WASTE FEW ULL
WASTE: FOOD - ENERGY - WATER URBAN LIVING LABs

A three year experiment aimed at identifying and reducing Bristol's food-energy-water inefficiencies

Can re-valuing Bristol's waste help us waste less?

Watershed, Bristol, 11th November 2021

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Household Food Waste (HFW)

	Tonnes	Total value (£million)	Treatment costs (£ 1000)
Total residential waste	77 761		
Of which: food waste	47972		
- Avoidable	33580	99.2	?
- Recycled (AD)	13660		478
- Residual (EfW)	19440		1808
- Home composted	3553		
- Sewer	11105		
- Other	213		

- **Nationally, the annual financial cost (of purchasing)** **the 4.4 Mt avoidable household food that is wasted is £13 billion** (WRAP 2017), which implies a price of c.£3,000 per tonne HFW.
- Assuming this price also for the 33,580 tonnes HFW in Bristol, then **the total financial cost of the avoidable HFW in Bristol in a year is almost £100m.**

Commercial Food Waste (HFW)

Waste stream	Financial (p.a.)	Million tonnes (p.a.)	Financial per tonne	Financial (p.a.)	Tonnes
	£bn	Mt	£/t	£million	t
Region		UK		Bristol	
Manufacture	1.2	1.7	706	13.562	19,212
Retail &wholesale	0.8	0.3	2667	9.041	3,390
Hospitality and Food Service	2.5	0.92	2717	28.253	10,397
Total	4.5	2.92	1541	50.856	33,000

- **Nationally, total annual financial (purchase) cost** **for almost 3Mt of commercial food waste is £4.5 billion**. If using Bristol data, that commercial food waste would be contaminated with **100,000 tonnes of plastic.**
- Assuming the sectoral share of CFW in Bristol is the same as that in the UK, then we can estimate the **total financial value (or direct economic cost)** **of the CFW in Bristol in a year to be c.£51m**.

HEADLINE NOTES

- **£151m annual cost** (purchase price) **of Bristol's avoidable food waste**.
- This includes **only half CFW** as it uses Avonmouth plant data.
- This is assumed to be reduced to nearly zero within 35 years **if targets are met.**
- **No data on cost of treating avoidable food waste.**
- **Households/families throw away** (WRAP data):
  - £40 - 60 per week
  - **£490 - £730 per yr**

Aims

1. To **value non-market 'externalities'**
2. To identify/measure **potential barriers and opportunities**
3. To **sense check whether this** combined **approach is useful**

Non-Market

- **What are the non-market and socio-environmental benefits** (of reduced food waste/increased recycling)?
- **What reductions in energy and other resource usage** (in food production/transport and waste disposal) might be gained?

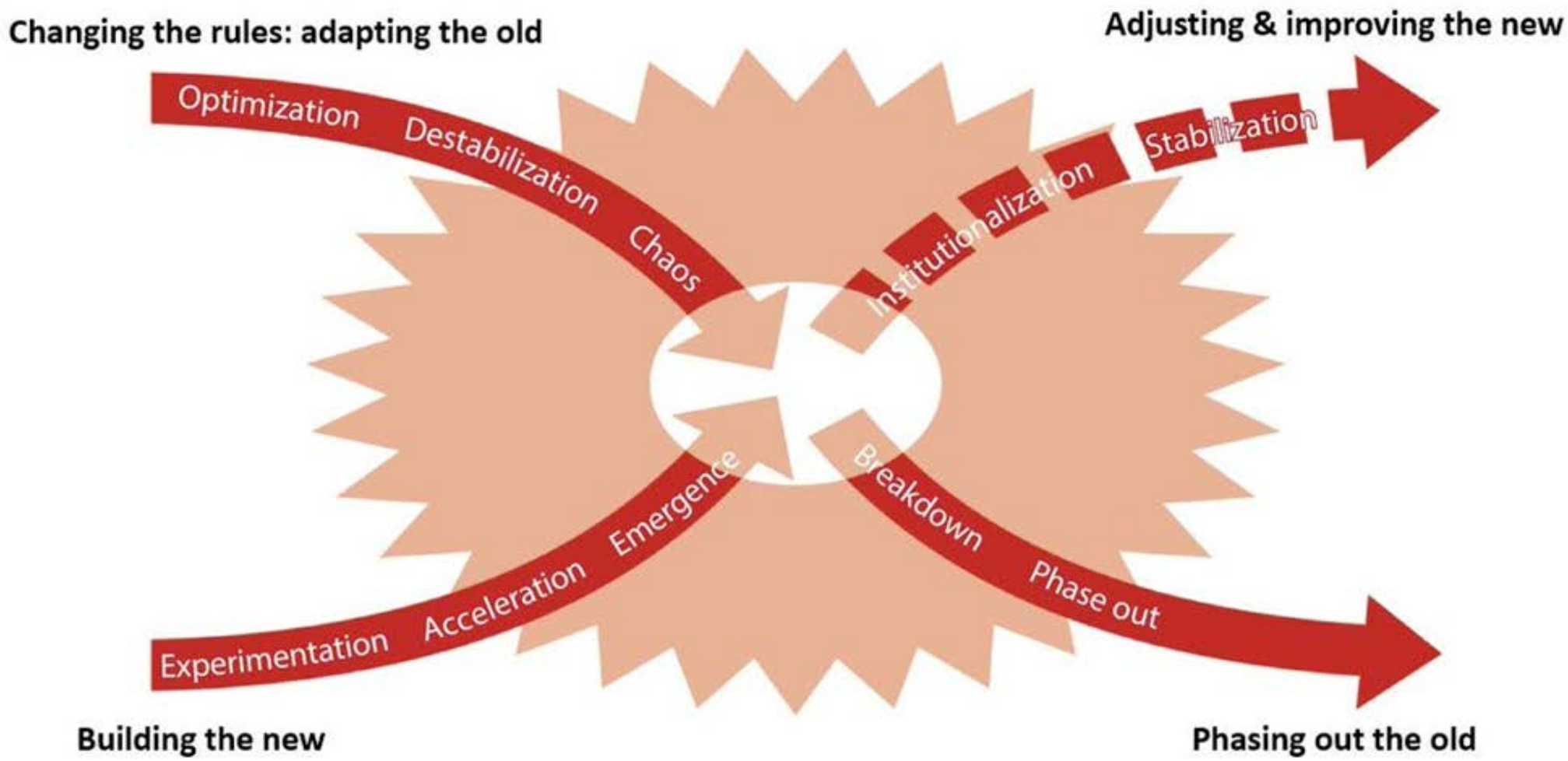
Scenario 1:
Recycling

Scenario 2:
Food Waste

Macro-economic

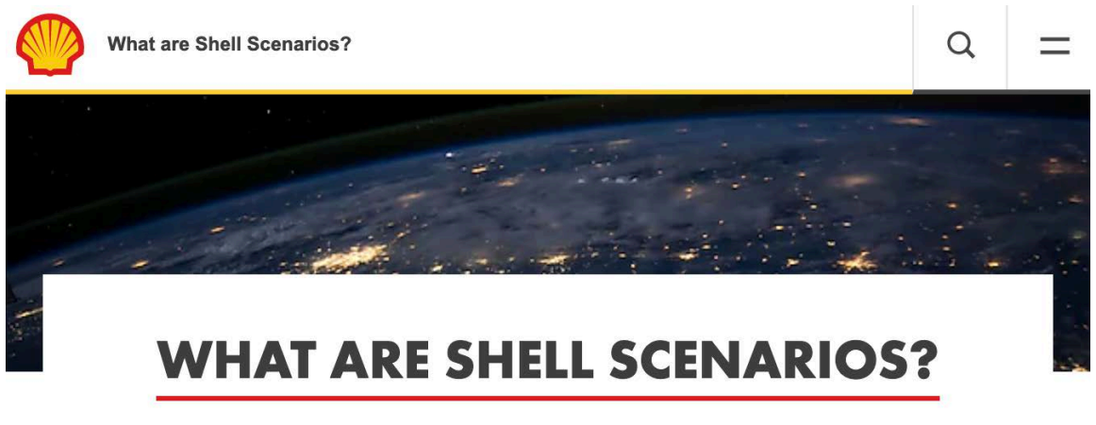
- What are the **consequences to different sectors** and the city's climate targets, both intended and unintended, **of achieving these targets?**
- Who are the **likely winners and losers** (and barriers to change)? *(i.e. are there vested interests at stake?)*
- Might we get **a sense of the scale** of those impacts? (i.e. *Is the cost of avoidable food waste processing sufficiently significant that it merits attention?)*
- What are the **carbon implications** of these changes, and how are wider socio-environmental implications robustly accounted for?
- **What does this mean for policy**, both locally at the city level, and nationally?

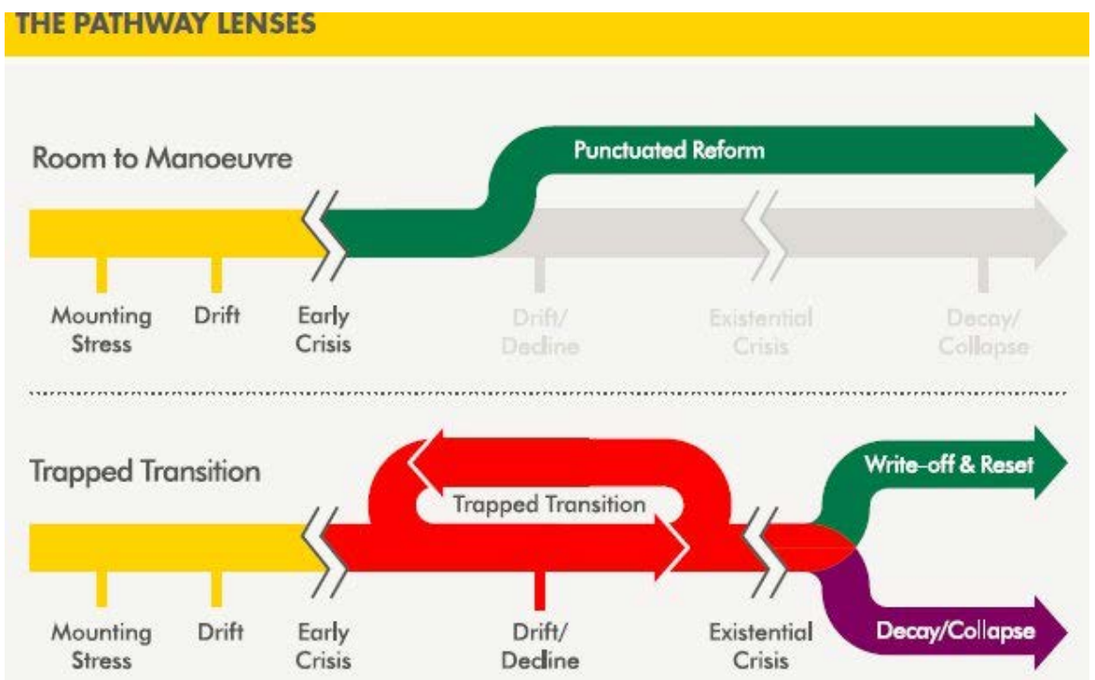
Is this combined approach useful and robust? What more is needed?



Transition pathway 'X-curve' that conceptualises the phasing out of unsustainable practice and the growing of sustainable practices (Loorbach D et al, 2017)

Embracing uncertainty





ELSEVIER

Technological Forecasting and Social Change
Volume 148, November 2019, 119712

'Aha' moments in the water-energy-food nexus: A new morphological scenario method to accelerate sustainable transformation

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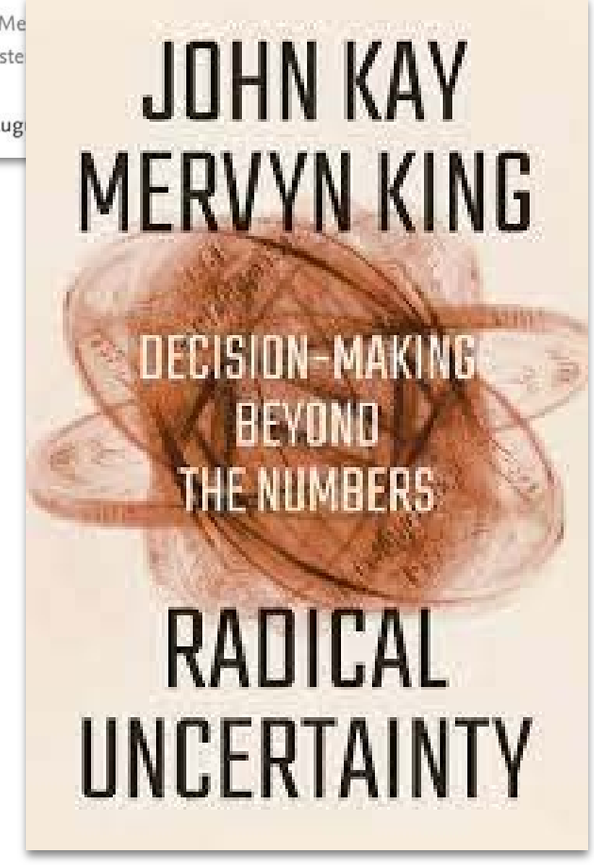
Received 22 February 2019, Revised 24 June 2019, Accepted 6 Aug

"Ask five economists and you'll get five different answers - six if one went to Harvard."

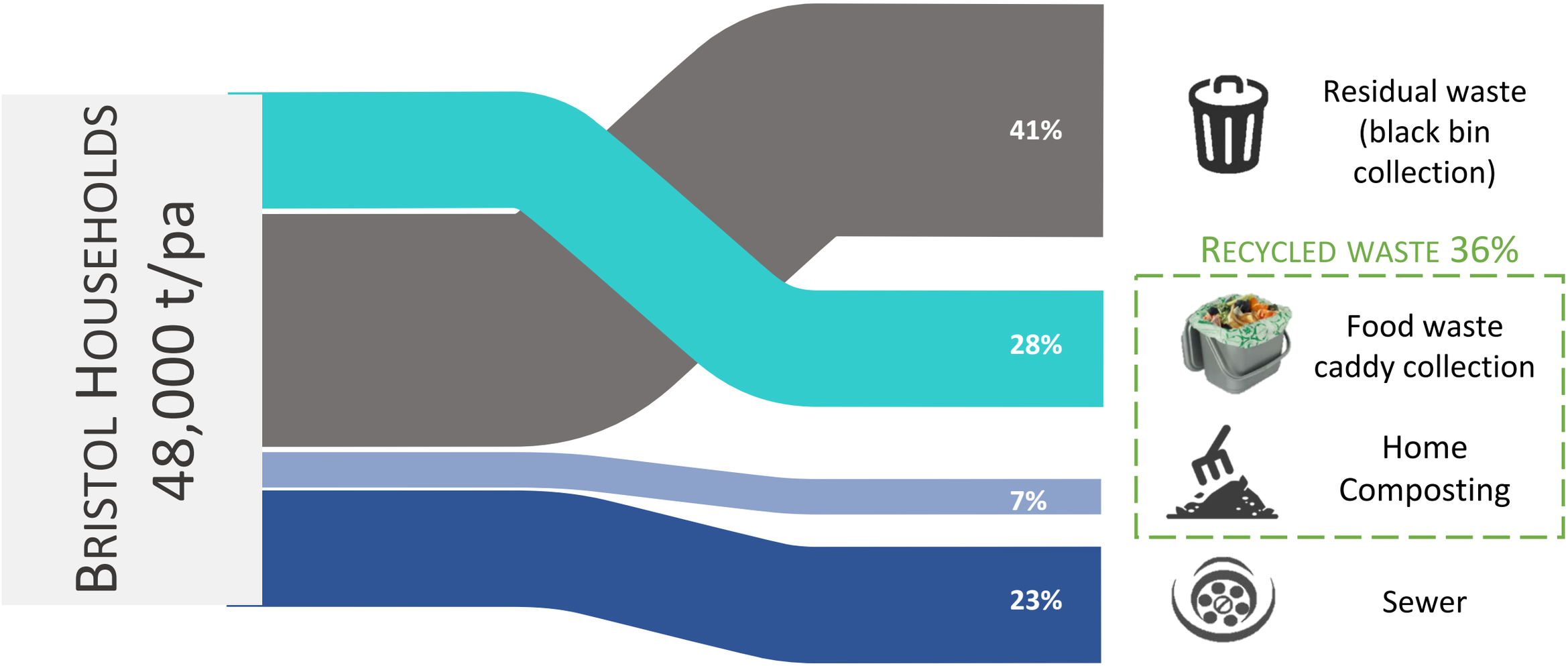
- Edgar Fiedler, Economist, Assistant Secretary to the Treasury, and Author of "Roots of Stagflation"



Valuing externalities

‘Non-market’ impacts
(socio-environmental)

Where does Bristol's food waste go?



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

Socio-Environmental outcomes: Example Metrics

Carbon/climate

- Effects expressed as £/t CO_2 equivalent
- High level of uncertainty (damage costs)
- CE Delft (2018): value of a reduction in 1t CO_2 equivalent using abatement cost approach
- Value forecast to rise almost fourfold by 2050

Health/toxicity

- Expressed as £/t 1,4DB equivalent or comparative toxicity units (£/t CTUh)
- Sum of effects of many different pollutants on human health
- Values for Human Toxicity are based on WTP 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.

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

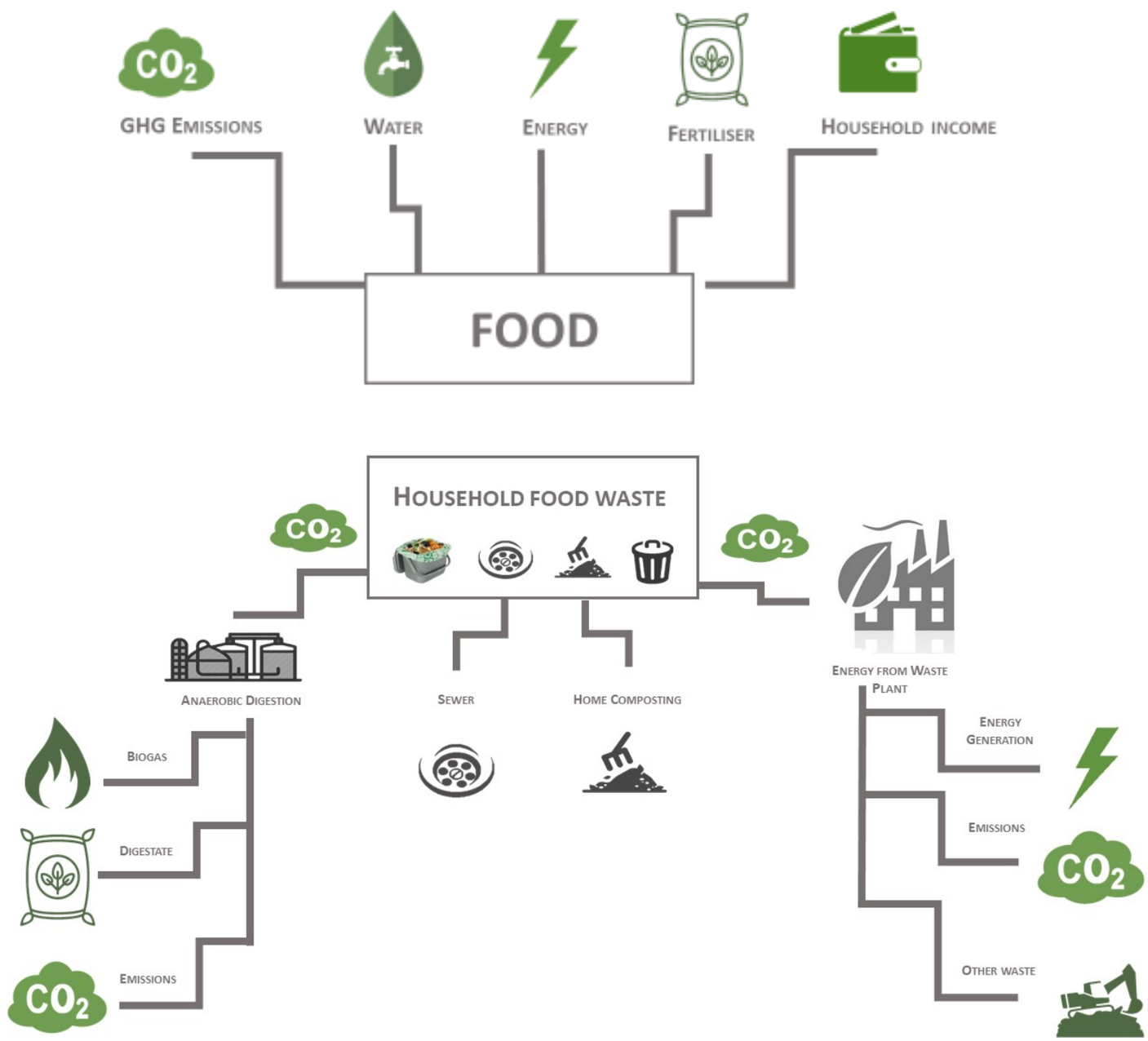
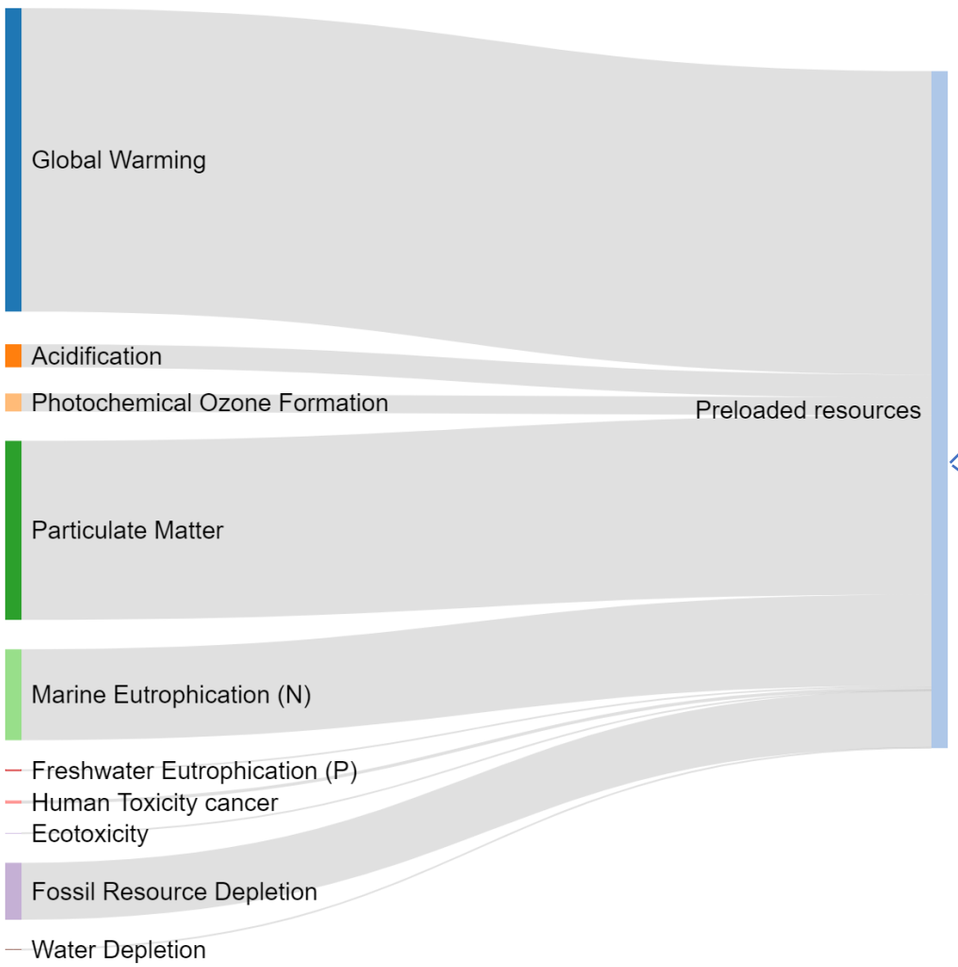


Image: mapping how household food waste is disposed of in Bristol

Socio-Environmental Outcomes

Food Production

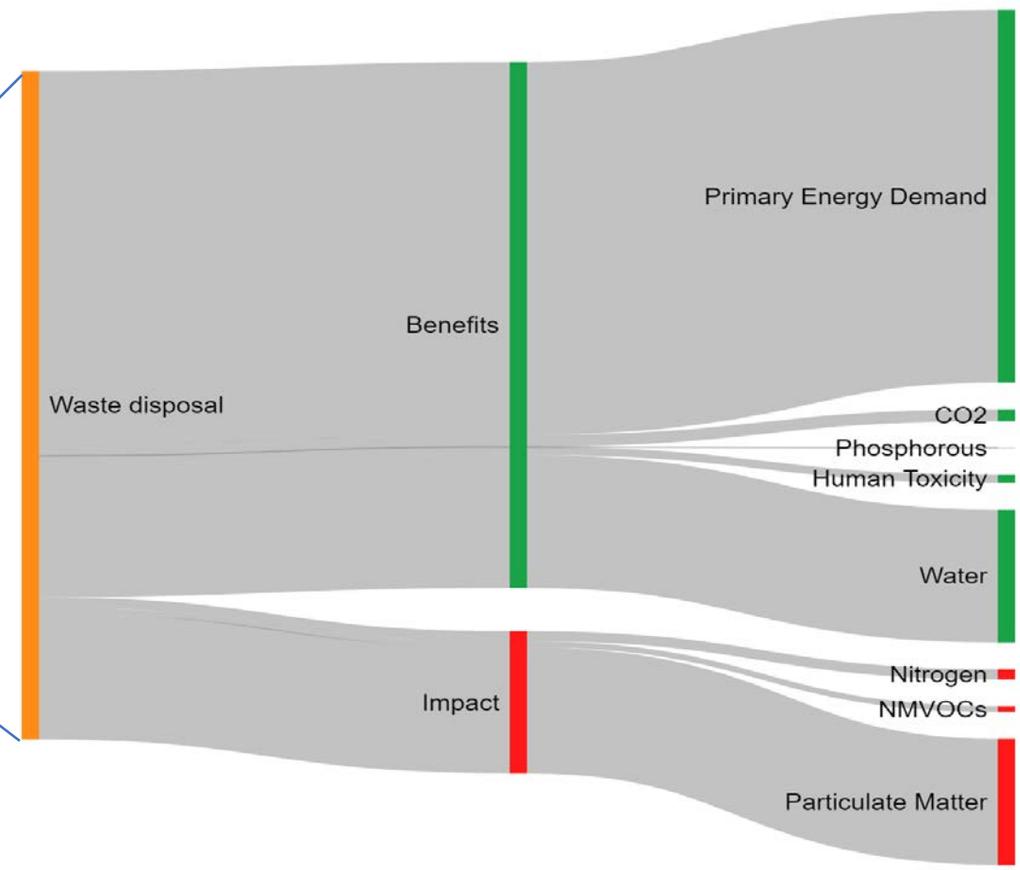
Image: relative weight of impacts in terms of value of impact (unit value x quantity of pollutant)



NOT TO SCALE

Waste Processing

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



- Global Warming: equivalent to **110,000 tonnes of CO_2**
- Photochemical Ozone Formation: **300 tonnes of NMVOCS**
- Particulate matter: equivalent to **100 tonnes of $PM_{2.5}$**
- Marine Eutrophication: equivalent to **600 tonnes (N)**
- Freshwater Eutrophication: equivalent to **20 tonnes (P)**
- Human Toxicity: equivalent to **2 cases of cancer**
- Water Depletion: **200,000 M^3 water**

- Less Primary Energy Demand: **-45,000 Gj**
- Less Global Warming Potential: **-700 tonnes CO_2 equiv**
- Less Freshwater Eutrophication: **-0.12 tonnes P equiv**
- Less Human Toxicity: **-300 t 1,4-DB equiv**
- Less Water Depletion: **-6 million tonnes water**
- More Marine Eutrophication: **12 tonnes N equiv**
- More VOCs: **18 tonnes NMVOCs**
- More Particulate matter: **17 tonnes PM10 equiv**

RECYCLING **VS** REDUCTION

- 3,888 tonnes more food 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…There may be an increase of 3 tonnes more PM_{10} and 2 tonnes more N-equiv because more material is processed by AD

10,000 tonnes less food waste, because every aspect of wasted food is affected

20% reduction in all environmental impacts:

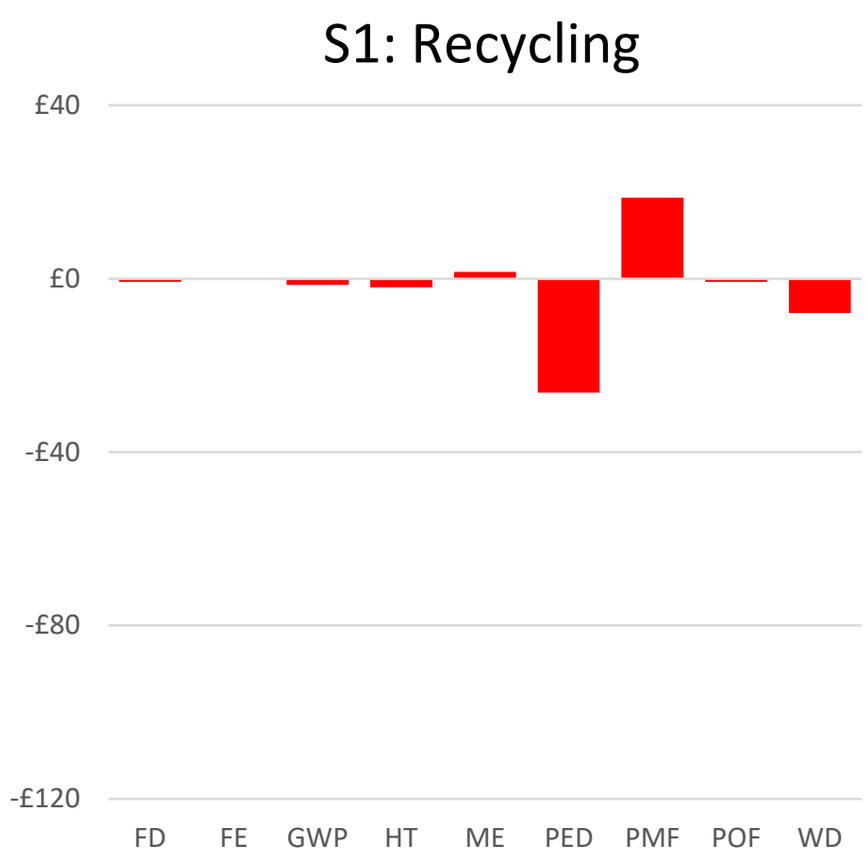
- 15,000 tonnes less CO_2
- 86 tonnes less Nitrogen (marine eutrophication)
- 122,000 Gj less fossil resource depletion

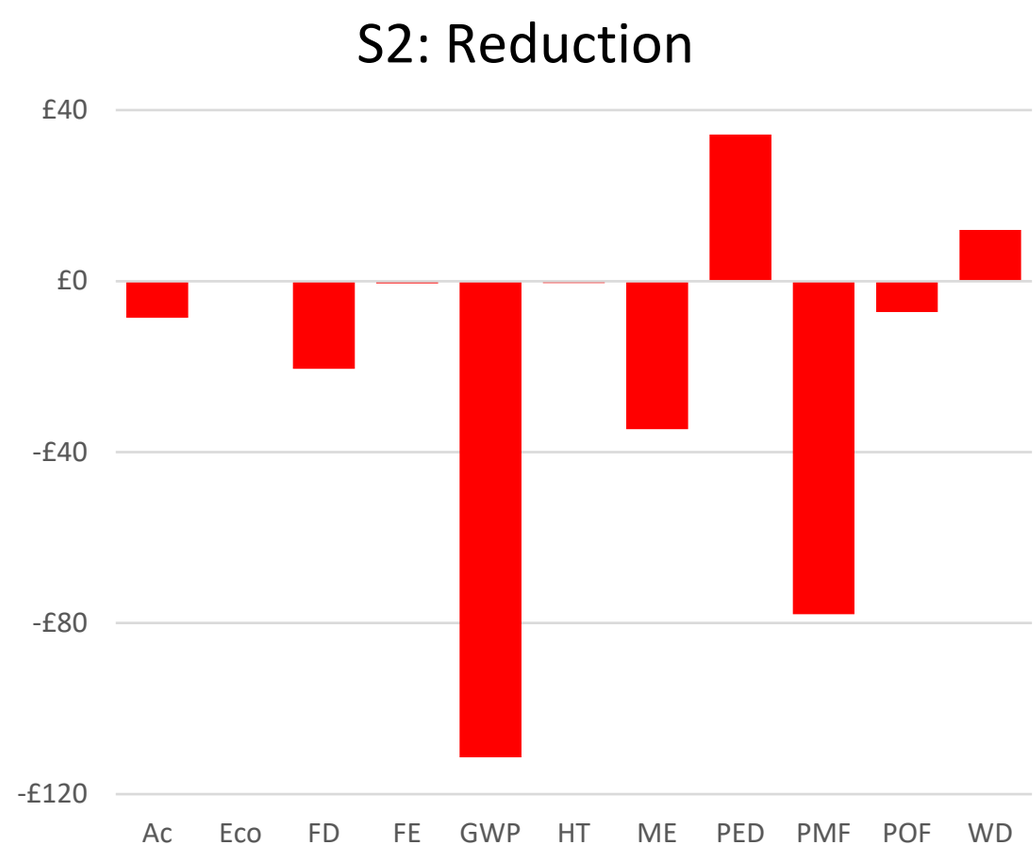
But… £230,000 less green energy

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

Total **quantity** of waste reduces by 20%, but the ratio of recycling to residual stays the same

RECYCLING **VS** REDUCTION





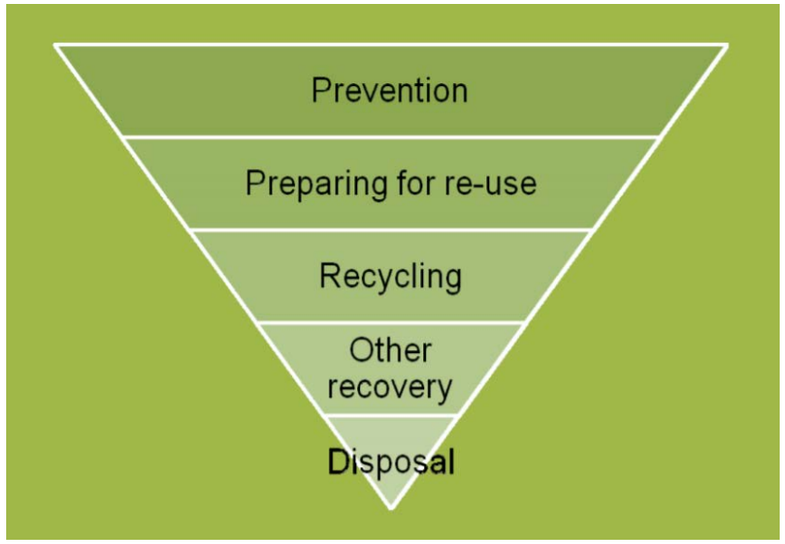
This is the net value of changes **including disposal and the burden of food production** compared.

N.B. the value of primary energy demand (PED) burden of food production not known so this element is incomplete

Limitations

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

Summary: Reinforcing the waste hierarchy



Bristol has relatively high recycling rates, and almost no food waste goes to landfill, but:

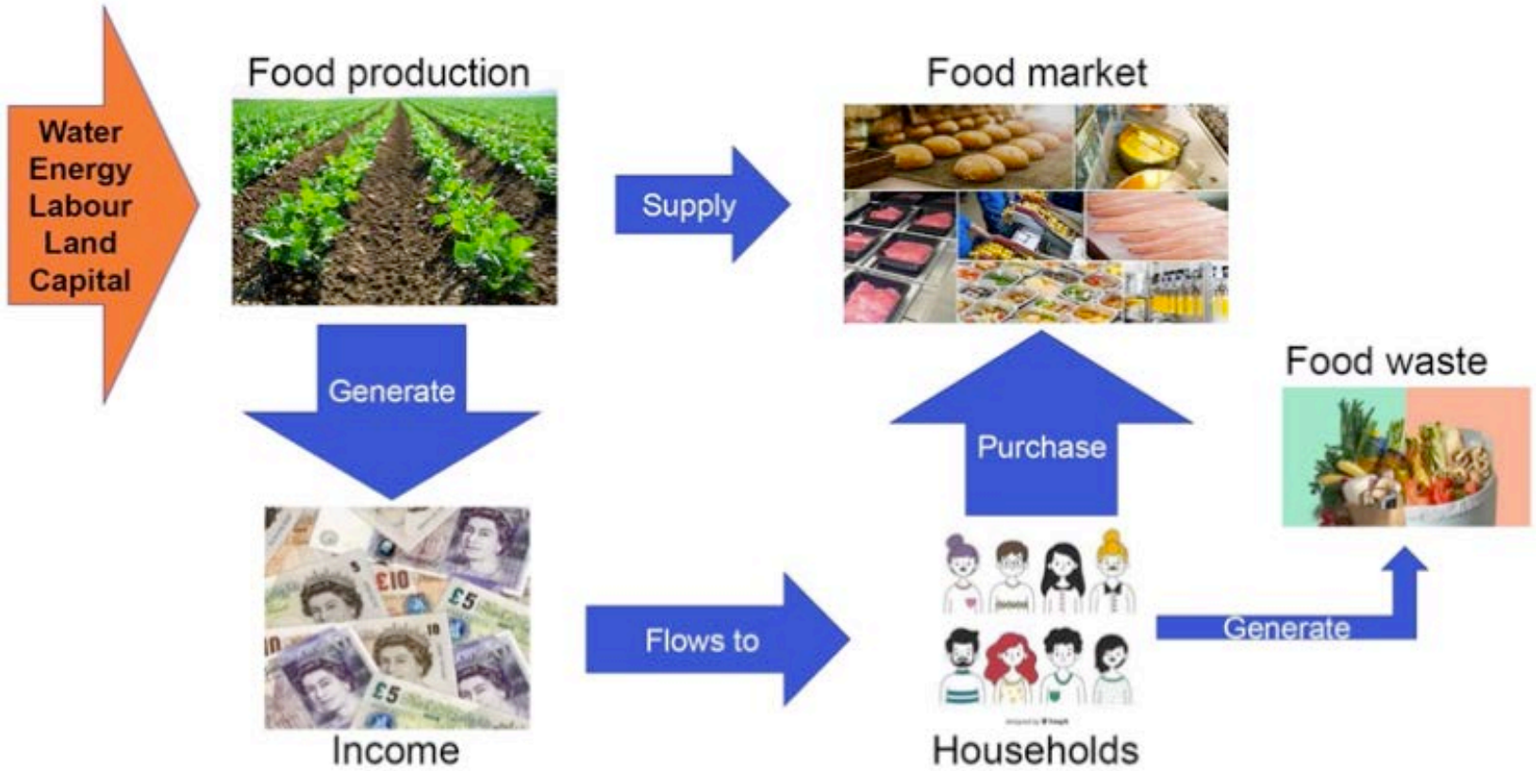
- **Prevention of food waste has far greater environmental benefits than recycling**, including improvements in air, soil and water quality.
- **30% of wasted food is not edible**, and this should be disposed of in the most efficient way possible.
- **Still valuable to move any unavoidable food waste from residual (black bins) to recycling**
- Compared to Incineration or Landfill, **Anaerobic Digestion has the most positive outcomes**, although some methods can increase particulate matter pollution (and poor usage of AD problematic)
- **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.

Macro-economic

‘Market’ impacts

(& carbon)

Macro-economic valuation…
paradoxical?



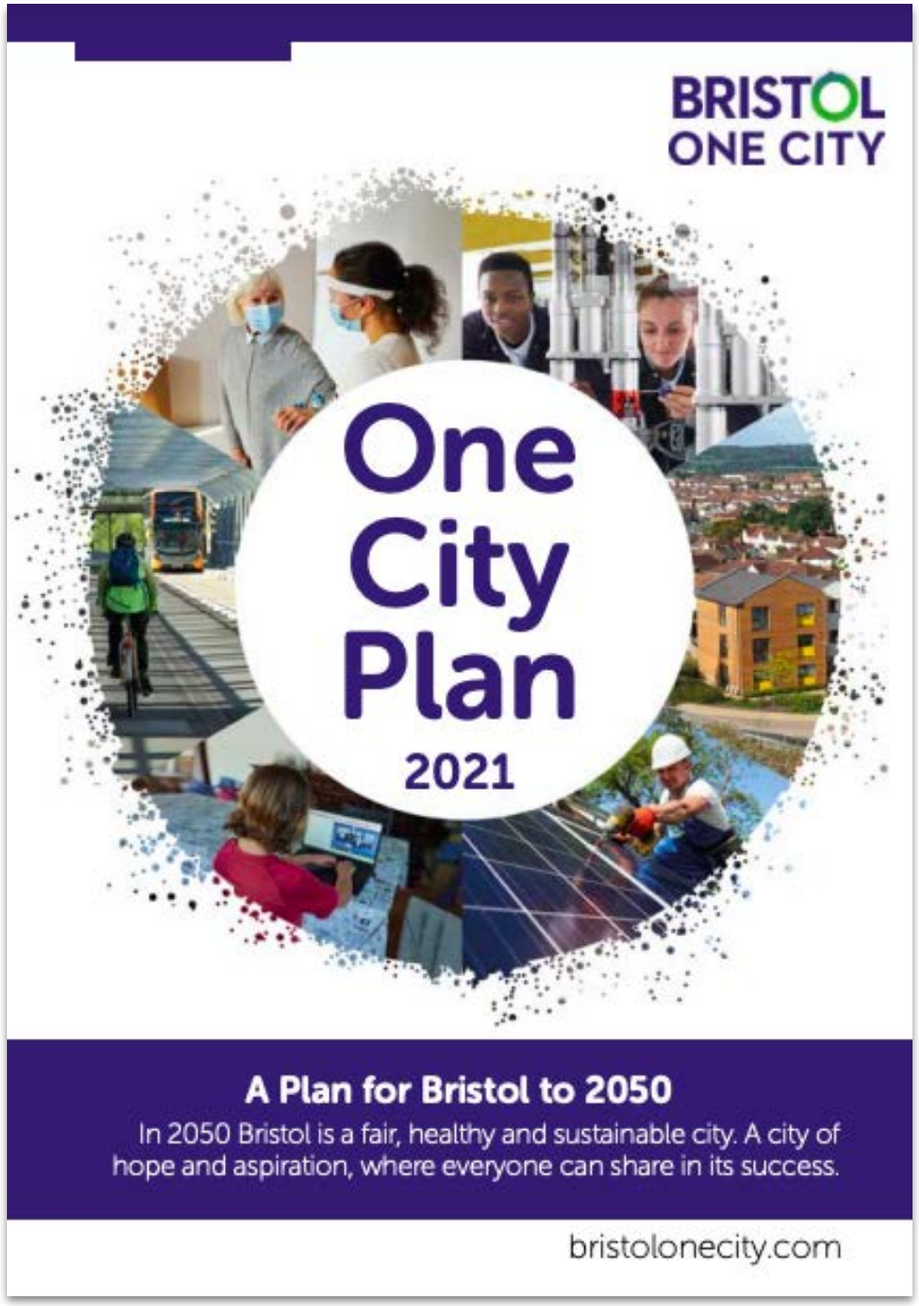
- Preliminary results show that, nationally, **households may save income up to £2.7 billion per year** given constant income.

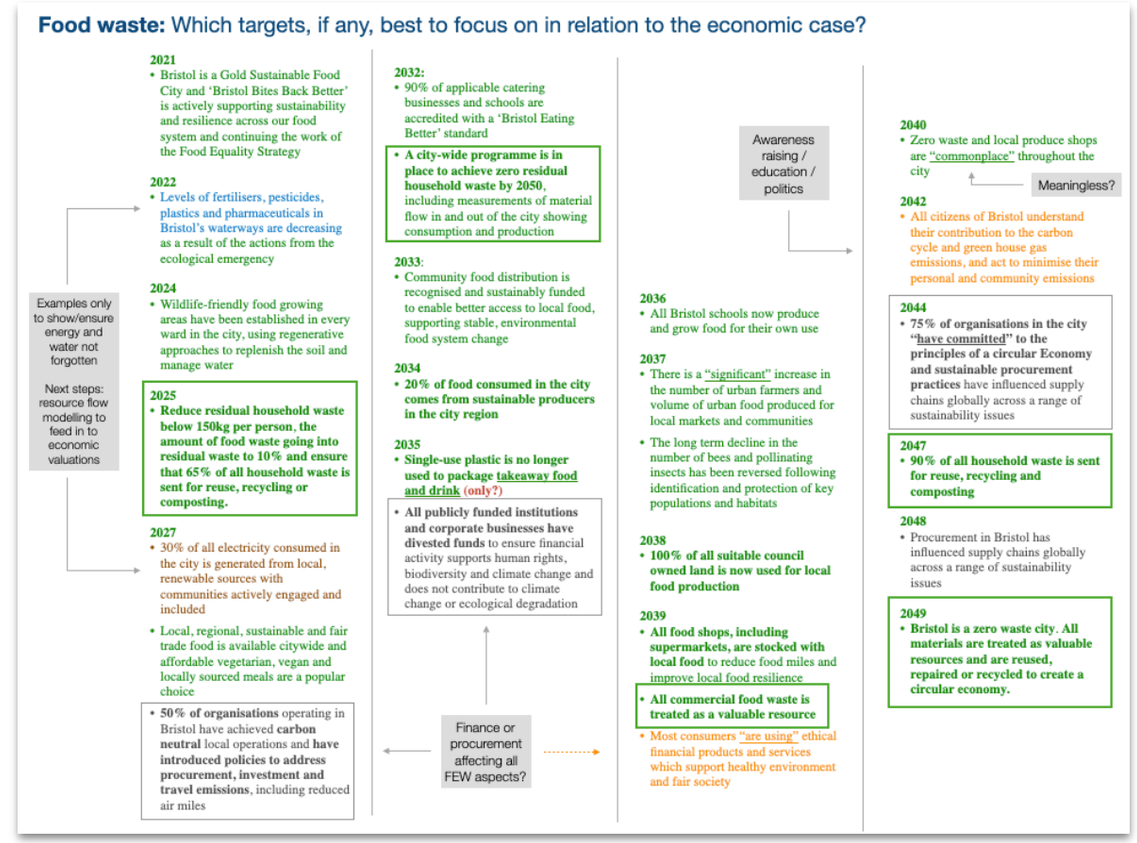
- However, **actual income savings of households may be reduced considerably (entirely?)**, depending on how the income is allocated among economic agents.

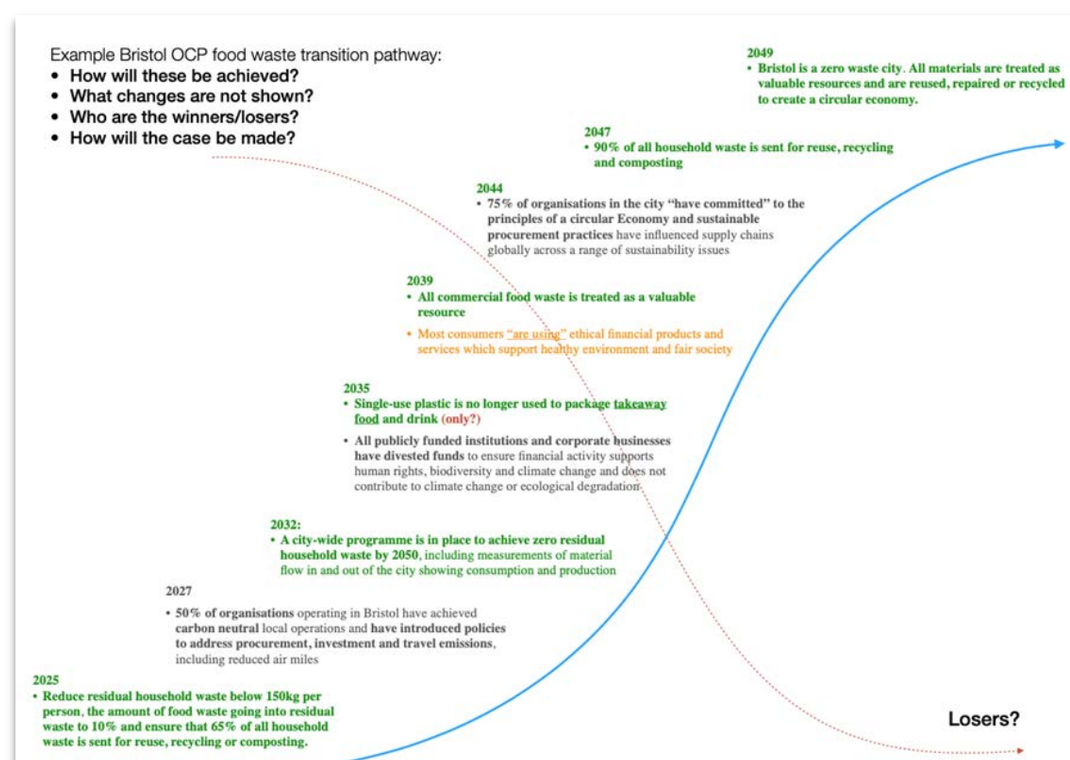
Direct income effect of a 20% reduction in food waste by the UK households

	Reduced values (£bn)			Shares in total (%)		
Sector	Domestic	imports	Total	Domestic	imports	Total
Food	1874.3	423.9	2298.2	82	18	100
Energy	60.7	37.7	98.4	62	38	100
Water	5.5	0.3	5.8	95	5	100
Waste	3.8	0.7	4.5	85	15	100
Others	777.9	154.9	932.8	83	17	100
Total	2722.2	617.5	3339.7	82	18	100

Linking scenarios to…







Selecting One City Plan Targets:
Exclusion Criteria

1. **Not explicitly related to nutrient waste**, even though potentially highly influential
   - (e.g. procurement practices, public investments, fertilisers and plastics in Bristol's waterways)
2. **No explicit quantifiable 'end point'**
   - (e.g. community food distribution "*recognised*", "*significant*" increase in number of urban farmers)
3. Were **considered** by stakeholder partners to be **too challenging** in terms of clarity of definition and data availability
   - (e.g. "local" food)
4. **Did not meet our core focus** in terms of socio-environmental impact
   - (e.g. residual food waste)
5. Ultimately became **redundant** given it is covered under end goal of Zero Food Waste City 2049 target
   - (e.g. commercial food waste being treated as valuable resource)

BRISTOL ONE CITY

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Goal 259 Year: 2035

Single-use plastic is no longer used to package takeaway food and drink

Give Your Feedback

Theme: Environment

Sub-theme: Healthy natural environment

SDG: Responsible Consumption

Goal 512 Year: 2049

Bristol is a zero waste city. All materials are treated as valuable resources and are reused, repaired or recycled to create a circular economy

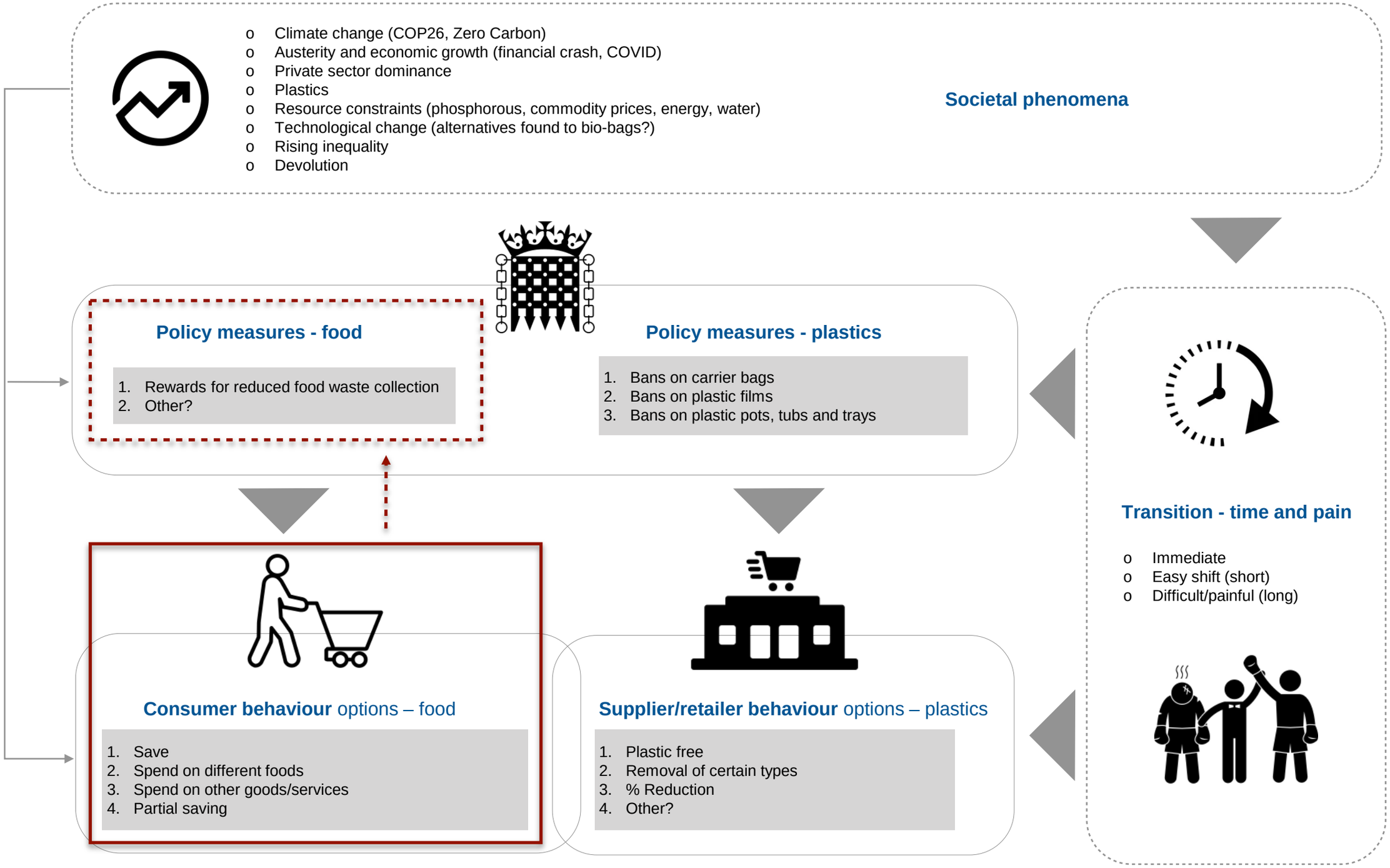
Give Your Feedback

Theme: Environment

Sub-theme: Carbon Neutrality

SDG: Decent Work and Economic Growth

Scenarios…within context…over time



Demand-side shift? e.g.

- Tax on food waste collection?
- Raised awareness (of societal costs)?
- Increase in food prices?

Caution!

Developing hypothetical scenarios for food waste reduction

Two scenarios at either extreme:

a. Households **will not re-spend their saving** elsewhere

b. Households **will re-spend their saving** on other goods

Re-spending option 1: equal re-spending across all areas?

Re-spending option 2: select just one, or a few of the more likely areas?

Scenario Name	N20	R20	N15	R15
Food waste reduction (Bristol 2015-2025)	**Food waste reduced by 20% during 2015-2025** (or 2.2% yearly) (WRAP 2025 target)	**Food waste reduced by 20% during 2015-2025** (or 2.2% yearly) (WRAP 2025 target)	**Food waste is reduced by 15% during 2015-2025** (or 1.6% yearly) (Following 2007-2015 trend)	**Food waste is reduced by 15% during 2015-2025** (or 1.6% yearly) (Following 2007-2015 trend)
Re-spending on other goods	**No re-spending** on alcohol, clothing, and tourism	**Savings** are **re-spent** on alcohol, clothing, and tourism	**No re-spending** on alcohol, clothing, and tourism	**Savings** are **re-spent** on alcohol, clothing, and tourism

CAUTION!

These are two extreme cases.

They are being used to illustrate potential future scenarios.

There will be multiple different cases between these two extremes.

Commodities / services *Standard Industrial Classifications (SICs)*	**% of disposable household income**
Food and non-alcoholic drinks	11
Rent	9
Mortgage and council tax	8
Household goods and services (furniture, textiles, appliances, cleaning)	7
Operation of personal transport	6
Holidays abroad	6
Purchase of vehicles	5
Electricity and gas	4
Clothing and footwear	4
Public transport	3
Internet and phone	3
Restaurant and café meals	3
Alcohol, water and hair products/toiletries	2

- ONS, 2018

Yearly changes in **demand for domestically produced goods** (£1000s)

Scenario name	N20 (20%, no re-spending)	R20 (20%, with re-spending)	N15 (15%, no re-spending)	R15 (15%, with re-spending)
Food	-1746.7	-1739.1	-1270.3	-1264.8
Alcohol	-24.0	-15.1	-17.5	-11.0
Clothing	-0.6	10.3	-0.4	7.5
Plastic	-4.7	-4.7	-3.4	-3.4
Energy	-18.7	-18.7	-13.6	-13.6
Water	-0.4	-0.4	-0.3	-0.3
Waste	-1.7	-1.7	-1.3	-1.3
Tourism (e.g. transport, hotel)	-84.6	2116.7	-61.5	1539.4
Others	-151.8	-151.8	-110.4	-110.4
Total	-2033.3	195.2	-1478.8	142.0

Yearly **income impact** (£1000s)

Scenario name	N20 (20%, no re-spending)	R20 (20%, with re-spending)	N15 (15%, no re-spending)	R15 (15%, with re-spending)
Food	-955.2	-921.5	-694.7	-670.2
Alcohol	-29.3	-21.1	-21.3	-15.4
Clothing	-1.4	5.5	-1.0	4.0
Plastic	-11.7	-5.8	-8.5	-4.2
Energy	-46.8	-20.9	-34.0	-15.2
Water	-2.5	-1.6	-1.8	-1.2
Waste	-4.3	-1.7	-3.1	-1.2
Tourism	-175.0	1186.5	-127.2	862.9
Others	-430.7	40.2	-313.2	29.3
Total	-1656.8	259.6	-1204.9	188.8

Changes in **CO2 emissions** (tonnes)

Scenario name	N20 (20%, no re-spending)	R20 (20%, with re-spending)	N15 (15%, no re-spending)	R15 (15%, with re-spending)
Food	-168.6	-158.0	-122.6	-114.9
Alcohol	-9.1	-6.5	-6.6	-4.7
Clothing	-0.6	1.8	-0.4	1.3
Plastic	-4.3	-2.1	-3.1	-1.5
Energy	-179.4	-68.5	-130.5	-49.8
Water	-0.4	-0.3	-0.3	-0.2
Waste	-1.1	-0.4	-0.8	-0.3
Tourism	-41.4	436.0	-30.1	317.1
Others	-38.9	-4.6	-28.3	-3.4
Total	-443.8	197.3	-322.8	143.5

Yearly impact on **income of resource owners** (£1000s)

Scenario name	N20 (20%, no re-spending)	R20 (20%, with re-spending)	N15 (15%, no re-spending)	R15 (15%, with re-spending)
Taxes	-105.8	27.6	-77.0	20.1
- Food	-70.5	-69.8	-51.3	-50.8
- Alcohol	-1.3	-0.9	-0.9	-0.7
- Clothing	-0.0	0.1	-0.0	0.1
- Plastic	-0.4	-0.2	-0.3	-0.1
- Energy	-5.3	-2.1	-3.9	-1.5
- Water	-0.3	-0.2	-0.2	-0.2
- Waste	-0.4	-0.1	-0.3	-0.1
- Tourism	-8.7	99.2	-6.3	72.1
- Others	-19.0	1.7	-13.8	1.2
Compensation of employees	-986.8	138.6	-717.6	100.8
- Food	-595.7	-573.5	-433.2	-417.1
- Alcohol	-12.1	-8.7	-8.8	-6.3
- Clothing	-1.0	3.7	-0.7	2.7
- Plastic	-8.1	-4.0	-5.9	-2.9
- Energy	-14.4	-6.4	-10.4	-4.7
- Water	-0.7	-0.5	-0.5	-0.3
- Waste	-1.9	-0.8	-1.4	-0.6
- Tourism	-111.3	718.1	-81.0	522.3
- Others	-241.6	10.6	-175.7	7.7
Gross operating surplus	-564.2	93.4	-410.3	67.9
- Food	-289.0	-278.2	-210.2	-202.3
- Alcohol	-15.9	-11.5	-11.6	-8.3
- Clothing	-0.4	1.7	-0.3	1.3
- Plastic	-3.2	-1.6	-2.3	-1.2
- Energy	-27.1	-12.4	-19.7	-9.0
- Water	-1.5	-1.0	-1.1	-0.7
- Waste	-2.0	-0.8	-1.5	-0.6
- Tourism	-55.0	369.1	-40.0	268.5
- Others	-170.1	27.9	-123.7	20.3
Total	-1656.8	259.6	-1204.9	188.8

Headline findings:
Economy, sectors, scale, tax, carbon

a. **No re-spending:** ***£4.6 billion decrease in economic activity***, esp. food sectors and associated employees (retail, logistics)

b. **With re-spending:** ***£702 million increase in economic activity*** (shift from food to tourism and clothing), with associated benefits to those sectors' employees and capital owners, in addition to modest increase in tax revenues (see box)

Tax revenue implications relatively minimal:

- Largest annual tax loss of £0.1 million (N20) only a small fraction of reduced demand for goods of £2 million*.
- **No re-spending:** loss to whole UK = £270 million (0.1*30*90) from 2020 to 2050
- **Re-spending:** benefit to whole UK = £81 million (0.03*30*90) from 2020 to 2050

**Significant part of reduced food waste comes from imported food*

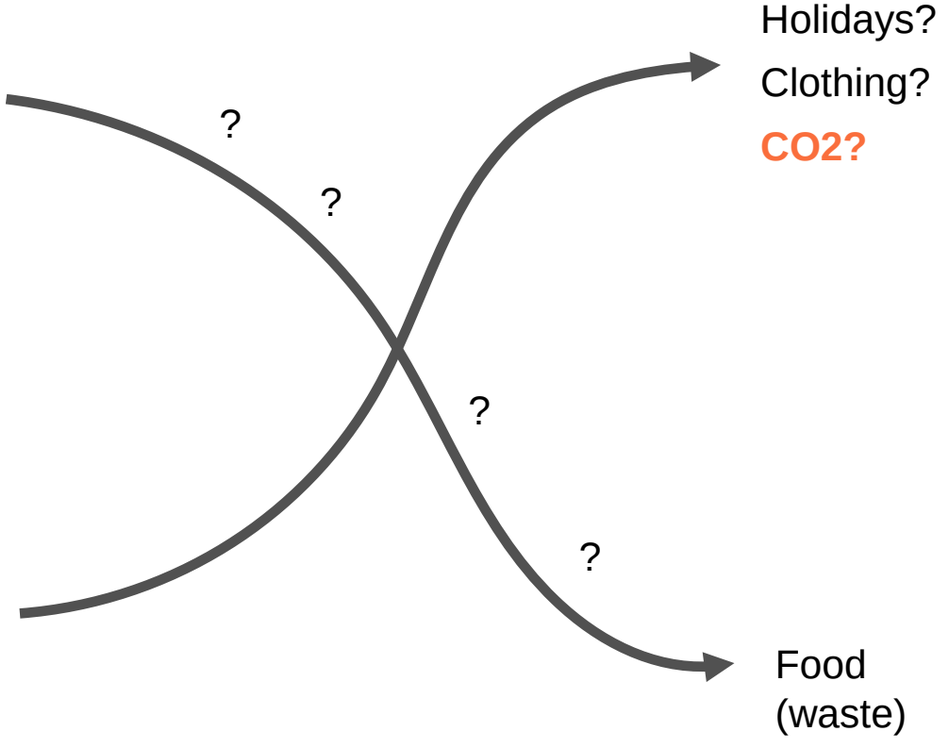
- **Carbon benefits appear to be relatively small** based on current estimates of shadow (or market) prices of different environmental pollutions. **If** in the future shadow (or market) **prices of environmental pollution increases dramatically** (e.g. CO2 prices in light of global warming), **then environmental benefits might become large enough** to overweigh the macroeconomic losses in income.
- **Overall increase in CO2 from shift from food to holidays**/clothing (transport).

Scenario name	N20 (20%, no re-spending)	R20 (20%, with re-spending)	N15 (15%, no re-spending)	R15 (15%, with re-spending)
Food	-168.6	-158.0	-122.6	-114.9
Alcohol	-9.1	-6.5	-6.6	-4.7
Clothing	-0.6	1.8	-0.4	1.3
Plastic	-4.3	-2.1	-3.1	-1.5
Energy	-179.4	-68.5	-130.5	-49.8
Water	-0.4	-0.3	-0.3	-0.2
Waste	-1.1	-0.4	-0.8	-0.3
Tourism	-41.4	436.0	-30.1	317.1
Others	-38.9	-4.6	-28.3	-3.4
Total	-443.8	197.3	-322.8	143.5

National policy implications:
Identifying the real problem?

- **Current economic policy landscape appears to be promoting the wasting of food** despite its clear resource inefficiencies, suggesting government policy and market failure. i.e.
  - **Wasted food is valued** currently – and perversely – **as a *benefit* to the economy**.
  - There is **currently no or insufficient economic motivations** for agents **to reduce food waste**

- **Risks** seen, understandably, as **significant - support needed**
- Food sector not keen on disruption? - **"second face of power"** - Cairney, P (2012)
- **Structural changes** in labour and capital markets imply **considerable transition costs**
- **Government intervention would likely be necessary to soften** or otherwise prepare for the **potential income losses in the food and plastic production sectors**
- **Support may be sought from those who substantially benefit** (e.g. the tourism sector).



- **Transition pathways**: i.e. while total value is large when considered over one year, **gradual reduction over decades, potentially, manageable?**

But…what does this mean for Bristol?

Work in progress…

STRENGTHS	WEAKNESSES
• ?	• **Reliance on national level intervention?** • Cities have such limited resource (inc. fiscal autonomy) • **Benefits** - especially environmental - **accrue nationally and internationally, so justification for city-level action is arguably weaker**. • **Other?**
OPPORTUNITIES	**THREATS**

• Cities have some control over consumer behaviour? (e.g. **local campaigns/awareness raising**)?
• Potential benefits nationally might be used in **negotiating with central government:** e.g.
  • Spending reviews
  • Bristol as city innovator for Govt
• **Better awareness of macro-challenge may incentivise local action?**
• **Other?**
	• ?

Next steps…FWAG workshop? Other?

?

Conceptual challenges

We suggest this approach can improve our understanding of possible impacts, their scale, and help identify winners and losers. However…

- **Other variables**: we did not consider issues such as population change, new technologies, and economic development.
- **Robustness of economic valuation** - see below
- **Buy-in** from decision-makers - local and national
- **Resource**:
    - Undertake labour-intensive (scenario-planning) work (in addition to economic valuation)
    - Implement solutions (e.g. local campaigns)

Economic challenges

Some of the findings are relatively robust, such as the income losses in the food and plastic production sectors and income losses of labour providers. However…

- **To provide a more robust estimate**, **we would need to: e.g.**
    - **relax the assumptions** adopted by the approach (e.g. the market prices assume no changes before and after a reduction in food waste, which is unrealistic).
    - The substitution between goods and inputs in production and consumption can also be introduced to **better mimic the macroeconomic responses** to a reduction in food waste.
    - Use a computable general equilibrium (CGE) model?

Thank you

Sustainable Urbanisation Global Initiative (SUGI)
FOOD - WATER - ENERGY NEXUS

The WASTE FEW ULL project was funded by JPI Europe and the Belmont Forum's **Sustainable Urbanization Global Initiative**.

The Bristol ULL was funded by ESRC, AHRC, Innovate UK, RCN and NSF.

Conveners

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