

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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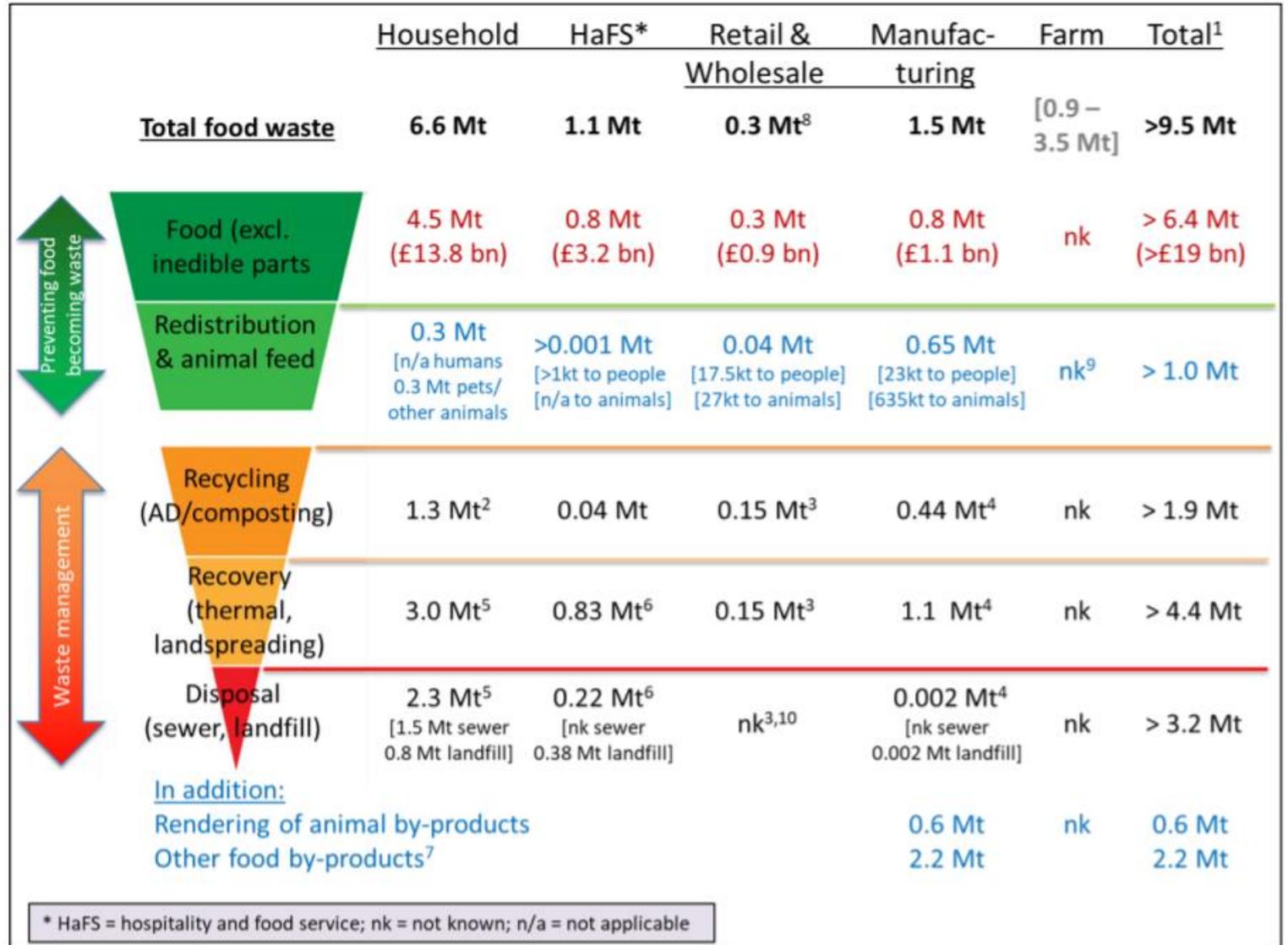
FOOD WASTE IN UK

10 MILLION CARS

The GHGs associated with the 9.5 Mt of food waste in the UK is around 25 million tonnes CO₂e – 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.”





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 CO₂ 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 CO₂ 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

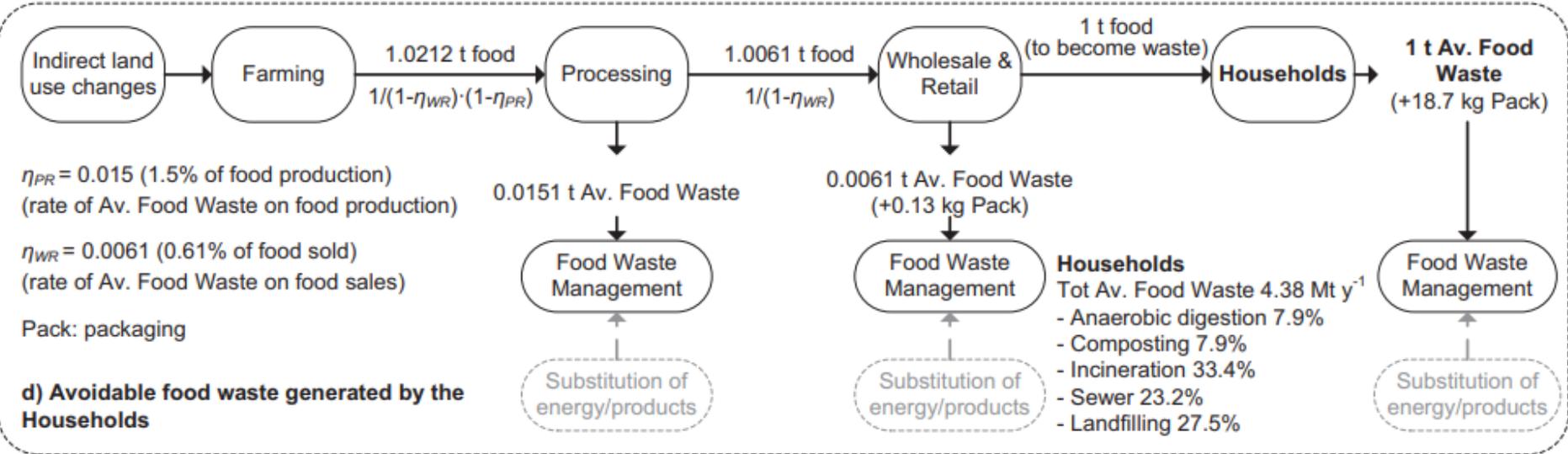


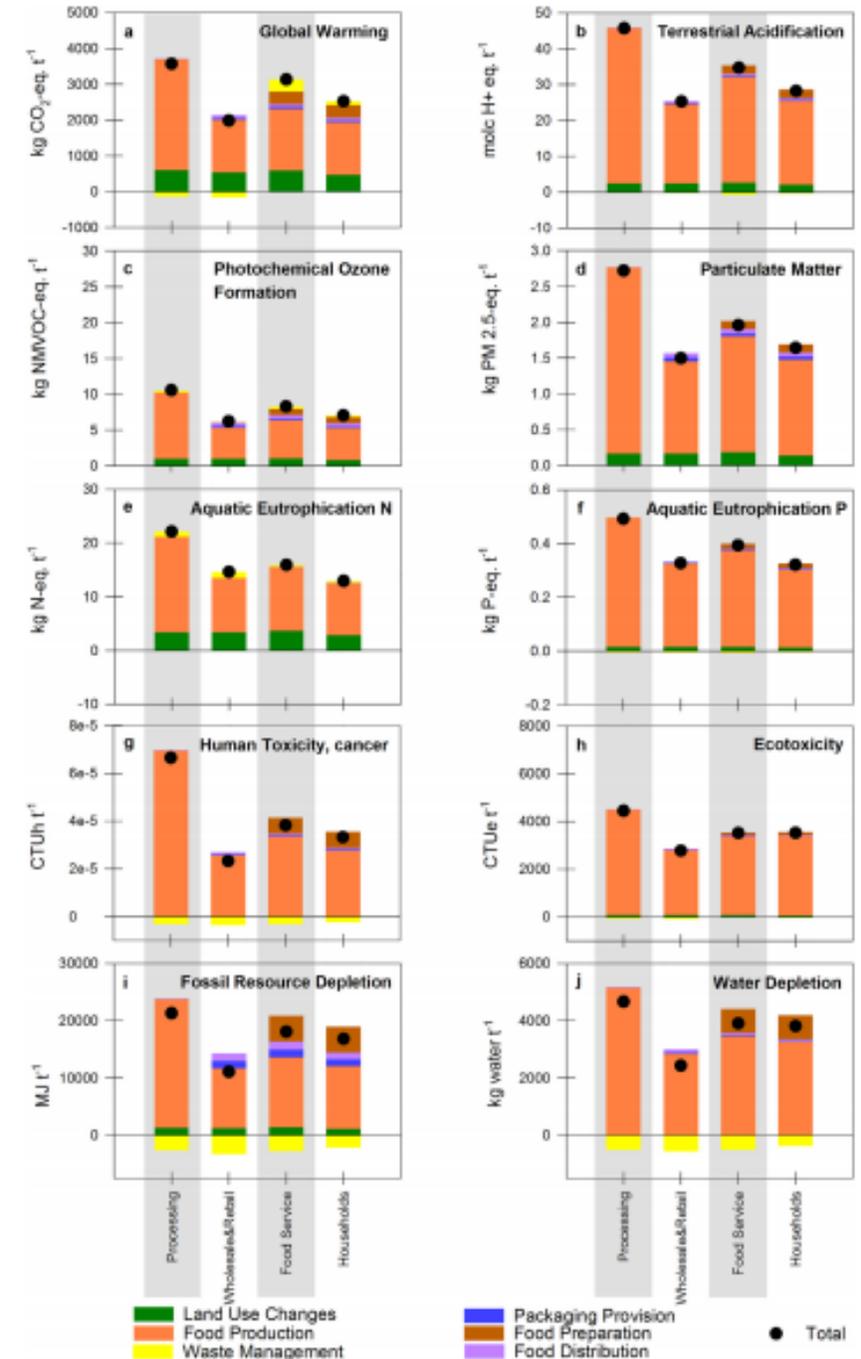
Fig. 1. System boundary for the assessment of the life cycle impacts of one tonne of avoidable food waste generated at: (a) Processing, (b) Wholesale & Retail, (c) Food Service, and (d) Households (the two latter share the same boundaries). Induced flows are illustrated with black-continuous lines. Avoided 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

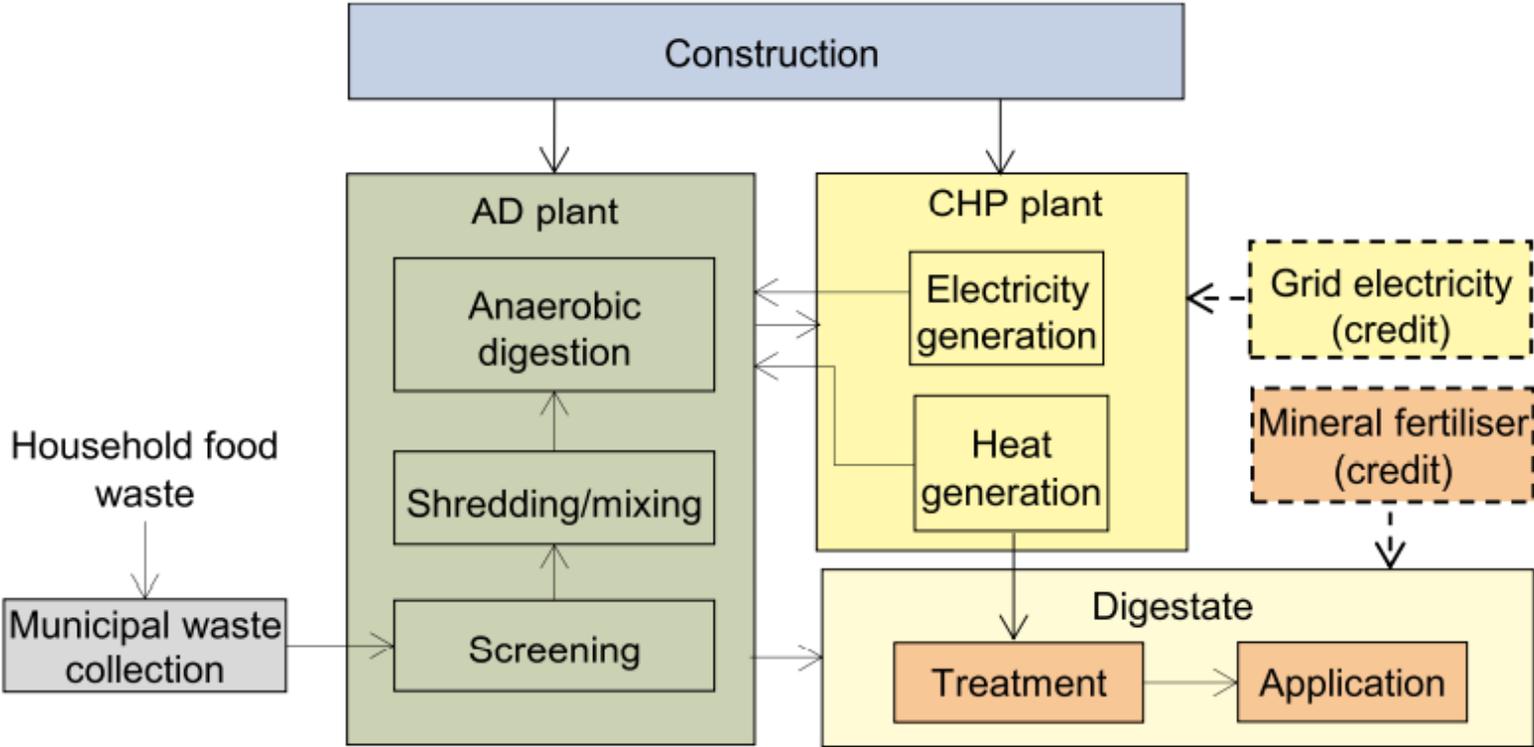


Fig. 1. Life cycle stages considered for anaerobic digestion of food waste (——— System credits. AD: anaerobic digestion. CHP: combined heat and power).

LCA ON FOOD WASTE: WASTE DISPOSAL

P.C. Slorach, et al.

Journal of Environmental Management 236 (2019) 798–814

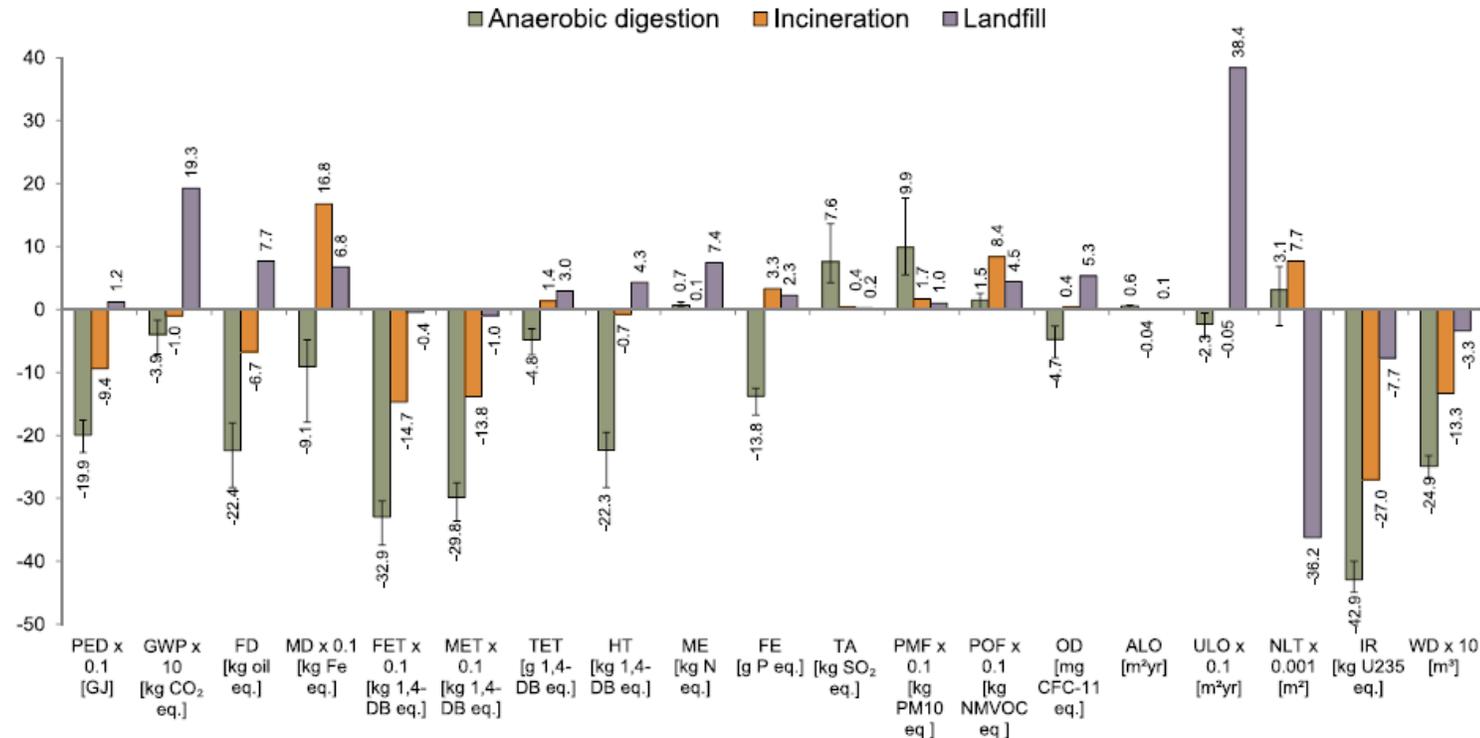


Fig. 4. Environmental impacts of treating food waste by anaerobic digestion (All impacts expressed per tonne of food waste treated. The solid bars and the data labels for the AD refer to the base case. The error bars represent the 90th and 10th percentile impacts obtained through Monte Carlo analysis 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.).



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

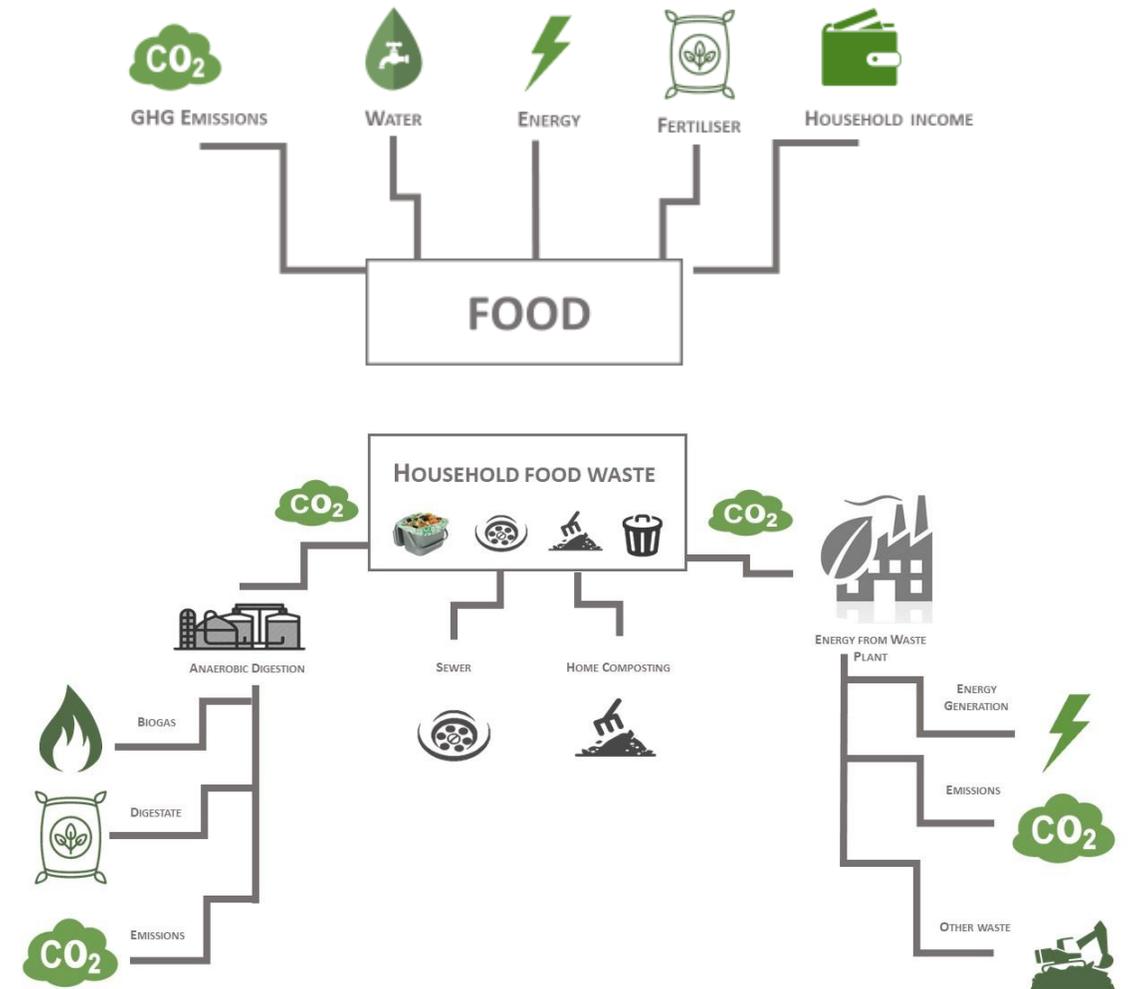


Image: mapping how household food waste is disposed of in Bristol

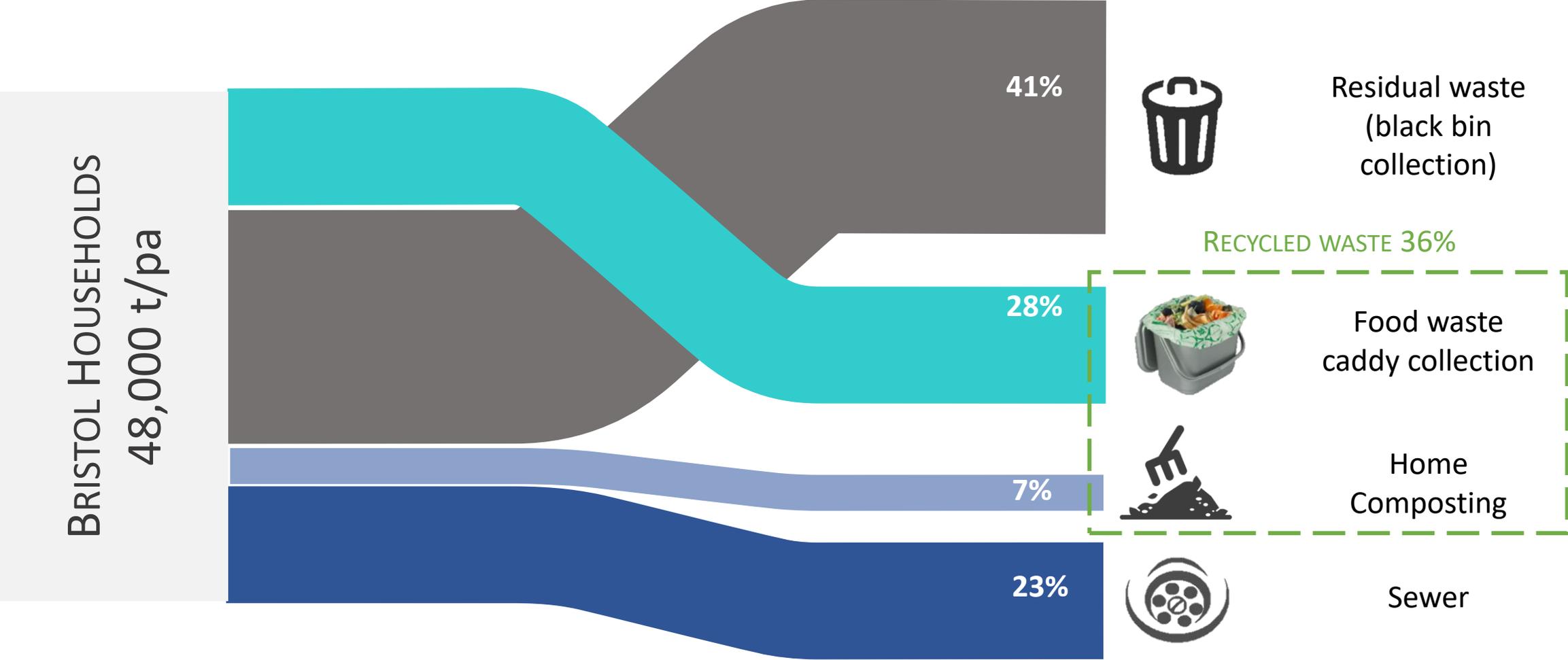
ASSUMPTIONS

- 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

About **11,000 tonnes** of food are poured down the drain every year



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 CO₂**

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

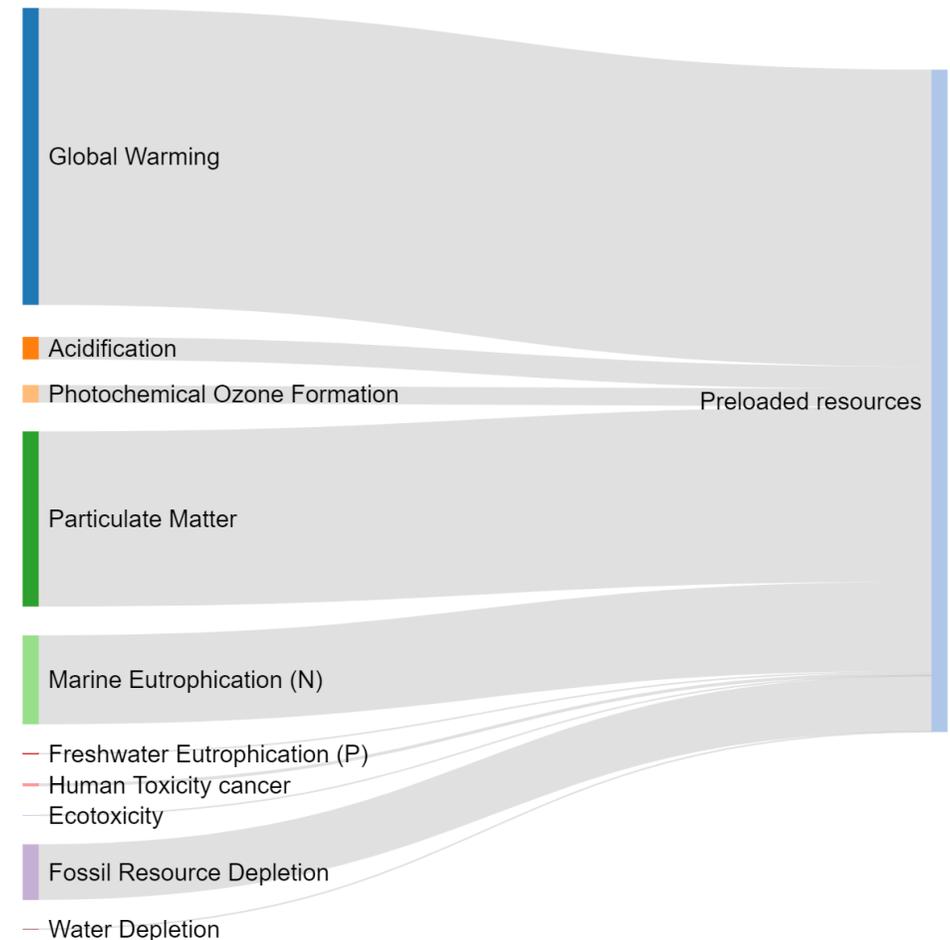
Particulate Matter: equivalent to **100 tonnes of PM_{2.5}**

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

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

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

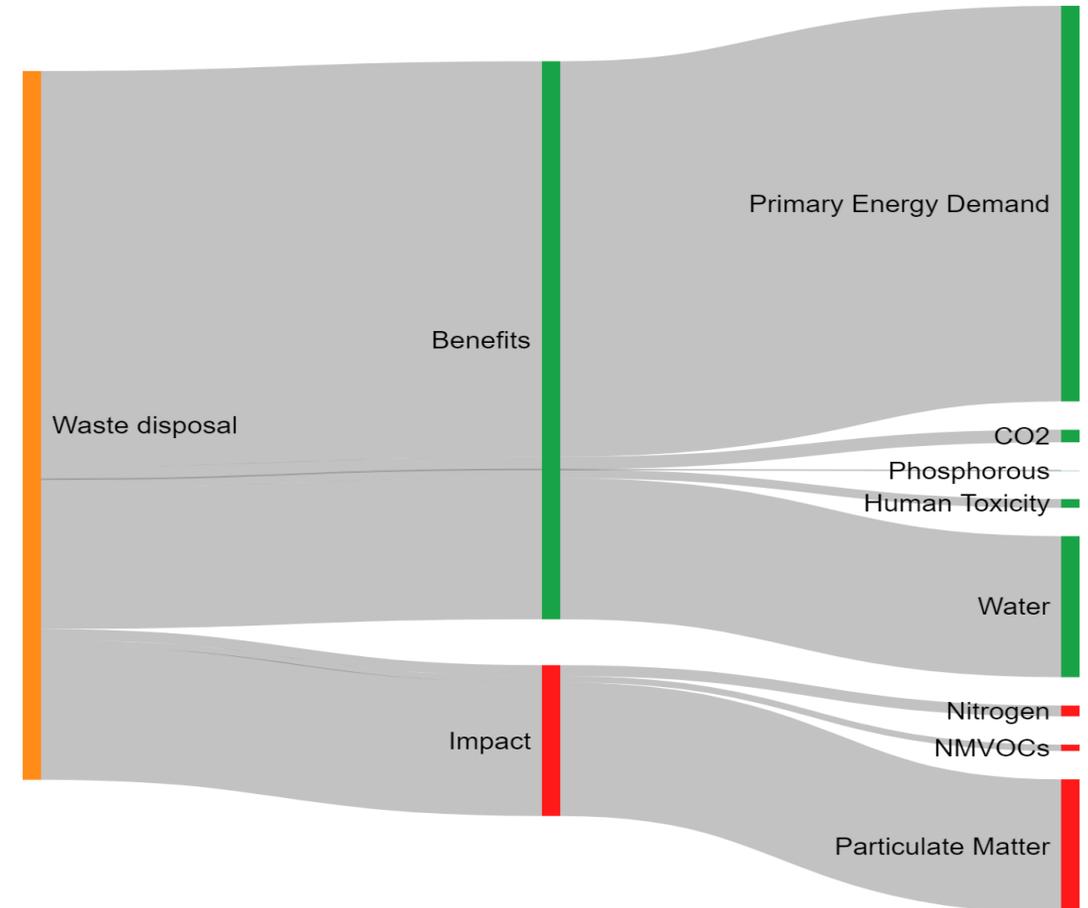
Water Use: **200,000 M³ water**



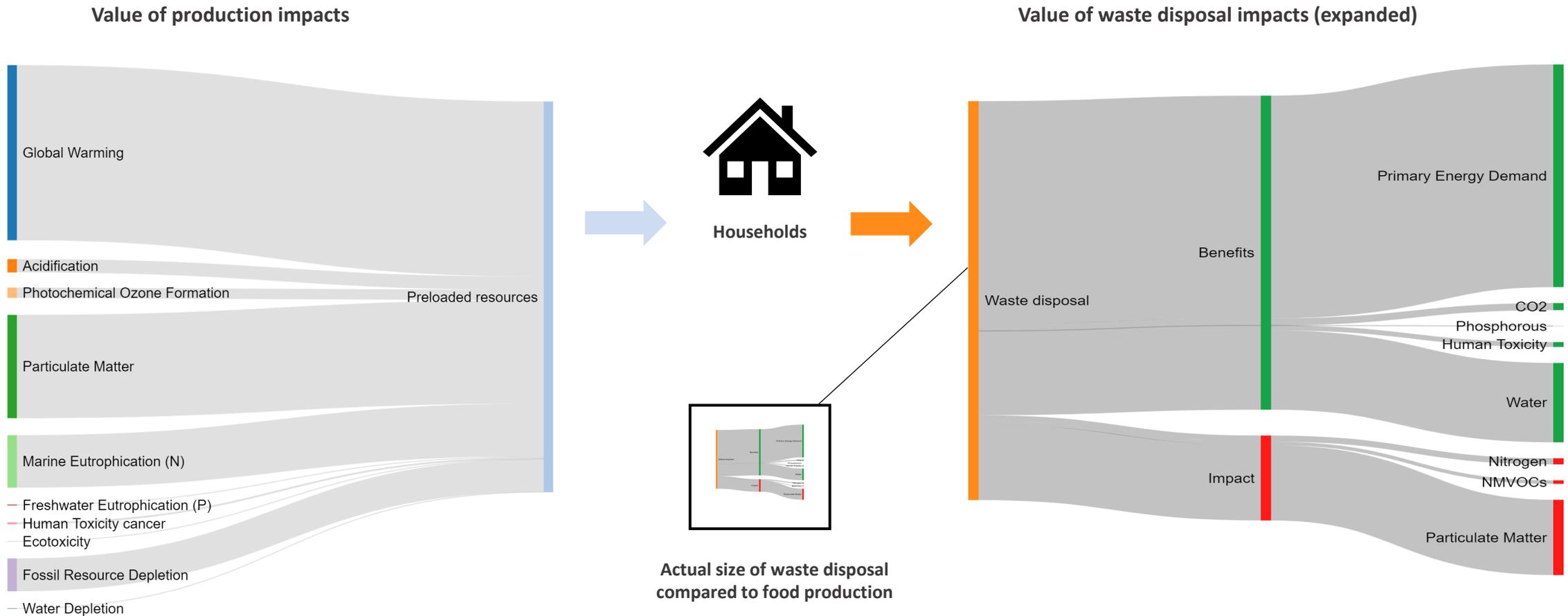
THE ANNUAL IMPACT OF BRISTOL'S FOOD WASTE ON THE ENVIRONMENT: EFFECTS OF WASTE DISPOSAL

- Less Primary Energy Demand: **-45,000 Gj**
- Less Global Warming Potential: **-727 tonnes CO₂ 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**



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



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 CO₂ equivalent related to electricity generation by Anaerobic Digestion
- 9% more green energy
- 451,000 less M³ 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 CO₂
- 86 tonnes less Nitrogen (marine eutrophication)
- 122,000 GJ less fossil resource depletion

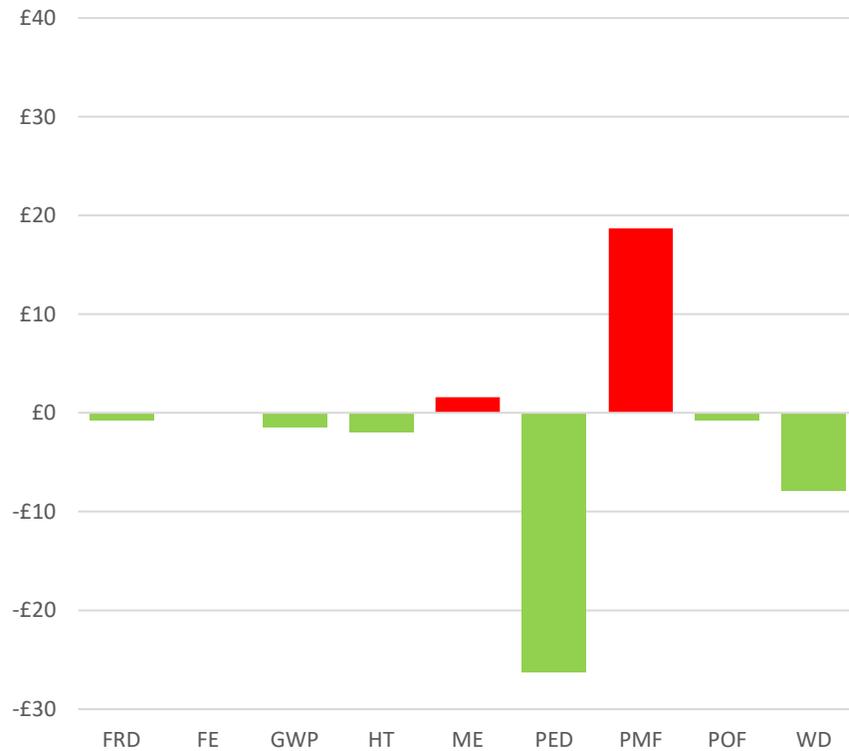
But... 20% less green energy

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

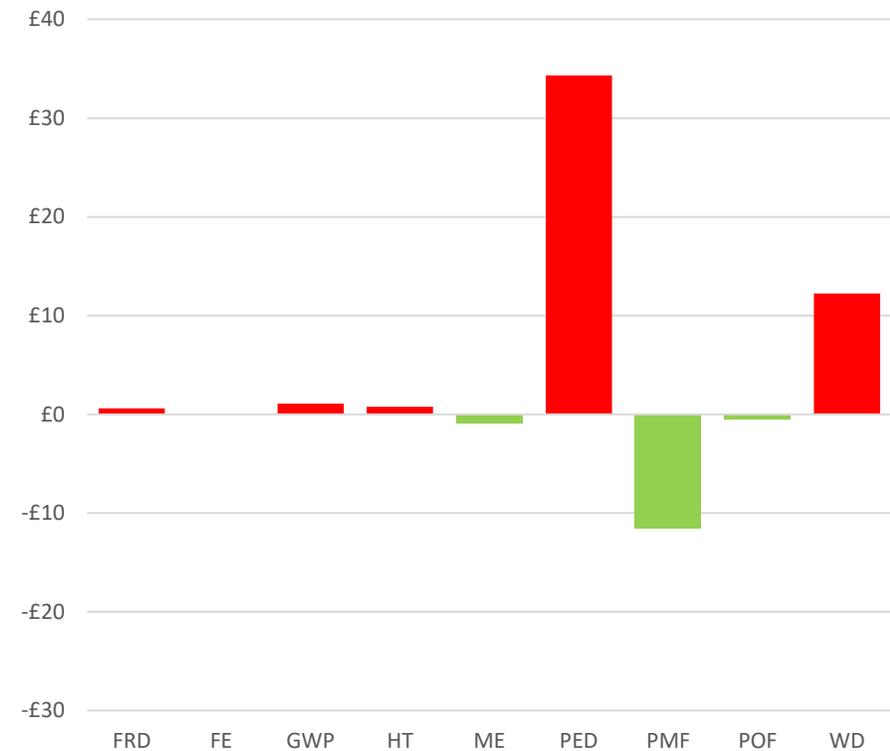


So...IS IT BETTER TO RECYCLE OR REDUCE WASTE?

S1: More recycling of 1 tonne of food



S2: Reduction of 1 tonne of food



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

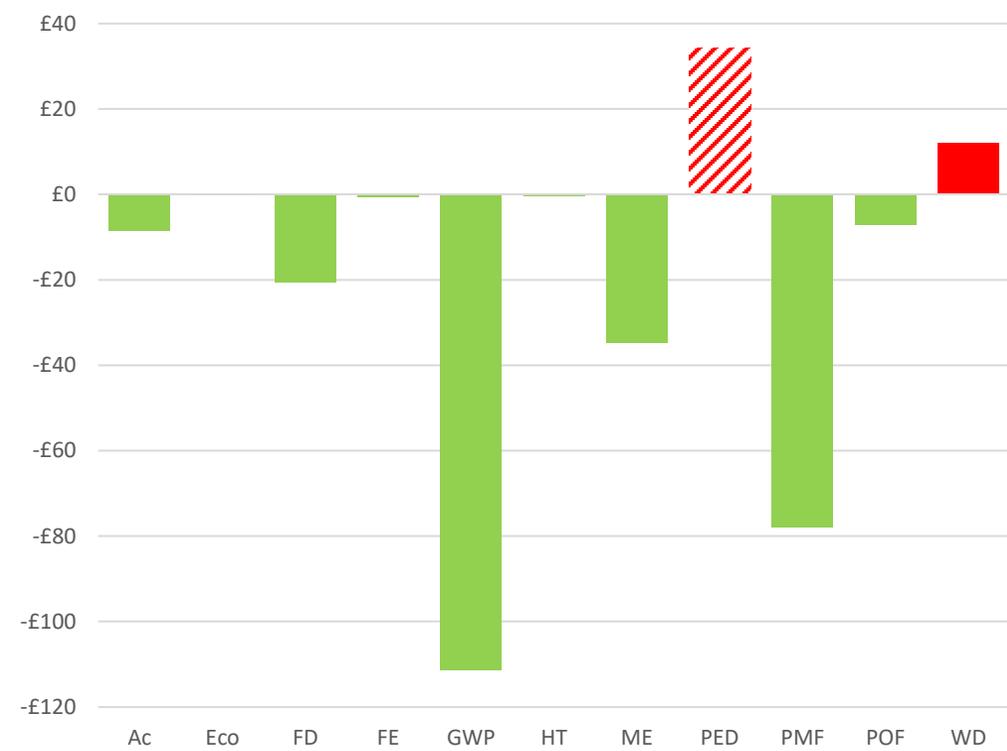
Negative figures (in green) relate to potential savings from reduced environmental impacts. Positive figures (in red) indicate increased costs.

COMPARING THE TOTAL ENVIRONMENTAL BURDEN OF RECYCLING VERSUS REDUCTION IN CONSUMPTION

S1: More recycling of 1 tonne of food



S2: Reduction of 1 tonne of food



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 CO₂/t versus our estimate of 2,413 kg CO₂/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 CO₂/t.

Water footprint may be c.870m³/t compared to 4.17m³/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.

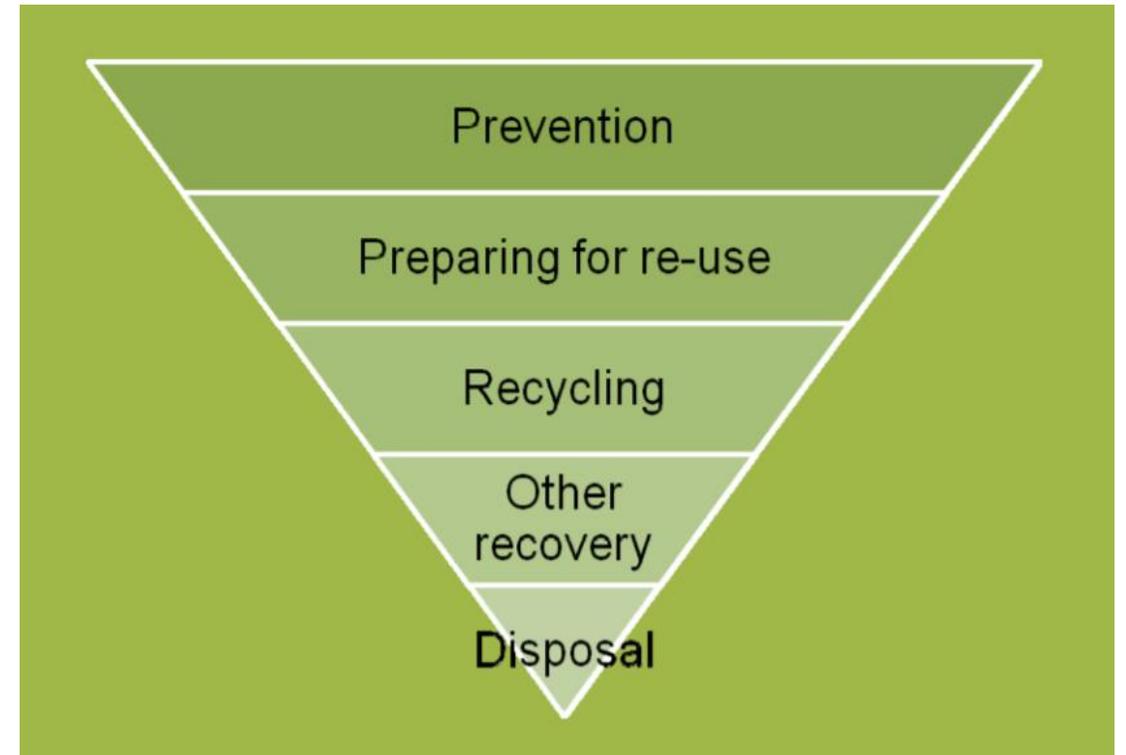
Our calculations reinforce the Waste Hierarchy: demonstrating that prevention of food waste has the largest number of environmental benefits, including improvements in air, soil and water quality.

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.



READ MORE

Earth & Environment | The Waste FEW ULL Project

Searching for inefficiencies in the food–energy–water nexus

The future facing humanity is one of climate change, dramatic population growth, and rapid urbanisation. This has thrust a spotlight on sustainable food production, energy generation, and water provision. The three are not separate priorities, but intricately intertwined, and reducing waste in the food–energy–water (FEW) nexus is a high priority for Earth's sustainability. One project with an international reach centred around urban living labs (ULL) hopes to make a major contribution by developing and testing applicable methods for identifying inefficiencies in a city-region's FEW nexus with focus on waste reduction, recovery or reuse.

In the history of human civilisation, two epochs stand out as of such dramatic social, technological, cultural, and economic advancement as to be termed 'revolutions' – one agricultural and the other industrial. The first was a set of developments – geographically independent of each other – starting about 12,000 years ago that marked humanity's transition from hunter-gathering to a more agrarian lifestyle. Humans began farming and domesticating livestock. This coincided with a predisposition towards establishing settlements and static communities. Significantly, humans were directly involved in producing their own food, drawing on the natural resources of energy and water. Other service sectors that arose remained largely small-scale, relying on hand production.

This relationship remained largely in place until the early 18th century when developments in mechanisation gave birth to the first industrial revolution. The shift from hand- to machine production coincided with unprecedented population growth and the rapid urbanisation of these areas. This drew people away from more direct involvement in producing their own food and set in place the foundations for today's globalised food supply chain.

One of the consequences of population growth and our consumptive economy is increased strain on the food supply chains that stretch around the world. Associated anthropogenic climate change also directly impacts two of the fundamental components of food production: energy and water. Today, increased urbanisation and economic growth demand diversified food production – it is no longer directly farm-to-table. Instead, with technologies as enablers, it now follows a convoluted path of processing, packaging, and distribution around the world, adding further layers of energy and water use (Cripps et al. 2021). For example, it's not uncommon for products to have originated in one country, sent to different parts of the world for processing, only to arrive back in the same country for sale. As a result, the demands on energy and water and related impacts on the environment from food production are unsustainable.

To better manage our resources we need to examine the three components upon which we rely so much – food, energy and water – not so much as separate domains for research but as directly interlinked, a nexus. Effective integration of FEW as a nexus also changes practice and performance, and how supply and demand is met.

The concept of a food–energy–water (FEW) nexus is relatively new and so far has not been widely implemented – it is simultaneously referred to as a 'water–food–energy nexus' or 'water–energy–food security nexus'. Until relatively recently, research, development, and interventions in food production, energy generation, and water provision have been sectoral in approach. The idea that the three are interlinked has therefore demanded a paradigm shift in the international development agenda. It has also highlighted the increased complexities in addressing sustainability challenges across all three.

Clean freshwater – the water we drink, bathe in, and irrigate our farm fields with – is in short supply, and many of the water systems that keep ecosystems thriving and feed a growing human population have become stressed. Energy, if renewable and correctly managed, can be inexhaustible in its supply. However, fossil fuel production – be it of coal, oil, or gas – is still a dominant global energy source, and it is a highly water-intensive.

Specifically, the largest fraction of water use is for production of food. According to the Organisation for Economic Co-operation and Development (OECD), agriculture irrigation alone accounts for 70% of water use worldwide. Agriculture also remains a significant source of water pollution – agricultural fertiliser run-off, pesticide use, and livestock effluents all contribute to the pollution of waterways and groundwaters.

So how do we feed a dramatically increasing global population in the face of climate change when the FEW

is not sustainable. There is another approach: focus on efficiencies across the FEW nexus – one example among many (access to land, reducing pollution, sustainable local food production, etc.) is by finding ways to waste less. The waste-reduction approach is more sustainable.

The transition to sustainability is a new milestone of civilisation and an urgent collective transition goal for maintaining a sustainable global coupled human–natural system.

WASTE NOT, WANT NOT

In terms of food production, energy generation, and water provision and use, current economies are primarily linear: natural resources are processed and consumed, and throughout this process there is significant waste. A commonly used maxim is 'take, make, waste'. If minimising – ultimately, eliminating – waste is a priority then an economy should be more circular. Here, the focus is on sharing, reusing, repairing, refurbishing, remanufacturing, and recycling to create a closed-loop system. This minimises the use of resource inputs and the creation of waste.

If you were to do a Google Scholar search into 'circular economy', you'd find a growing collection of research supporting real initiatives to encourage a move towards, at least, some configurations of circularity within individual sectors. A similar search into the FEW nexus (or any of its alternative framings) would produce a far smaller, largely theoretical, body of work. And while both fields of research may share themes and motivation, there is very little research investigating their overlap: applying the components of a circular system in an integrated food, energy, and water system.



The Waste FEW ULL project's four case studies: Brazil, UK, France/Spain, South Africa, Rotterdam, in the Netherlands, and São Paulo, in Brazil, Norway and the US contribute to the project or all ULLs by providing economic modelling, and communicating and disseminating the outcomes of the projects.

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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