What are the Benefits of Reducing food waste?

Using non-market and socio-environmental evaluations to quantify potential impacts for the city of Bristol, UK

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FOOD WASTE IN UK

10 MILLION CARS
The GHGs associated with the 9.5 Mt of food waste in the UK is around 25 million tonnes CO_2e – which is equivalent to c.5% of UK territorial emissions and the same as 10 million cars (or 1 in 3 cars on UK roads).
(wrap.org.uk)

COURTAULD COMMITMENT 2025:

"A 20% per person reduction in food and drink waste associated with production and consumption of food and drink in the UK, post farm gate."

		Household	HaFS*	Retail & Wholesale	Manufac-turing	Farm	Total[1]
	Total food waste	6.6 Mt	1.1 Mt	0.3 Mt[8]	1.5 Mt	[0.9 – 3.5 Mt]	>9.5 Mt
Preventing food becoming waste	Food (excl. inedible parts	4.5 Mt (£13.8 bn)	0.8 Mt (£3.2 bn)	0.3 Mt (£0.9 bn)	0.8 Mt (£1.1 bn)	nk	> 6.4 Mt (>£19 bn)
Preventing food becoming waste	Redistribution & animal feed	0.3 Mt [n/a humans 0.3 Mt pets/ other animals	>0.001 Mt [>1kt to people [n/a to animals]	0.04 Mt [17.5kt to people] [27kt to animals]	0.65 Mt [23kt to people] [635kt to animals]	nk[9]	> 1.0 Mt
Waste management	Recycling (AD/composting)	1.3 Mt[2]	0.04 Mt	0.15 Mt[3]	0.44 Mt[4]	nk	> 1.9 Mt
Waste management	Recovery (thermal, landspreading)	3.0 Mt[5]	0.83 Mt[6]	0.15 Mt[3]	1.1 Mt[4]	nk	> 4.4 Mt
Waste management	Disposal (sewer, landfill)	2.3 Mt[5] [1.5 Mt sewer 0.8 Mt landfill]	0.22 Mt[6] [nk sewer 0.38 Mt landfill]	nk[3,10]	0.002 Mt[4] [nk sewer 0.002 Mt landfill]	nk	> 3.2 Mt
	In addition:						
	Rendering of animal by-products				0.6 Mt	nk	0.6 Mt
	Other food by-products[7]				2.2 Mt		2.2 Mt

* HaFS = hospitality and food service; nk = not known; n/a = not applicable

(wrap.org.uk)

OUTLINE

- How do we value impacts on the environment and human health?
- Calculating the life cycle impacts of food and waste disposal
- Methodology applied to our case study of Bristol, UK
- Results for the city of Bristol
- Scenarios for improvements to efficiency
- Limitations & wider context
- Summary

Research Questions

This study set out to explore the following questions:

- What are the non-market and socio-environmental benefits of reduced food waste along the food/waste cycle for Bristol?
- What reductions in energy and other resource usage in food production/transport and waste disposal might be gained from reducing food waste by 20%?

What is non-market valuation?

- Need to describe costs which have no market value, such as human health, safety, happiness, biodiversity, and the value of intangible environmental assets such as beauty and cultural, spiritual and historical meaning of place.
- Relies on stated preference techniques which express preferences, via choice modelling or contingent valuation
- Values are based on principles of how much people express a willingness to pay (WTP) or willingness to accept (WTA) for a given change in environmental quality
- These intangible costs are used in conjunction with observed costs in order to estimate the societal impact of environmental change.

Example: Carbon and Climate Change

- Effects on climate change, or global warming potential, are expressed as £/t CO_2 equivalent
- Attempts to value the damage costs associated with climate change are extremely uncertain
- The value we use is derived from CE Delft (2018) who estimate the value of a reduction in 1 t CO_2 equivalent using the abatement cost approach
- The value of this element is forecast to rise almost fourfold by 2050

Example: Human Health

- Effects on Human Toxicity are expressed as £/t 1,4DB equivalent or comparative toxicity units (£/t CTUh)
- These units reveal the sum of effects of many different pollutants on human health
- Values for Human Toxicity are based on the societal costs of ill health, including willingness to pay to avoid the health outcomes associated with the pollutants. In the case of CTUh, the unit applied is the equivalent of the value of one new case of cancer.

LIFE CYCLE ANALYSES ON FOOD WASTE: FOOD

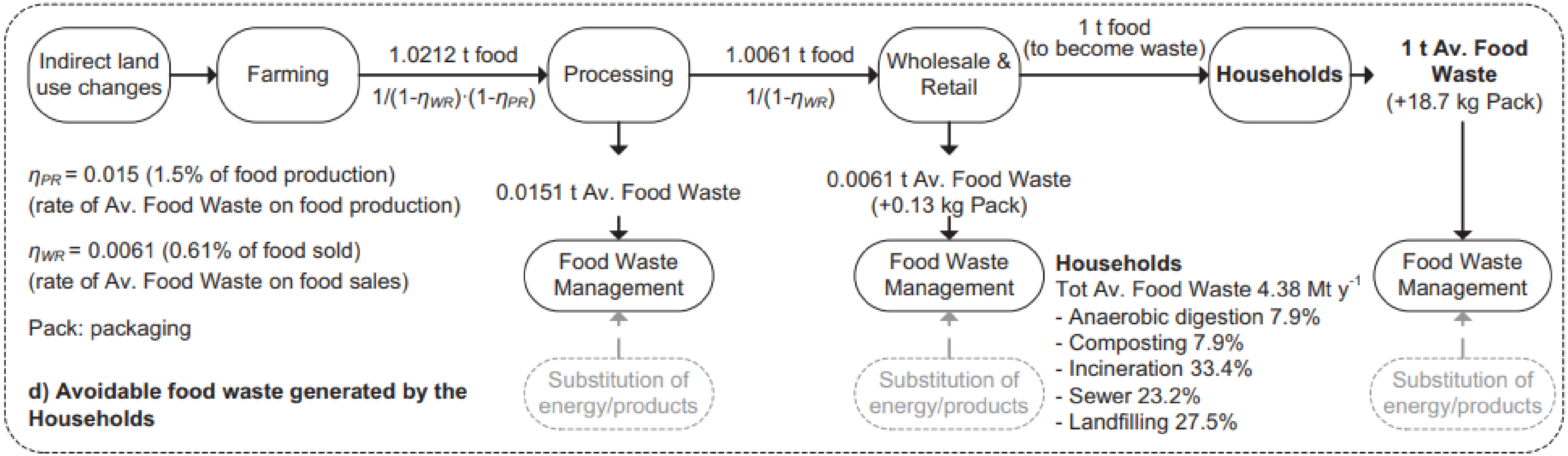


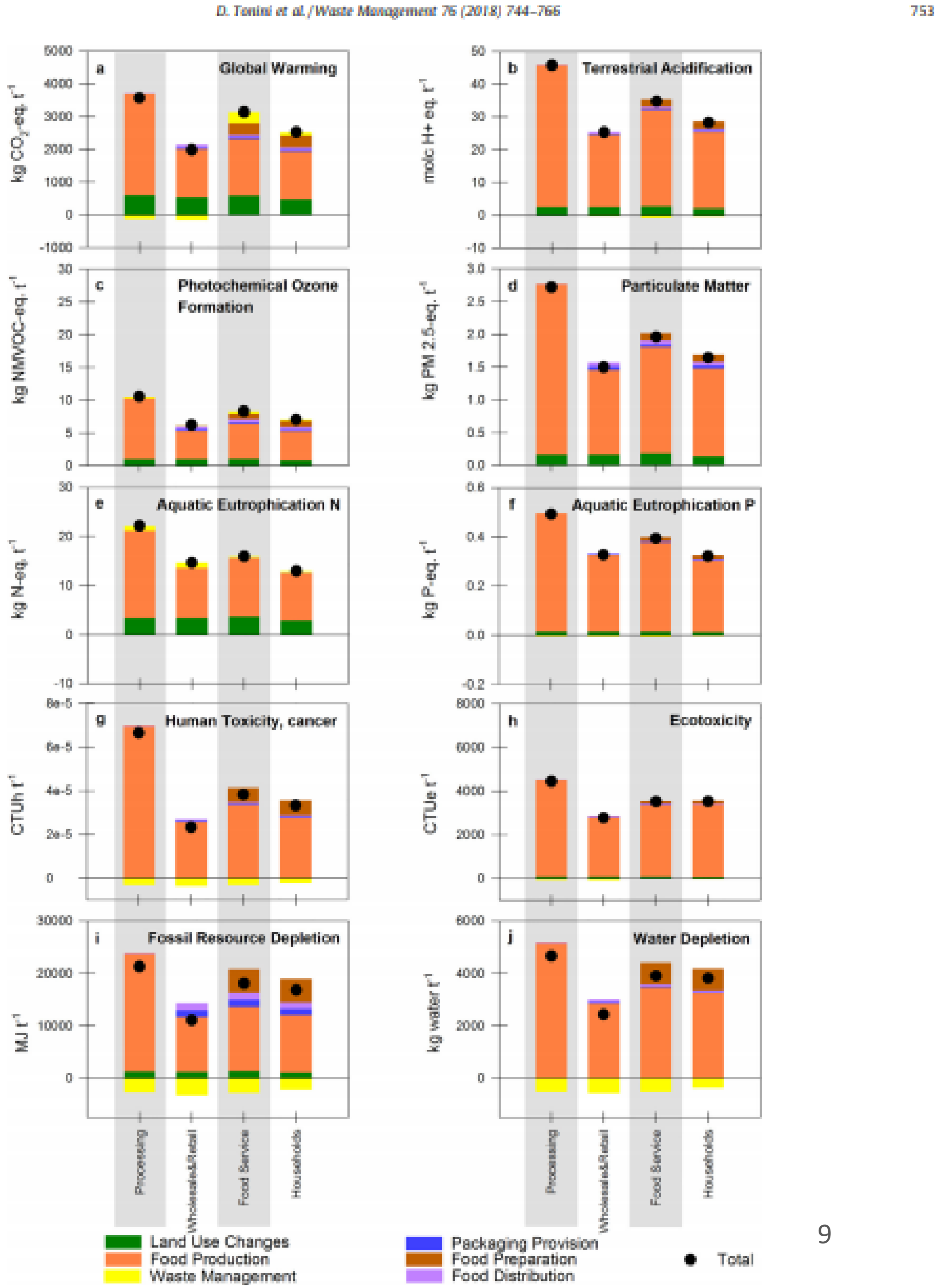
Fig. 1. System boundary for the assessment of the life cycle impacts of one tonne of avoidable food waste generated at: (a) Processing, (b) Wholesale & Retail, (c) Food Service, and (d) Households (the two latter share the same boundaries). Induced flows are illustrated with black-continuous lines. Avoided flows are illustrated with grey-dotted lines. Relevant information about the current food waste management practices at each sector is also provided on the basis of the information reported in WRAP (2017). With respect to the management of packaging waste: 59.2% was sent for recycling, 4.9% incinerated and 35.9% landfilled conformingly with current practice (DEFRA, 2016).

From Tonini et al, 2018.

LCA of Food: Impacts

- Functional unit: 1 tonne of food waste
- 10 different environmental categories
- Separated by four sectors and several points in the food supply chain
- Different compositions of waste in each sector
- Includes mitigating impacts of energy generation from waste disposal

From Tonini et al (2018)



LIFE CYCLE ANALYSES ON FOOD WASTE: WASTE

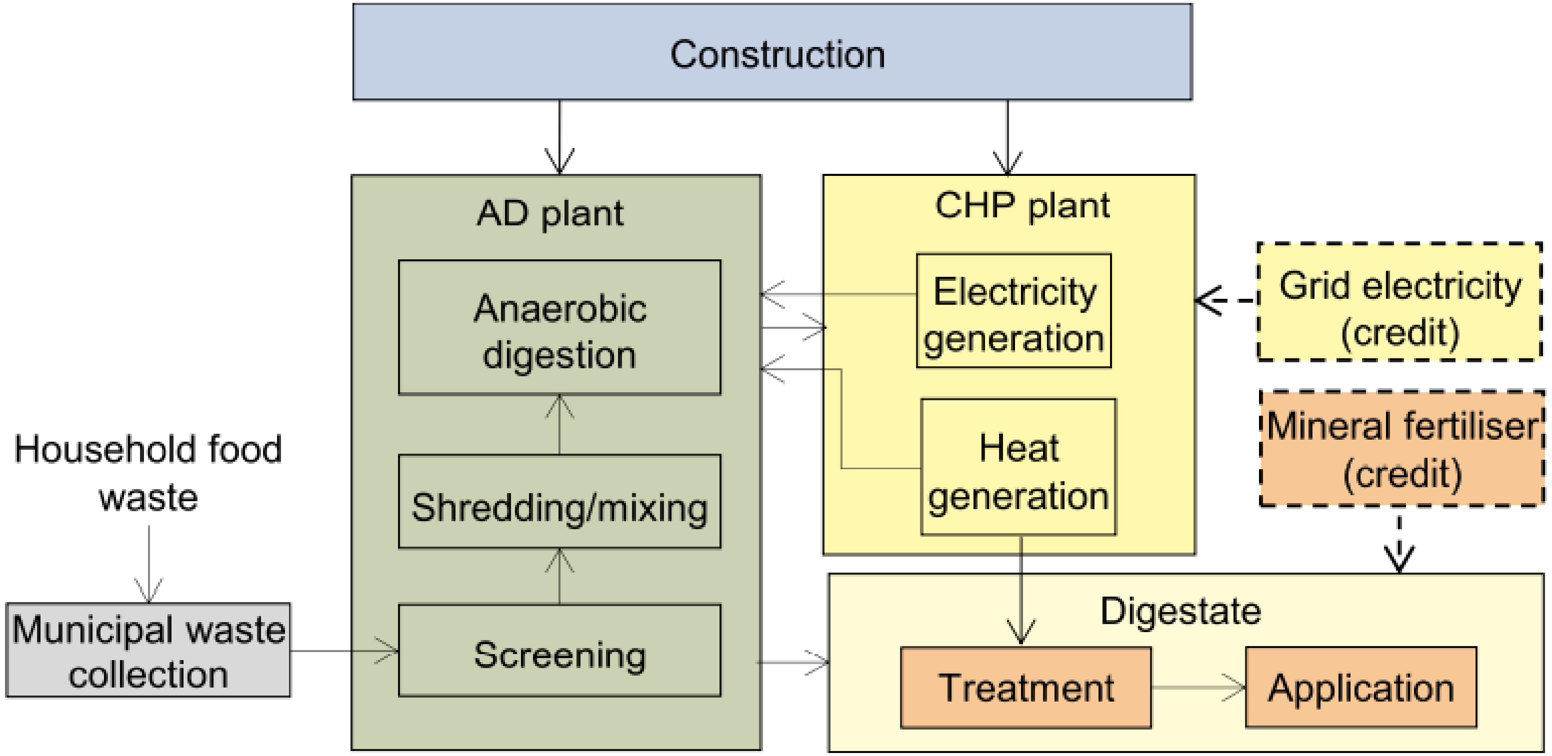


Fig. 1. Life cycle stages considered for anaerobic digestion of food waste (——— System credits. AD: anaerobic digestion. CHP: combined heat and power).

From Slorach et al (2019)

LCA ON FOOD WASTE: WASTE DISPOSAL

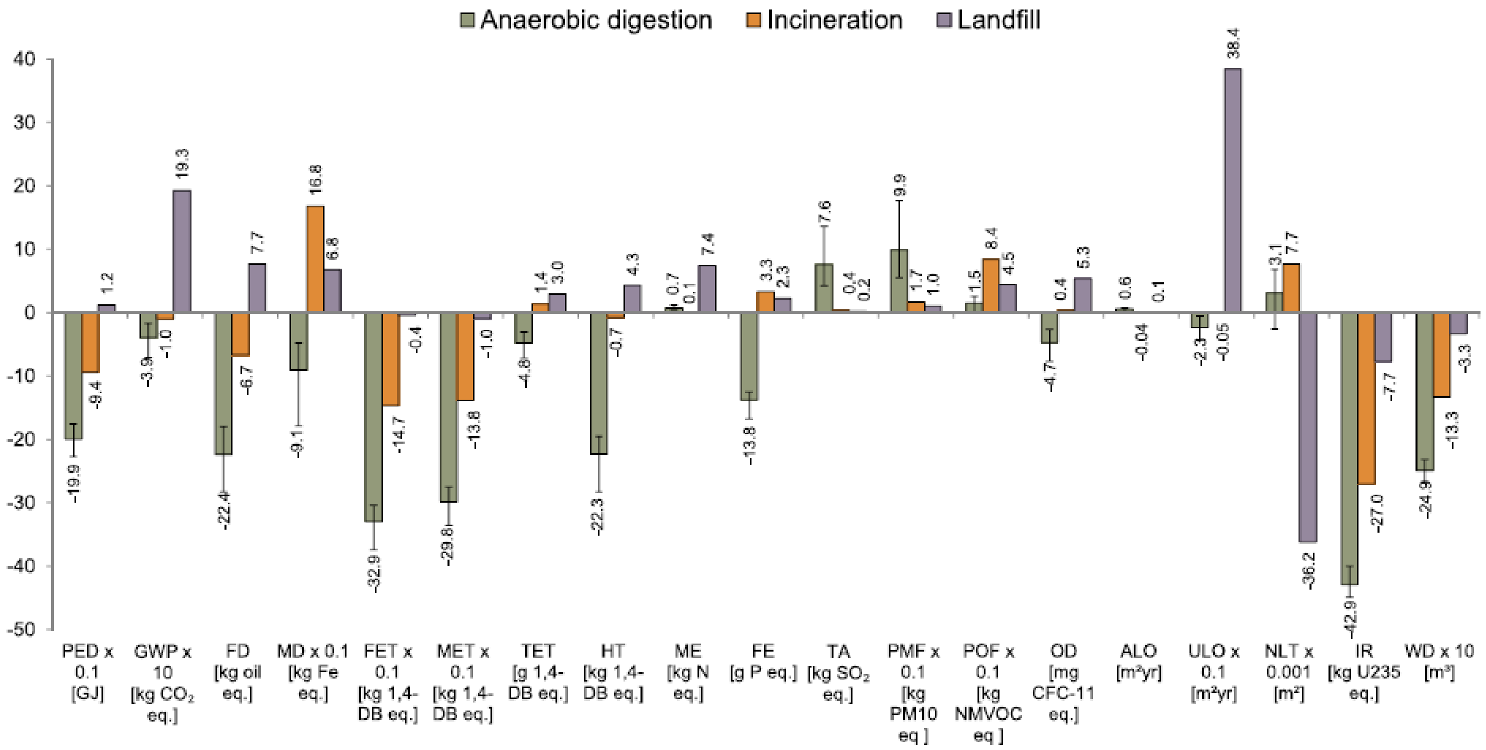


Fig. 4. Environmental impacts of treating food waste by anaerobic digestion (All impacts expressed per tonne of food waste treated. The solid bars and the data labels for the AD refer to the base case. The error bars represent the 90th and 10th percentile impacts obtained through Monte Carlo analysis using the inventory ranges in Tables 2 and 3. The values for incineration and landfill correspond to the average annual composition of waste (Table 1). Some impacts have been scaled – to obtain the original value, multiply with the factor shown on x-axis where relevant. PED: primary energy demand; GWP: global warming potential; FD: fossil depletion; MD: metal depletion; FET: freshwater ecotoxicity; MET: marine ecotoxicity; TET: terrestrial ecotoxicity; HT: human toxicity; ME: marine eutrophication; FE: freshwater eutrophication; TA: terrestrial acidification; PMF: particulate matter formation; POF: photochemical oxidants formation; OD: ozone depletion; ALO: agricultural land occupation; ULO: urban land occupation; NLT: natural land transformation; IR: ionising radiation; WD: water depletion. DB: dichlorobenzene. NMVOC: non-methane volatile organic compounds.).

From Slorach et al (2019)

About Bristol

- Bristol is the largest city in the South West UK
- Population of around 500,000 people
- Main economic centre for the West of England
- Ambitious targets towards sustainability, including reducing food waste

Methodology

Resource Components of food

- Estimated the environmental impacts of food production & retail using Life Cycle Assessment study by Tonini (2018)

Bristol Household food waste

- Mapping quantities of waste using data from Bristol Waste Company
- Proportions of avoidable and non-avoidable food waste from 2019 Bristol Waste Composition Report and WRAP (2018)

Waste Disposal & Management

- We mapped how waste is disposed of and how it is collected and managed in Bristol using information from stakeholders
- We estimated the environmental/ social impacts of waste and waste management using Slorach (2019) and WRAP (2011)

Non-Market impacts of waste management

- We estimated the value of these impacts by monetising these results using published environmental prices

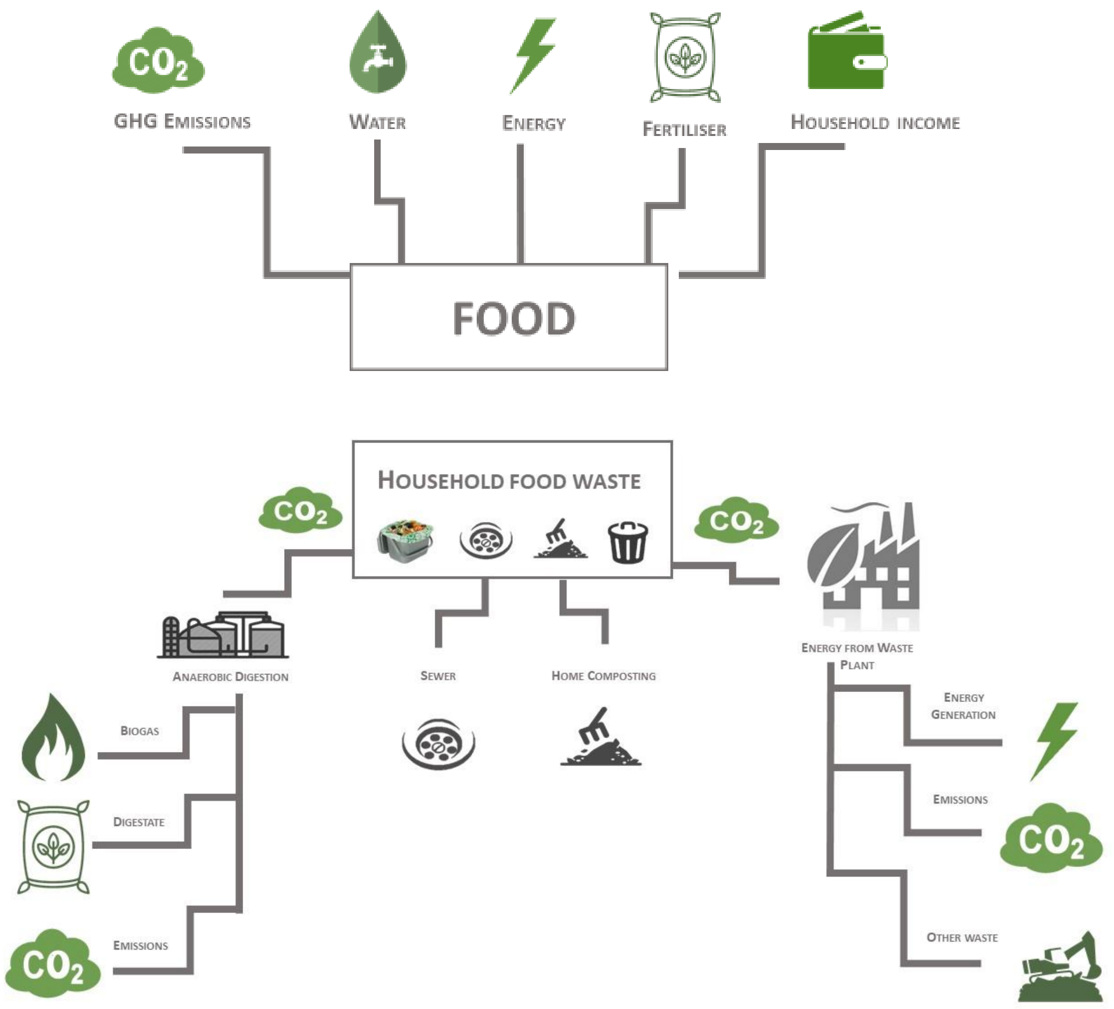


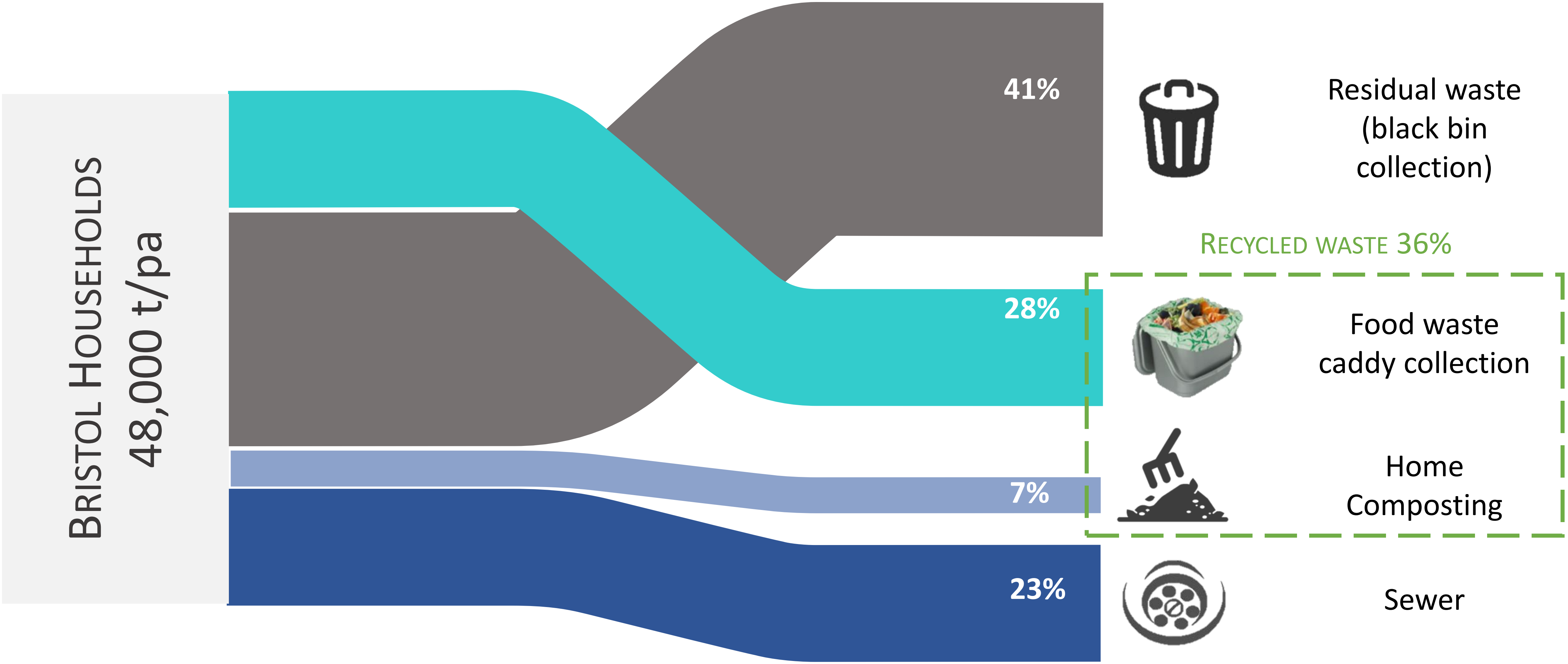
Image: mapping how household food waste is disposed of in Bristol

Assumptions

- We assume a linear (dose-response) relationship between quantities of food wasted and environmental impacts
- In real life we can see that there will be interactions between all elements of the system – for example differences in components of waste by disposal method.
- We do not model for market effects, such as changes to food and waste disposal prices, or socio-economic effects of food poverty.
- For clarity the values are presented are the central reference figures, but levels of uncertainty apply at each stage of the calculations, and more detail is given on the ranges for each value in our findings paper

The nexus of Food, Energy and Water: How Bristol's food waste is treated

Where does Bristol's waste go?

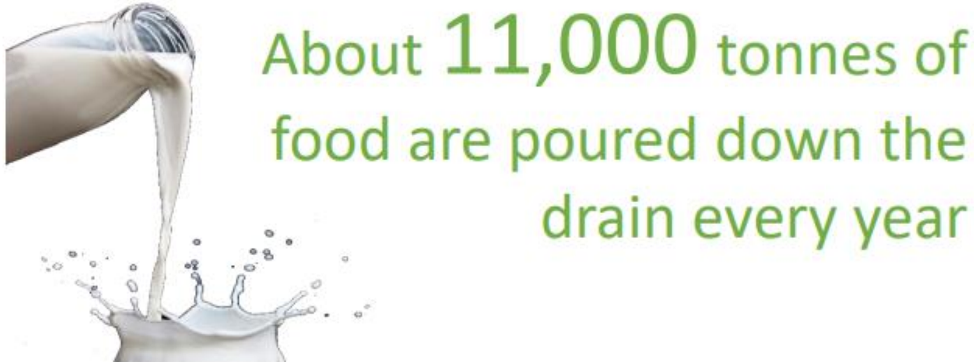


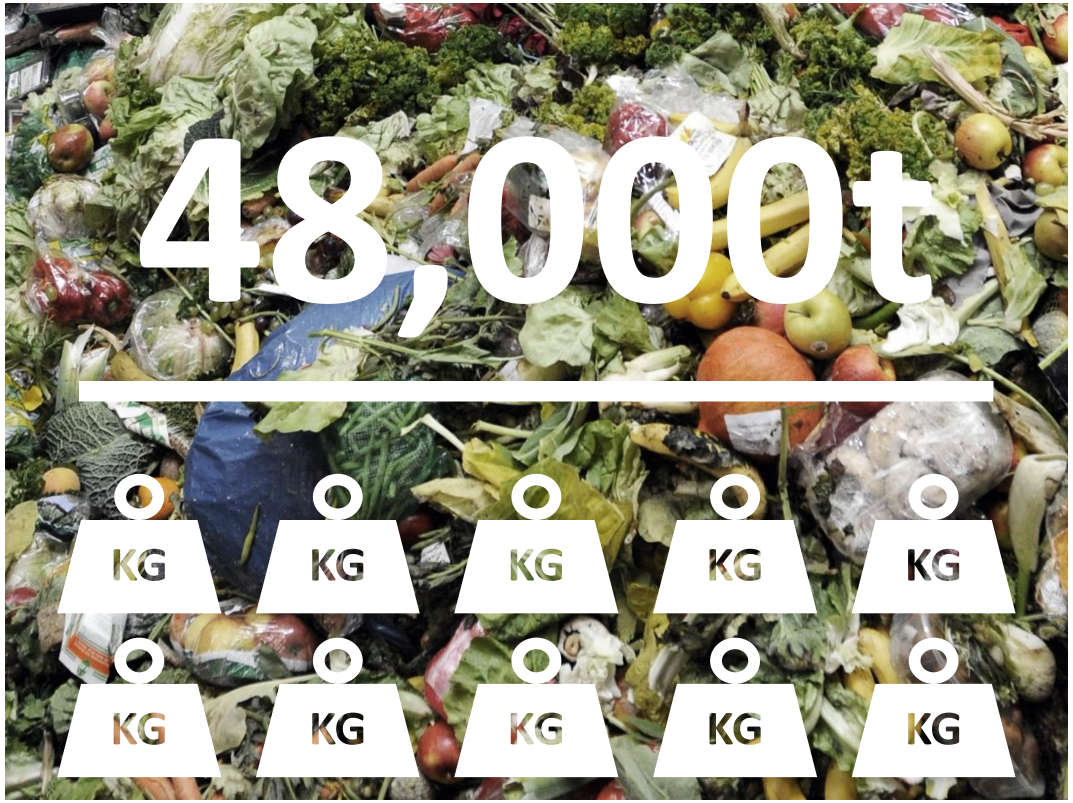
48,000 TONNES OF FOOD ARE WASTED IN BRISTOL EACH YEAR

72% or 34,500 tonnes

could have been eaten. Around 28% is classified as unavoidable waste, such as tea bags, bones, etc.

3.31 kilos equivalent avoidable food wasted per household per week





Figures are rounded for year ending March 2019

Bristol and the National Picture

6.6 Million tonnes of food is wasted by UK households each year

70% or 4.5 Million tonnes could have been eaten

3.4 kg avoidable food wasted by UK households per week – Bristol wastes 3% less than the UK on average

20% of all wasted food is recycled in the UK – Bristol recycles more of its avoidable food waste.

BRISTOL HOUSEHOLDS WASTE FOOD WORTH AROUND £100 MILLION PER YEAR

- We estimate that Bristol households are throwing away around £40 **per month** worth of edible food.
- This is equivalent to £490 per year.
- Nationally, households waste around £500 per year.
- For a family, the average is around £730 per year.
- Each household spends around £60 on food on average per week.

The annual impact of Bristol's food waste on the environment: Resources pre-loaded into food

Global Warming: equivalent to **110,000 tonnes of CO_2**

Photochemical Ozone Formation: **320 tonnes of NMVOCS**

Particulate Matter: equivalent to **100 tonnes of $PM_{2.5}$**

Marine Eutrophication: equivalent to **600 tonnes (N)**

Freshwater Eutrophication: equivalent to **16 tonnes (P)**

Human Toxicity: equivalent to **2 cases of cancer**

Water Use: **200,000 M^3 water**

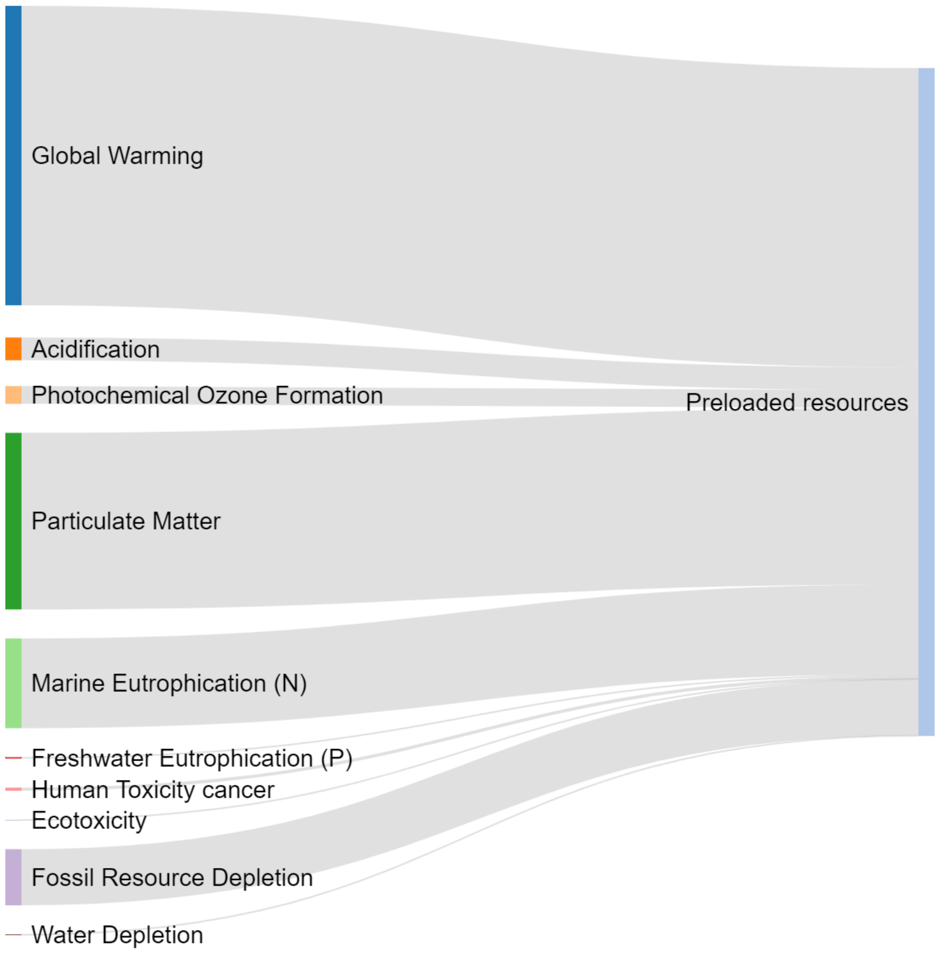


Image: relative weight of impacts in terms of value of impact (unit value x quantity of pollutant)

THE ANNUAL IMPACT OF BRISTOL'S FOOD WASTE ON THE ENVIRONMENT: EFFECTS OF WASTE DISPOSAL

Less Primary Energy Demand: **-45,000 Gj**

Less Global Warming Potential: **-727 tonnes CO_2 equiv**

Less Freshwater Eutrophication: **-0.12 tonnes P equiv**

Less Human Toxicity: **-300 t 1,4-DB equiv**

Less Water Use: **-6 million tonnes water**

More Marine Eutrophication: **12 tonnes N equiv**

More VOCs: **18 tonnes NMVOCs**

More Particulate matter: **17 tonnes PM10 equiv**

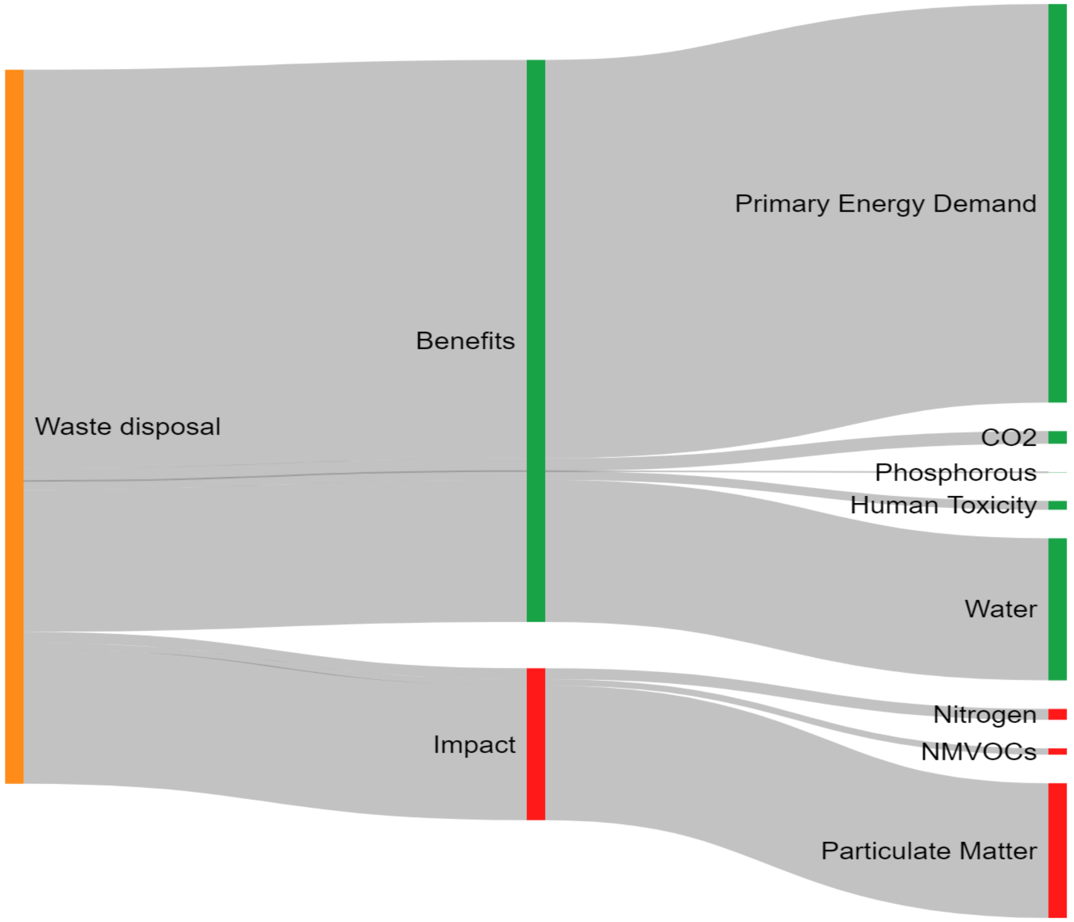
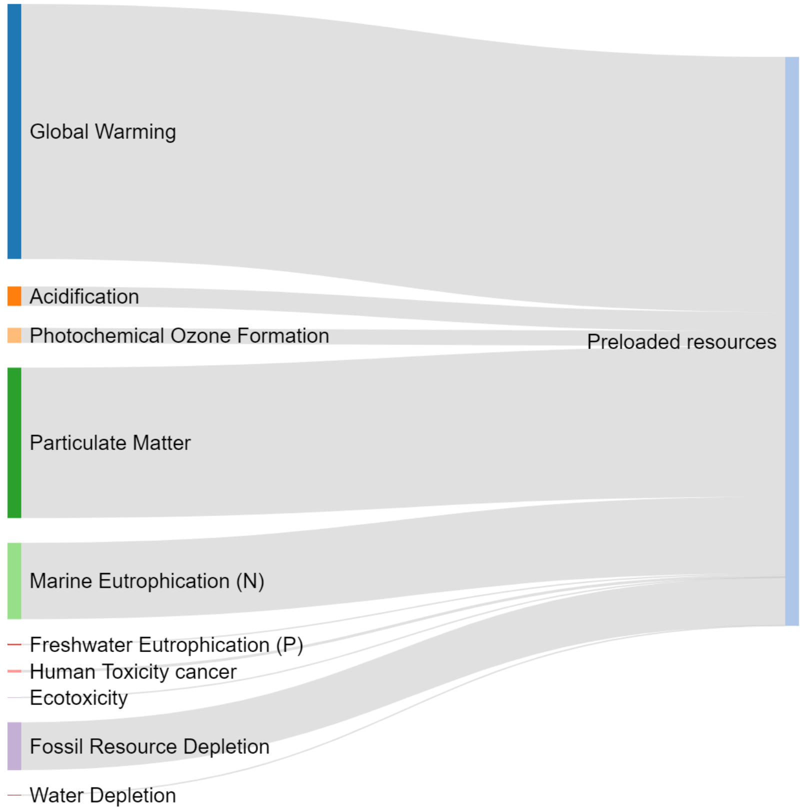
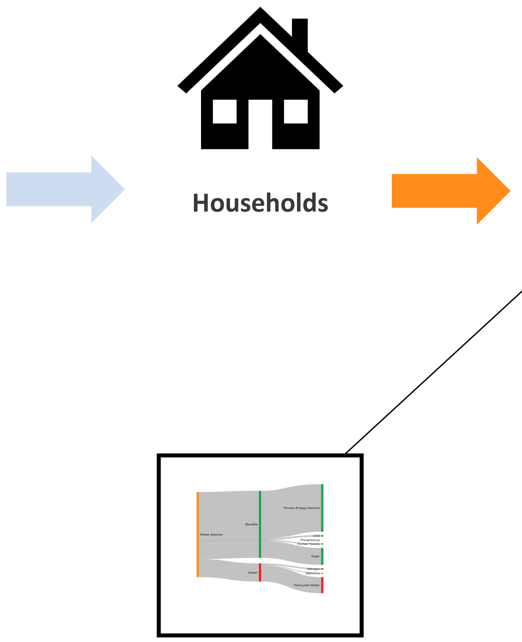


Image: relative weight of effect in terms of value of impact or benefit (unit value x quantity of pollutant)

THE NEXUS OF FOOD, ENERGY AND WATER: THE IMPACT OF WASTED FOOD

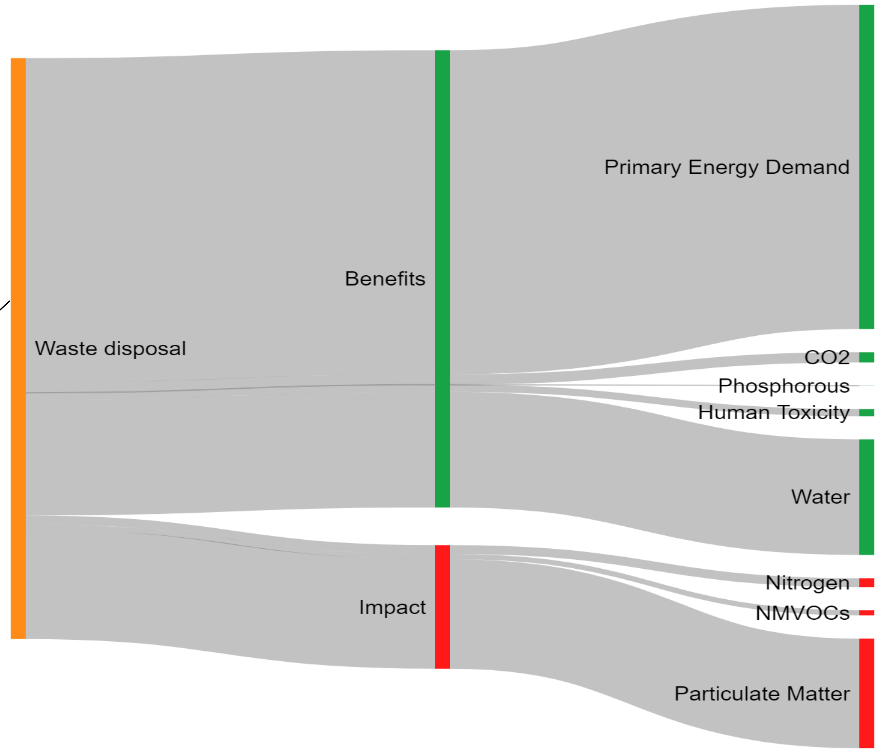
Value of production impacts





Actual size of waste disposal compared to food production

Value of waste disposal impacts (expanded)

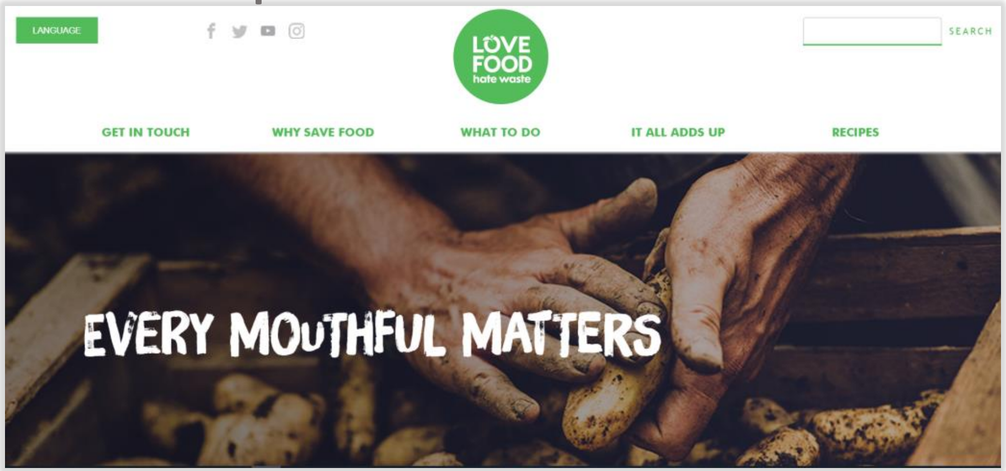


TWO SCENARIOS FOR REDUCTION IN FOOD WASTE:

1. More recycling:
   i.e. moving food out of residual (black bins) and into recycling

2. Reduction at source:
   i.e. change in behaviour so that food purchasing matches food consumption

Examples of change based on 20% change in behaviour, based on targets outlined in UK government's Cortauld Commitment for 2025

Recycling versus reducing waste

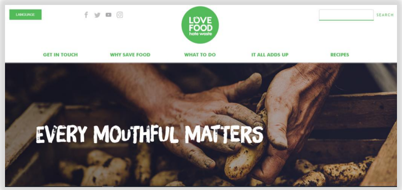
20% more recycling

3,888 tonnes waste going to caddies for recycling instead of black bin

- 113 tonnes less CO_2 equivalent related to electricity generation by Anaerobic Digestion
- 9% more green energy
- 451,000 less M^3 water

But… more PM10 and Marine Eutrophication (N)

20% reduction in waste at source



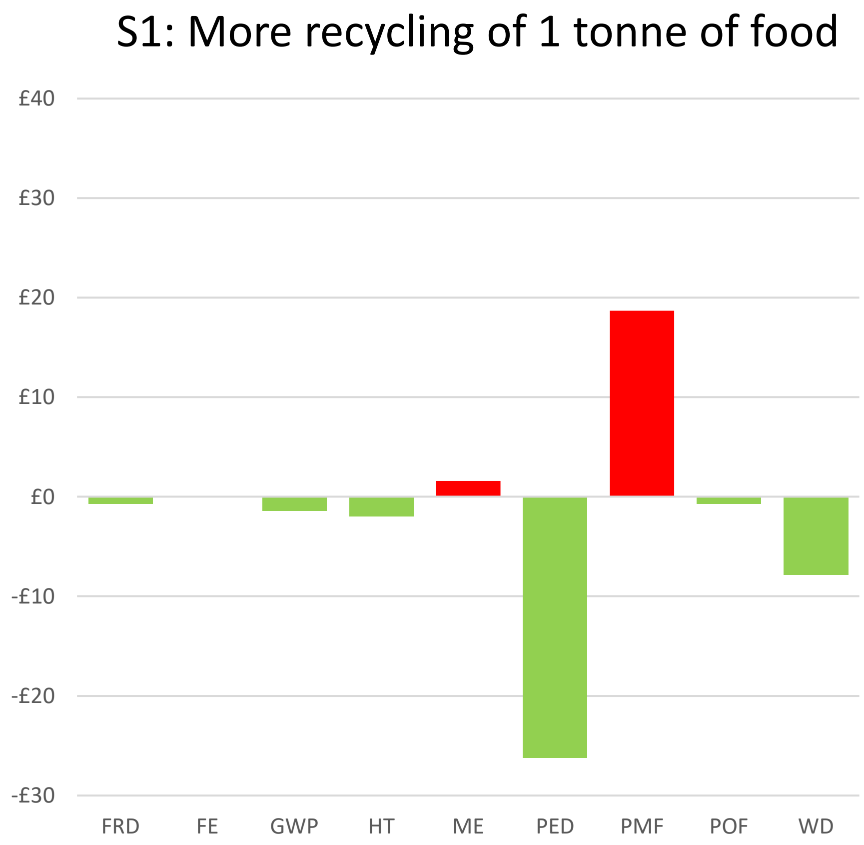
10,000 tonnes less food waste: every aspect of food cycle is affected

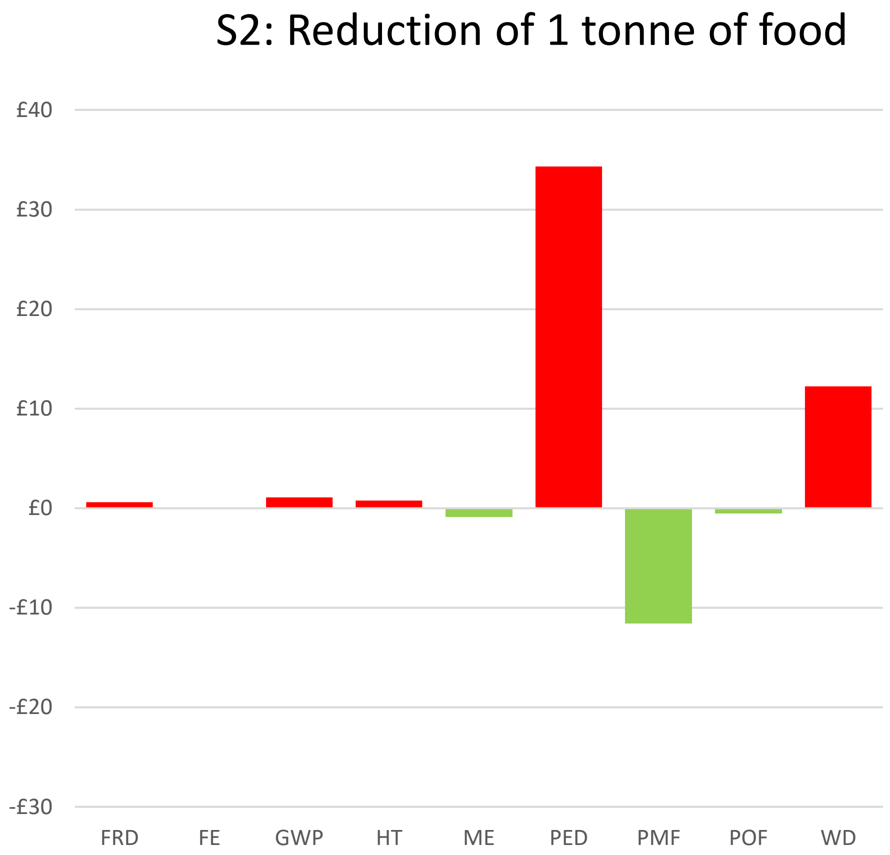
- 15,000 tonnes less CO_2
- 86 tonnes less Nitrogen (marine eutrophication)
- 122,000 Gj less fossil resource depletion

But… 20% less green energy

The loss of benefits from energy generation is outweighed by much larger reduction in the resource burden of food

So…Is it better to recycle or reduce waste?

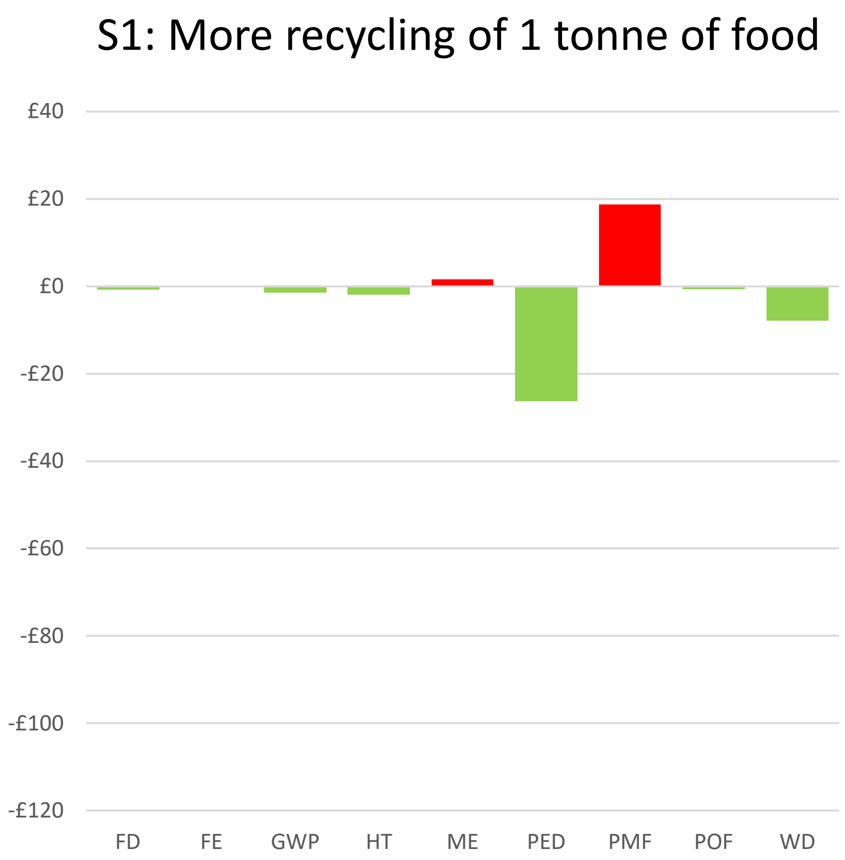


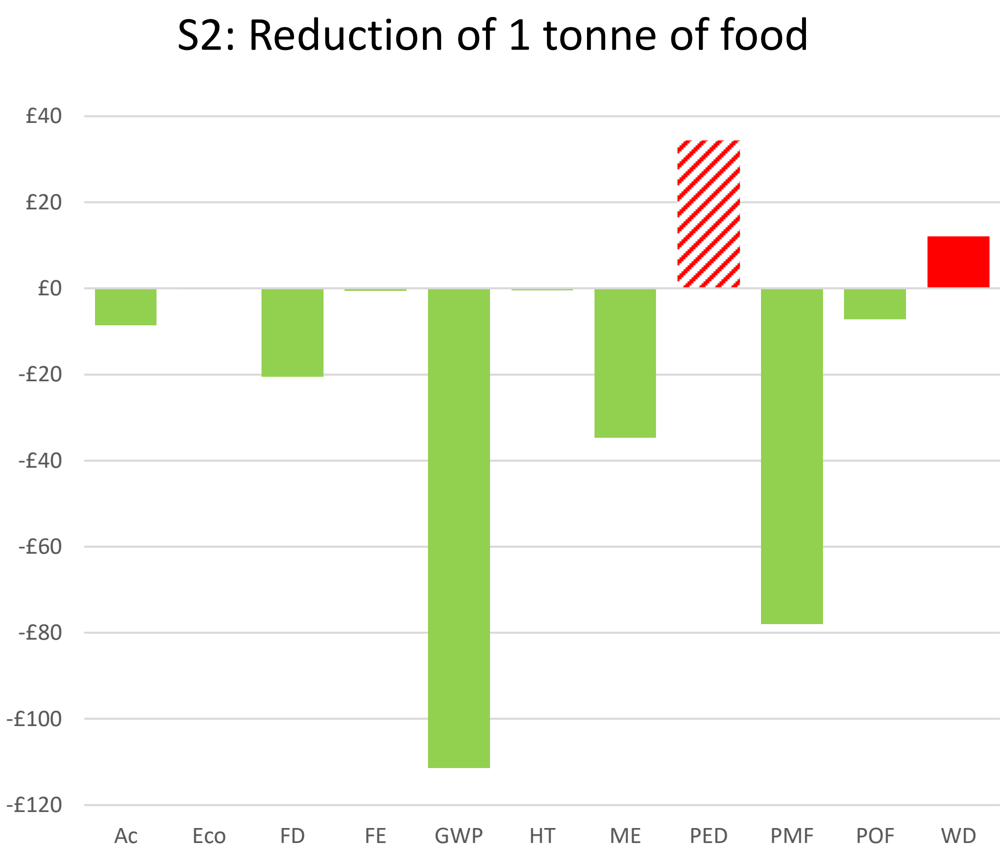


This is the net value of changes relating to the **method of disposal of food waste only** (not total burden)

Negative figures (in green) relate to potential savings from reduced environmental impacts. Positive figures (in red) indicate increased costs.

Comparing the total environmental burden of recycling versus reduction in consumption



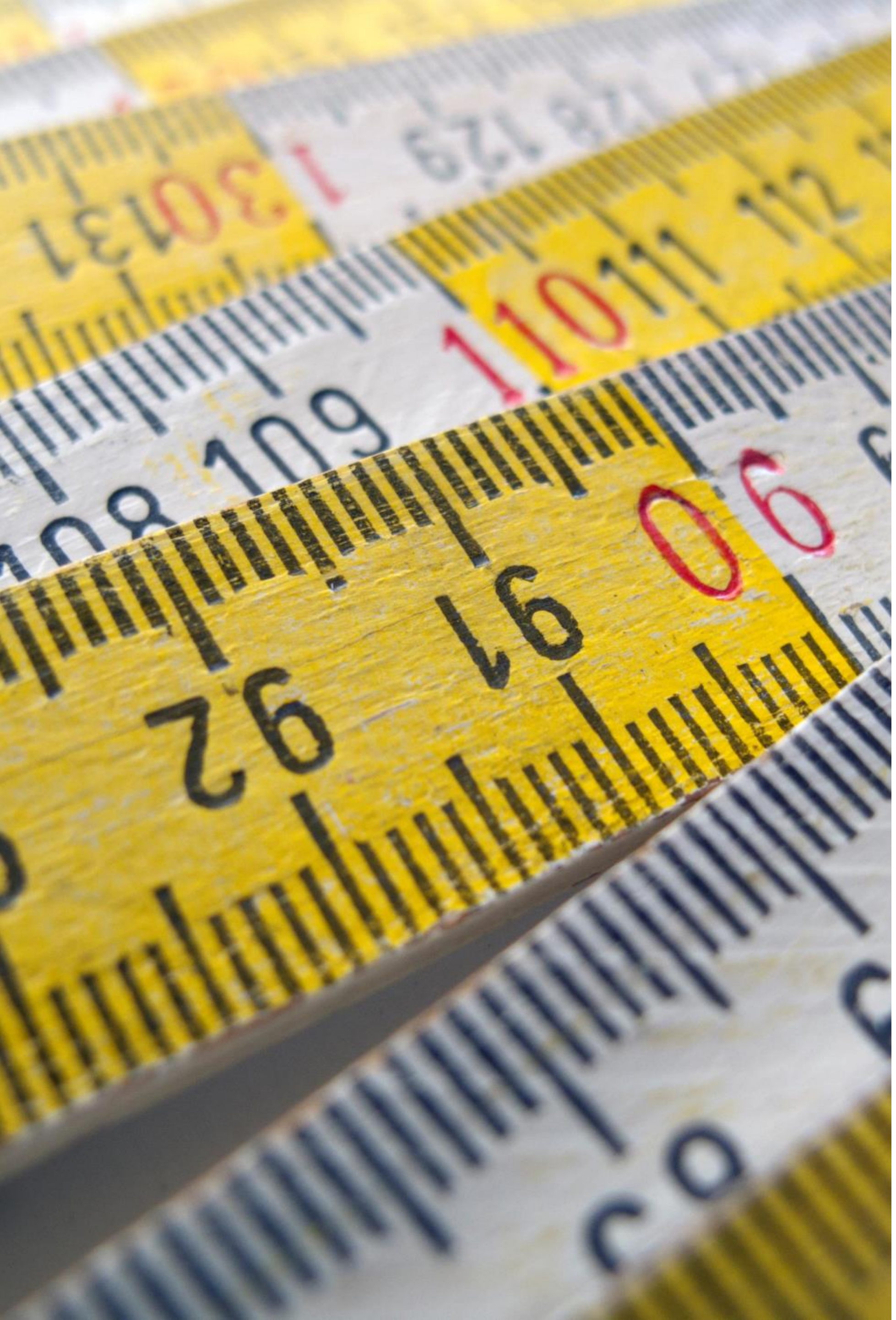


This is the net value of changes **including disposal and the burden of food production** compared.
NB the value of primary energy demand (PED) burden of food production not known so this element is incomplete

Putting findings into context

Saleemdeep (2017):
Environmental valuation of food waste UK:
GWP impact of food waste is estimated at 1,419 kg CO_2/t versus our estimate of 2,413 kg CO_2/t due to rebound effect

Chapagain & James (2011):
Carbon and water burden of food waste UK:
GWP impact is estimated at 2,000 – 3,800 kg CO_2/t.
Water footprint may be c.870m^3/t compared to 4.17m^3/t in Tonini study: differences in definition of unit



LIMITATIONS

- Methodological challenges – comparable units and assumptions
- Uncertainty in valuations
- Assumptions dependent on local mix of waste disposal methods and national grid energy mix for many environmental impacts
- Impacts are on a global scale
- Snapshot in time – does not model changes in carbon pricing, gate fees, or the socio-environmental effects of behaviour change
- Does not model market changes in food/energy/waste economies and the impact of these on household incomes

SUMMARY: REINFORCING THE WASTE HIERARCHY

Bristol is unusual for the UK, in that households send more of their waste for recycling, and almost no food waste goes to landfill.

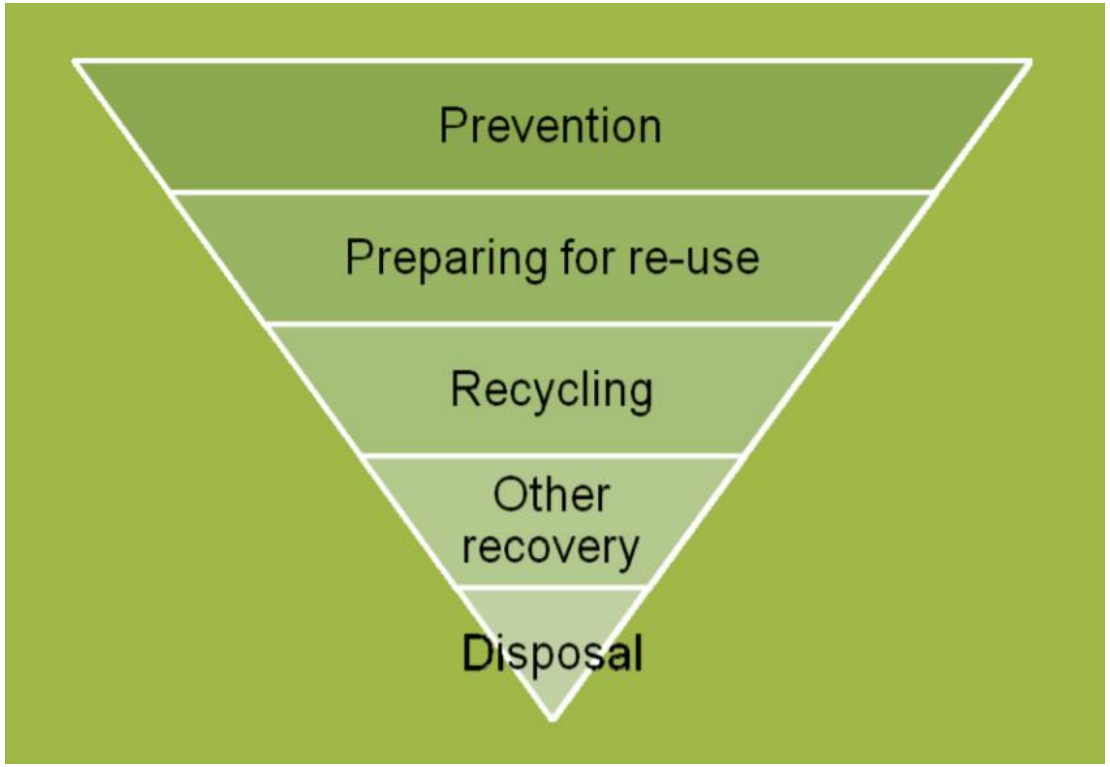
Our calculations reinforce the Waste Hierarchy: demonstrating that prevention of food waste has the largest number of environmental benefits, including improvements in air, soil and water quality.

However, 30% of wasted food is not edible, and this should be disposed of in the most efficient way possible.

Compared to Incineration or Landfill, Anaerobic Digestion has the most positive outcomes, although some methods can increase particulate matter pollution.

Therefore it is still valuable to move any unavoidable food waste from residual (black bins) to recycling, as this has many significant environmental benefits for the city.

However, benefits from energy generation rely on how much green energy can replace grid energy – as the proportion of renewables in grid energy rises, these benefits will reduce.



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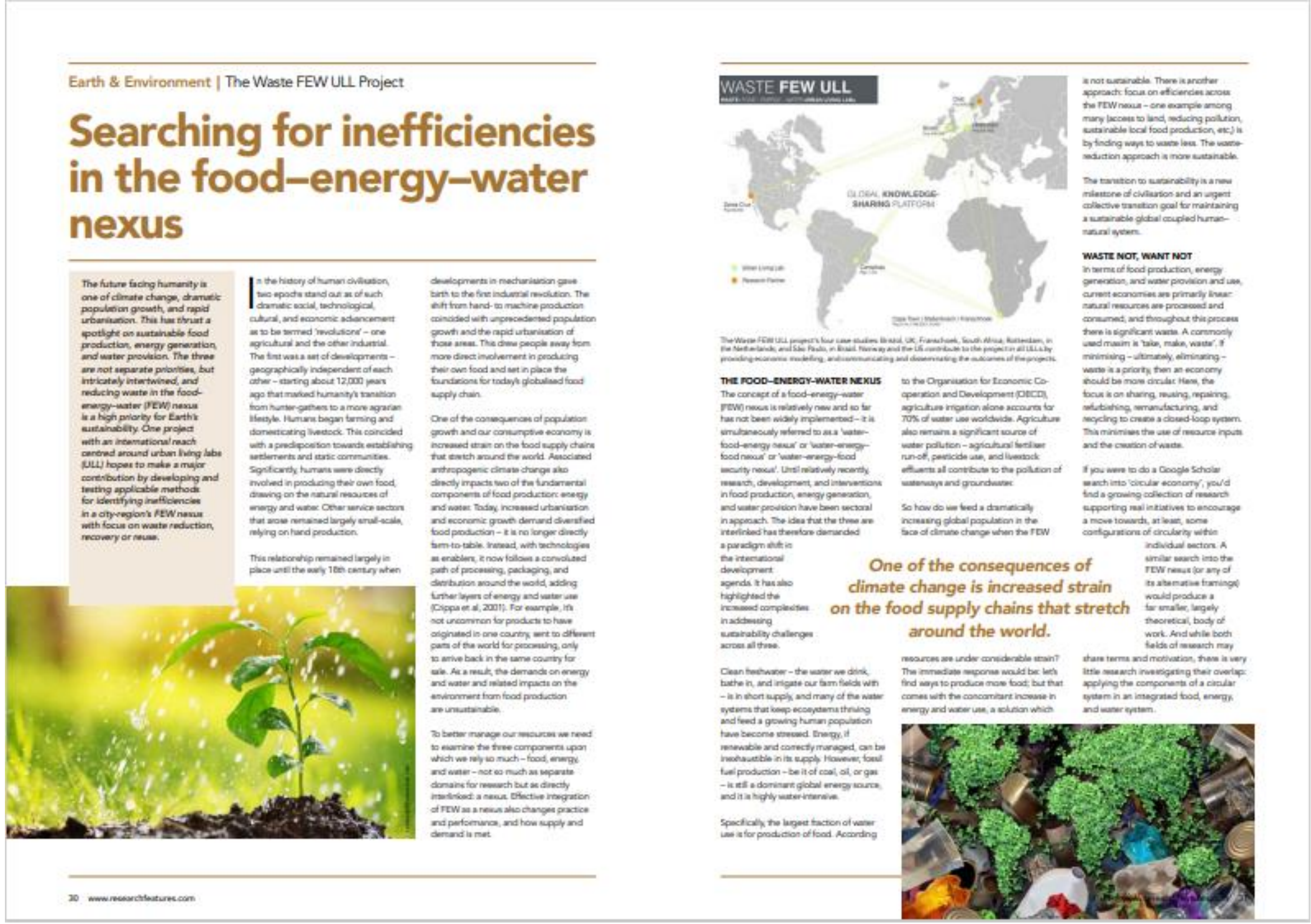
Earth & Environment | The Waste FEW ULL Project

Searching for inefficiencies in the food–energy–water nexus

WASTE FEW ULL

THE FOOD–ENERGY–WATER NEXUS

WASTE NOT, WANT NOT

One of the consequences of climate change is increased strain on the food supply chains that stretch around the world.

30 www.researchfeatures.com

Payntun et al (2022) Searching for inefficiencies in the food–energy–water nexus;
***Resource Futures*, Jan 28 2022**

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Thanks for your time

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REFERENCES

- Tonini et al (2018) Environmental impacts of food waste: Learnings and challenges from a case study on UK, *Waste Management* 76 (2018) 744–766
- Slorach et al (2019); "Environmental sustainability of anaerobic digestion of household food waste", *Journal of Environmental Management* 236 (2019) 798–814
- Dundon, C (2019); "Waste Compositional Analysis Report: Bristol Waste Company", Resource Futures, Confidential Report (Unpublished), Bristol 2019.
- WRAP (2011), *Estimates for household food and drink waste in the UK 2011*, http://www.wrap.org.uk/content/estimates-household-food-and-drink-waste-uk-2011
- Sam Gillick and Tom Quested for WRAP (2018*) Household food waste: restated data for 2007-2015*, WRAP, Banbury 2018.
- WRAP (2018) *Courtauld Commitment 2025: food waste baseline for 2015*, WRAP 2018, http://www.wrap.org.uk/sites/files/wrap/Courtauld%20Commitment%202025%20-%20baseline%20report%20for%202015.pdf
- WRAP (2020), *Food surplus and waste in the UK – key facts (Updated January 2020),* WRAP 2020.
- ONS (2019) *Family spending in the UK: April 2017 to March 2018*, published online at https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/expenditure/bulletins/familyspendingintheuk/financialyearending2018
- Ashok Chapagain and Keith James for WRAP (2011), *The water and carbon footprint of household food and drink waste in the UK*, WRAP, Banbury 2011.
- Saleemdeeb et al (2017); A holistic approach to the environmental evaluation of food waste prevention, *Waste Management* 59 (2017) 442–450
- Defra (2011), *Guidance on applying the Waste Hierarchy* https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/69403/pb13530-waste-hierarchy-guidance.pdf
- Payntun et al (2022) Searching for inefficiencies in the food–energy–water nexus; *Resource Futures*, Jan 28 2022; doi: 10.26904/RF-139-2175769885

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