e per year'.

4.21 How much difference could be made?

In fact, a renewably-powered, vegan Cheshire and Warrington with no food waste could reduce food system emissions across the whole supply chain by 76%. But as interventions these ideas fall at the first hurdle, practicality. A great deal of resources could be put into campaigning for these changes, with very little overall impact on emissions.

Instead, while keeping the big picture in mind, the approach advises starting where realistic differences can be made. Below is an Alternative FoodPrint Scenario that suggests a range of stretching but achievable targets in some of the areas where Cheshire and Warrington could make the biggest reductions, considered against current baselines.

These mitigations are designed to be challenging enough to create a focal point for collective action, but still within the realms of possibility. If these targets were met, they would cumulatively reduce food consumption GHG emissions by 15%, and food production GHG by 8% – a total of just over 400,000 tonnes CO_2e per year.[67]

Table 5: Cheshire and Warrington Alternative FoodPrint Scenario

Mitigation measures (100% adoption)	Additional GHG reduction – tonnes CO_2e	Cumulative total – tonnes CO_2e
Consumption: reduce meat and dairy by 20%, increase fruit, vegetables, cereals and grains by 20%*	66,000	66,000
Energy: Cheshire and Warrington meets national 2020 renewable energy target of 15%**	60,000	126,000
Food waste: eliminate 50% of avoidable food waste in household and catering***	171,000	297,000
Waste disposal: reduce disposal of food waste to landfill to below 20%****	27,000	324,000
Primary production: beef, sheep and dairy farms in Cheshire and Warrington meet 2020 emissions reduction targets*****	96,000	420,000

*****Consumption** – Baseline taken from Defra Family Food Survey (Defra 2012a).'

******Energy** – Baselines assumes 4.2% of energy consumption is from renewable sources. Based on DUKES figures for 2012 (Defra 2013).'

*******Food waste** – Baseline is that 19% of household food purchased is currently wasted (WRAP 2013a) and 15% for food purchased by hospitality and food service (based on figures from WRAP 2013b).'

********Waste disposal** – Baseline assumes 82% of household food waste goes to landfill, and 88% of hospitality and food service food waste. These figures are taken from WRAP 2013a and WRAP 2013b.

*********Primary production**: Baseline is primary production emissions estimate created using conversion factors from Audsley et al 2009, and Sonesson 2009

[67] The data in this chart has been modeled using the FoodPrint tool and represents a scenario in which cumulative reductions are made, e.g. the figure in row 4 for savings from waste disposal assumes that 50% of avoidable food waste has already been eliminated in row 3.

4.22 Analysis of options

Materiality

The findings from the food consumption and agriculture FoodPrints for Cheshire and Warrington, in combination with an understanding of UK food system GHG emissions (Section 2), and the menu of mitigation options (Section 3), allows us to see clearly the scale of the challenge and where the GHG hotspots are. This is a critical step in the analysis process for selecting mitigation measures – ensuring that effort is expended where it will have the biggest effect. But selecting mitigations is not just about where the hotspots are, it's also about how much of an impact can realistically be hoped to be achieved.

Resonance

The next stage in the process brings in the principles of practicality and resonance to break these targets down into initiatives that could feasibly find support and be piloted in Cheshire and Warrington. Proposed interventions have to resonate with local conditions in order to be able to mobilise resources and forge effective partnerships. Ultimately local stakeholders and champions must decide on and own interventions targeted at reducing food system GHGs. Experience tells us that locally-based solutions work, and that all successful solutions are more than just technical fixes – they cohere with and work alongside existing interests and initiatives.

Materiality and resonance can be considered with respect to each other using a matrix, as described in Section 3.3. This allows the identification of areas of high materiality and high resonance for a specific LEP area

The aim therefore in the final section of this report is not to prescribe a set of rigid recommendations for Cheshire and Warrington, but rather to provide some gambits to provoke thought and discussion, and to demonstrate what might be achieved by following a process such as the one described.

Cheshire and Warrington's economy is structured around engineering, life sciences and chemicals, financial and professional services, automotive, aerospace, agritech, and oil and gas. Key firms include Tata, Bentley Motors, Vauxhall, Barclays.

Cheshire and Warrington is already one of the best performing economies in England – future aspirations for the LEP include increasing annual GVA by £10 billion, increasing population and creating 20,000 jobs focused on manufacturing and exports.

'Life sciences, food and chemicals' and 'energy and environment' are priority sectors for the LEP.

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4.3 How to act: some think pieces

In this section two possible strategies for taking action are sketched out, to give an idea of the kind of interventions that could be developed in Cheshire and Warrington.

1 Cheshire and Warrington leads the industry in reducing emissions from the dairy sector through novel technical solutions

Cheshire and Warrington is a dairy producing area, producing some 700 million litres of milk every year – dairy emissions make up 70% of the area's agricultural emissions.
The milk industry body DairyCo has a roadmap aiming for 30% reduction in GHG emissions from dairy farms compared to 1990 levels, including 40% of energy use of dairy farms to be from renewable sources.
Cheshire and Warrington is well placed to push these targets further through the development of novel technical solutions such as feed reformulation, energy efficiency and on-farm energy generation.
There are potential promising collaborations with Reaseheath College, a local agricultural training institution, and the Brunel University Centre for Sustainable Energy Use in Food Chains.
There is strong potential to take a holistic lifecycle approach to GHG reductions incorporating not only primary production but also subsequent stages in the supply chain e.g. processing, transport and retail, through both Brunel University and Reaseheath College's dairy training facility, which has close links to major dairy companies like Arla, Dairy Crest and First Milk.
The effects of investment in research in this area could be felt not just across Cheshire and Warrington but across the dairy industry.
If dairy farms across Cheshire and Warrington achieved the UK agriculture industry's 2020 targets, emissions of 92,000 tonnes CO_2e every year could be avoided.
If Cheshire and Warrington's dairy farms achieved 60% of their energy from renewable sources, savings of 15,000 tonnes CO_2e could be achieved.

Existing measures, stakeholders and potential champions:

Reaseheath College:
www.reaseheath.ac.uk
Agricultural training institution

Brunel University Centre for Sustainable Energy Use in Food Chains
sites.brunel.ac.uk/foodenergy

Dairy Roadmap:
www.dairyroadmap.com
Milk industry organisation DairyCo's sustainability strategy

NoWFOOD:
www.nowfood.co.uk
North West Food Research Development Centre, University of Chester

2 Reducing food waste

Food wasted at household level is one of the biggest individual causes of food system GHG emissions.
Cheshire and Warrington has an above average income profile and by 2030 the LEP aims to grow the population by another 100,000 – embedding a low food-waste culture now will have significant GHG benefits in the future.
The average UK household needlessly throws away food and drink every year worth £470, rising to £740 a year for larger households.
Reductions in food waste are possible, and already happening: between 2007 and 2012 there was a 15% reduction in household food waste, resulting in emissions reductions of 4.4mt CO_2e, the same as would have been saved from taking 1.8 million cars off the road.
Cheshire and Warrington has a small but strategically important food and drink manufacturing sector, which could be used as a show-case for low food waste best practice, with the aim of linking into a wider public education campaign to change household behaviour.
Business innovations such as on-site food waste recycling and energy from food waste, whilst offering relatively small potential benefits from a systems view of GHG emissions, could act as a catalyst for wider behaviour change.
Restaurants and caterers also have a role to play, with eating out in Cheshire and Warrington responsible for around 12,500 tonnes of food waste every year. If half of all avoidable eating out food waste could be eliminated, 17,200 tonnes of CO_2e emissions would be saved every year.
If half of avoidable household food waste was eliminated, GHG emissions savings would total 153,000 tonnes CO_2e.

Existing measures, stakeholders and potential champions:

Love Food Hate Waste:
www.lovefoodhatewaste.com

Hospitality and Food Service Agreement:
www.wrap.org.uk/content/hospitality-and-food-service-agreement-3

Courtauld Commitment:
Reducing food waste in the UK grocery sector:
www.wrap.org.uk/node/14507

Follow-up plans:

Expand further food waste reduction work across all households and into the catering sector.

Roll out the 'Too Good To Waste' box, supported by the Sustainable Restaurant Association, to HaFS venues across the region to reduce plate waste from eating out. **www.toogood-towaste.co.uk**

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GLOSSARY

C&W	Cheshire and Warrington
CO_2e	Carbon dioxide equivalent
GHG	Greenhouse gas
GM	Greater Manchester
GJ	gigajoules
HaFS	Hospitality and Food Service
IPCC	Intergovernmental Panel on Climate Change
LEP	Local Enterprise Partnership
MWh	Megawatt-hours

Appendix 1:
Options Appraisal Matrix

Blank Matrix

Resonance – what chimes with local context?							
Materiality – what makes the difference	UK agriculture industry	Food manufacturs	Retailers	Caterers	Consumers	Government	NGOs
UK/EU agriculture							
Land cover change							
Processing (M)							
Packaging (L)							
Transport (L)							
Retail (M)							
Catering (L)							
Household energy							
Dietary change (H)							
Waste reduction (H)							
Waste disposal (H)							

Example of Completed Matrix

Resonance – what chimes with local context?							
Materiality – what makes the difference	UK agriculture industry	Food manufacturs	Retailers	Caterers	Consumers	Government	NGO's
UK/EU agriculture	H	M	H	L	L	H	L
Land cover change	L	M	H	M	M	M	H
Processing (M)	L	H	L	L	L	M	M
Packaging (L)	L	H	H	L	L	M	M
Transport (L)	L	M	H	M	M	L	M
Retail (M)	L	L	H	L	H	M	M
Catering (L)	L	L	L	H	H	L	M
Household energy	L	M	M	L	H	H	M
Dietary change (H)	L	M	H	H	H	M	M
Waste reduction (H)	L	L	H	M	H	H	M
Waste disposal (H)	L	M	M	H	H	H	M

Appendix 2:
Technical approach taken in this report

1.0 Summary

The FoodPrinting model starts with estimates of food and drink consumption for each area being studied. These are derived from the Defra Family Food Survey, and modified to reflect likely local socio-economic differences. The raw consumption data are grouped into analytically useful categories to show e.g. how many kg of red meat, or how many kg of grain and cereal products an 'average person' in each area is consuming. Each of these categories is then associated with different conversion factors for calculating the impacts of consumption. The conversion factor is a number that can be used to multiply a kg of food consumed in a given category to reach an estimate of environmental impact. For example, a kg of milk is on average responsible for 1.17 kg CO_2e emissions in all stages up to retail. So to come up with the farm-to-retail emissions associated with one person's milk consumption over a year, the quantity of milk they consumed is multiplied by 1.17.

These conversion factors are derived from published literature and integrate a large number of published studies. In order to obtain splits for different stages of the lifecycle of products, two different methods are used. Where possible within the time allowed in this project, and where data is available, each lifecycle stage is calculated according to the same bottom-up methodology, e.g. multiplying consumption by detailed conversion factors for the average retail energy use, use of plastic bags, and in-store lighting used for each food category. In other cases lifecycle splits have been calculated by applying a top-down generic assumption to all categories. For example, published studies suggest that, on average, packaging is responsible for 5-10% of food system cradle-to-grave emissions.

The figures presented are an informed synthesis of current literature on food systems impacts. The FoodPrint model is not primary research – it brings together disparate studies in order to demonstrate where interventions into the food system can hope to have greatest impact in reducing environmental impacts.

2.0 Improvements implemented for this version of the FoodPrinting Model

The model used to provide the outputs for the ENWORKS sustainable food systems project is a refined and updated version of the original FoodPrint Model ('FoodPrint 1.0') which was used to produce the FoodPrinting Oxford report. Improvements include the following:

- Using the most recent socio-economic and production data and incorporating a comprehensive and up-to-date set of conversion factors from reliable literature (the conversion factor is the figure by which a kg of food in a given consumptions category is multiplied to come up with an estimate of the environmental impact of that consumption in terms of greenhouse gases (GHG) emitted, or water and land resource used)
- Separating household food and drink consumption from eating out consumption, spurred by the likely importance of the catering and public procurement sectors as a lever for change, especially in Greater Manchester.
- Changing the basic consumption units from calories (FoodPrint 1.0) to kilograms (FoodPrint 2.0) – this is considered to give a more accurate picture of overall consumption. A kilogram-to-calorie conversion feature is included as a basic check to ensure that alternative dietary scenarios still provide adequate nutritional energy.
- Expanding the range of dietary categories modelled from 10 to 17 to give greater resolution and to map more accurately onto consumption data and suggested nutritional intakes.

As a result of these adjustments, the outputs from the FoodPrint 2.0 model are not directly comparable to those from FoodPrint 1.0 (i.e. the same input data will produce a different analysis of impacts). The FoodPrint 2.0 model is considered to be an improvement in terms of accuracy (see benchmarking below), however, this does not invalidate the results of FoodPrint 1.0 and the FoodPrinting Oxford report. All models are based on assumptions that will change over time – they are a rough pencil sketch rather than a photorealistic portrait of reality. What is important is that models are internally consistent and that assumptions are stated in order that errors can be spotted, improvements can be made, and so that the models provide a believable and 'good enough' basis for taking effective action.

2.1 Benchmarking

It is good practice to compare the outputs of the FoodPrinting model to other published estimates of the environmental impact of the food system. This allows the identification of any glaring points of difference and, if a sufficient degree of congruence can be achieved, allows cross-fertilisation of insights from different analyses. The results of this benchmarking are below, based on UK average input data:

GHG emissions (excluding land use change)
FoodPrint: 2.36 tonnes CO_2e per person per year
Audsley et al 2009: 2.4 tonnes CO_2e per person per year

The source used for the comparison is Audsley et al 2009: 'How low can we go: an assessment of GHG emissions from the UK food system and the scope for reduction by 2050' published by WWF and the Food Climate Research Network (FCRN). The research was carried out by Cranfield University and Ecometrica and is one of very few studies to attempt a comprehensive assessment of lifecycle GHG emissions from UK food consumption.

Water
FoodPrint: 1,286 m3 per person per year
Mekonnen & Hoekstra 2011a: 1,103 m3 per person per year

Comparison data comes from the Water Footprint Network (WFN), the most authoritative and comprehensive set of data on water use at nation state level (see Mekonnen and Hoekstra 2011a). The overall figure for UK water use was adjusted according to their assumption that 87.64% of the UK's consumption water footprint is from agriculture.

Land use
FoodPrinting: 0.17 hectares per person
Meier et al 2014: 0.24 hectares per person (Germany)
Lugschitz et al 2011: 0.74 hectares per person (UK)

This is the most problematic of the four impacts to benchmark as, as far as is known, no study has carried out a comprehensive analysis of the land-use impacts of UK food consumption. The closest basis for comparison identified is Meier et al (2014) (from which the land use conversion factors used in the model are also derived), who estimate land use from food consumption in Germany using a bottom-up methodology.[69] Their higher figure is likely to result from differing data collection methods for reporting dietary composition in addition to potentially higher consumption of meat and dairy products in Germany. Nonetheless the figure is within a margin of error of less than one tenth of a hectare per person. A greater divergence from the results of this study is found in work by the Sustainable Europe Research Institute (SERI) (Lugschitz et al 2011), who would put land use from UK food consumption at roughly 4 times greater than the estimate derived from this work. While Meier et al follow a similar methodology to FoodPrinting, SERI take a top-down input-output approach, which is likely to be the source of this divergence. In their analysis (Giljum et al 2013) it is acknowledged that the state of play for food consumption land footprint indicators is still under-developed, and 'methodological improvements and harmonisation [of approaches] still need to be achieved.' In the context of this uncertainty it should be noted that although the land foodprint figure is likely to represent an underestimate, it is nonetheless an acceptable interim figure based on transparent assumptions that are open to modification as and when more accurate conversion factors become available.

In summary, benchmarking undertaken as part of this study gives a degree of confidence in the FoodPrint model outputs for GHG emissions, which are no more 4-5% divergent from the selected comparison figures. The water footprint figure has greater divergence (16.6% higher than comparison figure), but confidence levels are high that the methodology used to arrive at this figure is internally consistent. The most uncertain output is for land use. Across all of the four impacts it should be noted that there remains considerable variation in methodological approaches and data input across the food footprinting field, so variation is to be expected. It is also important to note that for the purposes of this project the interest is not so much in the absolute impact figures but rather the relative reduction in impacts that can be achieved via proposed interventions.

[69] Bottom-up and top-down are two differing methodological approaches to footprint type analysis. Bottom-up methods start at the point of the product or product group and take a life cycle approach to calculating impacts. Top-down methods start at the level of regional or national level data on resource use or emissions, which is then disaggregated. Both methods have advantages and disadvantages.

Appendix 3:
How the FoodPrinting model works

3.1 Outline

The FoodPrinting model is a consumption-based lifecycle approach to analysing the environmental impacts of the food system. This means that the starting point is the quantity and type of food that is consumed (or wasted) by end users in a given study population. This could be a household, restaurant or canteen, town, city, region or country. Taking this consumption input data the model then uses 'conversion factors' to turn the amount of different foods consumed into an estimate of the environmental impacts along the entire supply chain to the point of consumption and waste disposal, including any food not eaten due to wastage at any level. A lifecycle assessment will take into account everything from the diesel required to drive tractors, to the energy used in producing fertiliser for crops then used to feed cattle. Factors such as processing, packaging, transportation, cooking and chilling and waste disposal are also included in impacts. The advantage of this bottom-up approach is that it allows identification of specific hotspots in both dietary profile and supply chain that may be responsible for disproportionately high emissions. Taking a consumption-side approach allows the linking of impacts to the choices made by end consumers, where there may be considerable scope for change.

3.2 Input data (food purchases)

Defra's Family Food Survey (Defra 2012a) provides UK average estimates of food and drink purchased, both for household consumption and outside of the home. The FoodPrint model uses the data set presenting kg quantities of food purchased per person per week, which is further broken down into a large number of detailed food categories. Food purchases are also split by income deciles, showing how purchases of different food groups differs according to socio-economic indicators.

For the FoodPrint model, the food types purchased were grouped into categories likely to be analytically useful, and according to whether reliable conversion factors are available for the product category.

This average UK consumption profile was then modified according to the localised socio-economic profile of the study population. For example in Greater Manchester there is a slightly higher than national average percentage of people in lower income groups, so the local consumption profile is weighted towards the average consumption profile in lower income deciles. The method for doing this is described in the main document.

3.3 Food waste

Food purchase data was adjusted to provide estimates of food waste. Data on household food waste is taken from WRAP 2013a 'Household food and drink waste in the UK', which estimates household waste rates in different product categories. It also classifies waste as avoidable, possibly avoidable, or unavoidable. This data was used to quantify the impacts of wasted food by working out what percentage of purchased food was not eaten – this differs depending on food category.

Adding the food waste component of the model for eating out was more complex, since the Defra purchase data refers to quantities purchased by consumers. Although plate waste (uneaten food from diners' plates) is part of this, other waste incurred prior to serving (prep waste and spoilage waste) evidently is not included. Data on eating out food waste from WRAP 2013b, 'Estimates of food and packaging waste in UK grocery' was used to estimate the total amount of food purchased by the restaurant, and these figures were used in subsequent calculations of GHG impact.

3.4 Conversion factors

These kg figures for per capita food purchase and consumption (including waste) in the study population are then multiplied by conversion factors to give an estimate of land, and water use and GHG emissions for different lifecycle stages. A lot therefore depends on the reliability and consistency of the conversion factors chosen.

GHG conversion factors: Fisher et al (2013), the Product Sustainability Forum's 'initial assessment of the environmental impact of grocery products' (Appendix 4) which gives cradle-to-retail carbon footprint data for 217 food and drink, personal care and household products derived from 727 data points from a variety of sources including peer reviewed journals, industry studies, government reports and eco-labels.

GHG conversion factors for the retail stage are taken from Defra (2008) 'The GHG impacts of food retail', which splits out impacts for refrigeration, refrigerant leakage, lighting, HVAC, plastic bags etc.

GHG factors for consumer and eating out cooking and chilling were derived from data on the energy required for cooking and chilling from INCPEN (2009) and subsequently converted to GHG emissions values using conversion factors from the Defra Greenhouse Gas Conversion Factor Repository (http://www.ukconversionfactorscarbonsmart.co.uk/), which is also the source of GHG conversion factors for food waste disposal. This conversion assumes that household chilling uses electric energy only, while cooking uses 50% gas and 50% electric.

Water conversion factors: Mekonnen & Hoekstra (2011b) – 'The green, blue and grey water footprint of crops and derived crop products' – and Mekonnen & Hoekstra (2012) – 'A global assessment of the water footprint of farm animal products' – provided a set of methodologically consistent water footprints. These are the basis for the figures used by the well-recognised Water Footprint Network.

Land conversion factors: Taken from Meier et al (2014) (Table 1), which compiles land use conversion factors for a number of products based on SEEA/Schmidt & Osterburg (2010) and Farm Accountancy Data Network for German production, and FAO Stat 2012 for imported products. These factors are considered to have a larger margin of error than the other three impact categories, which may account for the probable underestimation of land impacts in the model used for this study (see above). Other studies (e.g. Nijdam et al 2012) give significantly higher estimates for land use for specific products. However, it was decided to use Meier et al for purposes of methodological consistency, since the study presents a more comprehensive list of impact categories than other studies available, e.g. Nijdam et al 2012 which only covers meat and seafood.

3.5 Products, categories and weighted averages

Since conversion factors apply to specific products and the FoodPrint categories include multiple products, in most cases a weighted average of representative products was chosen for the category, based on the category composition, knowledge of product impacts, and availability of data. For example, the alcoholic drinks category was based on 50% wine and 50% beer, while the vegetables category was based on 28% fresh potatoes, 12% processed potatoes, 10% green vegetables, 10% carrots and onions, 5% tomatoes and cucumbers, 20% canned and frozen vegetables and 15% other. A similar methodology was employed for composite products without conversion factors, for example, chocolate confectionary assumed 10% cocoa, 10% milk products, 50% sugar, 10% vegetable oil and 20% cereal. Carbonated drinks was approximated using a figure of 10g sugar for every 100g drink. In a few cases where sufficient data for additional products was not available, only one product was used in order to represent a category (e.g. vegetable oil spreads for the fats category). While there is a risk from this of misrepresenting category outputs, the categories with only one representative product are minor and their contents relatively homogeneous, so the distortion is considered minimal.

Appendix 4: Adjustments and scenarios

The FoodPrinting tool allows various input variables to be adjusted to probe the effects of potential mitigations. For example:

Food waste
The model's standard set of assumptions about food waste are derived from WRAP (2013a, b and c). For example, this data tells us that on average 8% of milk products, 20% of meat products and 40% of fresh fruit and vegetables purchased by households is wasted. The adjustment allows the specification of a percentage reduction in waste (either avoidable or total waste) across all categories, modifying the original figures to produce new outputs.

Renewable energy
The standard GHG intensity of cooking and chilling in households and catering establishments is derived from category energy data (INCPEN 2009) converted to GHG using Defra conversion factors assuming 50% energy use is gas and 50% electric (more accurate data for this could not be sourced). The model's standard assumption is that 4.1% of this energy is currently from renewable sources (DECC 2013). This feeds into outputs by making a corresponding modification to the GHG intensity of these activities, applied irrespective of whether electric or gas source assumed. Adjustment allows the percentage of energy from renewable sources to be increased or decreased.

Dietary adjustment
Standard dietary composition values are derived from Defra Family Food Survey, over 17 food categories. The model allows individual adjustment (via percentage increase or decrease) of each category. This is not a detailed dietary model so adjustments are not necessarily nutritionally optimal – however as a basic check, a calorie calculator provides a check that any adjustments still provide caloric sufficiency. Calorie conversion factors for categories are taken from NHS data.

Waste disposal
The standard waste disposal routes and percentages
The standard waste disposal routes and percentages in the model are taken from WRAP 2013a and WRAP 2013b – currently around 10% of household food waste goes to municipal composting or AD, is home composted or is fed to animals. The figure is around 12% of commercial sector waste. The remainder goes to drains or landfill. Conversion factors for emissions from drain disposal (liquid categories) and landfill disposal (solid food) are taken from Defra conversion factor repository. The adjustment available through the model allows the percentage diverted from landfill/sewer to be increased or decreased.

These adjustments may be combined together to create scenarios. Section 4 of the report presents a number of these applied to the LEP areas. These figures are cumulative in the order presented – i.e. if intervention #1 changes the dietary composition, then intervention #2 applies to this changed diet rather than the standard diet. The tables of mitigation measures provided in Section 3 of the report are individual rather than cumulative measures, and as such each percentage value is calculated separately.

About ESTA

The Environmental Sustainability Technical Assistance (ESTA) project is funded by the Environment Agency (EA) and ERDF to support the five North West LEP areas to embed environmental sustainability into their economic development priorities and work streams; it runs from April 2012 to December 2014.

For more information visit

www.enworks.com/ESTA-intro

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