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Consumption-based Greenhouse Gas Emissions for Bristol 2016

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1. Key findings

- In 2016, the City of Bristol's greenhouse gas (GHG) emissions associated with consumption were 5432 $KtCO_2e$[1].
- Of these, the amount of GHG emissions associated with consumption attributed to residents was 4149 $KtCO_2e$.
- The GHG emissions per capita for the City of Bristol in 2016 were 11.96 tonnes CO_2e. This is very close to the 2016 UK average of 11.94 tonnes CO_2e.
- The consumption item with the highest impact is transportation (public transport, private vehicle use and aviation), making up 32% of the emissions from households. Transportation is a key area to focus reduction policy.
- Emissions associated with fuelling, powering and maintaining the home contribute a further 29% towards the household footprint and are another key area to focus on.
- Food is the third largest consumption item with 13% of the total. This increases to 17% if restaurants and hotels are included.

2. Introduction

This report documents the Consumption-based Greenhouse Gas Emissions Accounts (CBA) for the City of Bristol for 2016, the latest year of available data. CBA offers a different perspective from the standard approach for assigning greenhouse gas (GHG) emissions to a territory. Instead of purely considering the emissions that are released in the territory of the City of Bristol, CBA considers the emissions that occur due to the consumption activities of Bristol's residents, including all the emissions associated with the production of goods and services throughout their complete supply chain (more detailed definitions are provided below).

University of Leeds is responsible for producing the CBA for the UK Government and Scottish Government providing national level figures. The same methodology has been applied to calculate the CBA for London. The predominant methodology is an "Environmentally Extended – Multi Regional Input Output" model (EE-MRIO). This has become the standard approach to assess the consumption based emissions of a country or region. EE-MRIO is the most comprehensive, versatile and compatible approach for consumption-based accounting of greenhouse gas emissions and has already become the norm (Davis and Caldeira, 2010; Peters and Hertwich, 2008; Peters et al., 2011; Wiedmann, 2009; Wiedmann et al, 2011).

The UK has adopted consumption-based emissions as an official government indicator and has undertaken numerous reports that employ the approach to evaluate the effectiveness of climate mitigation measures beyond technological solutions. These include an assessment of the role of resource efficiency in climate change mitigation policy, the role of services and an

[1] $KtCO_2e$ and tCO_2e indicate kilo tonnes of CO_2e and tonnes of CO_2e, respectively, where CO_2e refers to 'Carbon Dioxide equivalent'. This means that the impact greenhouse gases have on global warming is expressed as the amount of CO_2 with and equivalent impact on global warming. These are based on conversion factors reported by the Intergovernmental Panel on Climate Change (Department for Business, Energy & Industrial Strategy. 2016).

understanding of drivers of GHG emissions between 1992 and 2004 (Barrett and Scott, 2012; Minx et al, 2009; Baiocchi and Minx, 2010).

In summary, employing the EE-MRIO methodology and ensuring consistency with the national accounting, this report provides consumption-based emissions for the City of Bristol for 2016, for both carbon dioxide and greenhouse gases providing figures in absolute and per capita emissions.

3. Definitions

GHG emissions can be allocated to countries and cities in different ways. Three different methods of allocating emissions are now in common use: 1) territorial-based, 2) production-based, and 3) consumption-based.

1) The United Nations Framework Convention on Climate Change (UNFCCC) requires countries to submit annual National Emission Inventories. The UNFCCC follows the Intergovernmental Panel on Climate Change's guidelines in term of the allocation of GHG emissions which is, "emissions and removals taking place within national (including administered) territories and offshore areas over which the country has jurisdiction" (IPCC, 1996, pp.5). According to this definition, however, GHG emissions emitted in international territory, international aviation and shipping, are only reported as a memo and not allocated to individual countries. We call these "territorial-based emission inventories".

2) Some countries and cities also report GHG emissions using the same system boundary as the System of National Accounts (SNA), such as are already done with Gross Domestic Product (GDP). This allocation is necessary to make the emission statistics consistent with economic data used in economic modelling. These inventories are often called "National Accounting Matrices including Environmental Accounts (NAMEAs)". In the EU, NAMEAs are reported to Eurostat, though most other developed countries develop NAMEAs but do not report them internationally. The main difference between NAMEAs and the UNFCCC territorial emissions is the allocation of emissions occurring in international territory, and the allocation of tourist activities. In the SNA, international aviation and shipping are typically allocated to countries based on the operator of the vessel, likewise, international tourists are allocated emissions based on where they are resident and not where they are travelling. We call the NAMEAs "production-based emission inventories".

3) Consumption-based emissions allocate emissions to the consumers in each country or city, usually based on final consumption as in the SNA but also as trade-adjusted emissions (Peters, 2008). Conceptually, consumption-based inventories can be thought of as consumption equating to production-based emissions minus the emissions from the production of exports plus the emissions from the production of imports (Consumption = Production – Exports + Imports). We call these "consumption-based emission inventories".

4. Methodology

4.1. EE-MRIO

EE-MRIO is a peer-reviewed method having applications in the calculation and reporting of consumption-based emissions accounts and in climate change policy (Minx et al., 2009; Wiedmann and Barrett, 2013).

Input-output models (IOM) make the link between the environmental impacts associated with production processes and the consumers of products. The IOM is constructed from observed economic data and shows the monetary transactions between industrial sectors (intermediate consumers) and final consumers[2]. Economic sectors purchase goods and services from other sectors; pay wages; pay taxes and potentially receive subsidies in the process of making their own product. Final consumers demand goods and services such as food, energy, transport, domestic appliances, leisure activities and so forth. Government sectors are recognised as both a final consumer with an annual budget to spend, and an intermediate sector providing public services (e.g. health care and education).

EE-MRIO allows analysts to consider the impact of traded goods. Essentially, an MRIO model for *n* countries each with *m* sectors generates a matrix of dimensions '*m x n*' rows by '*m x n*' columns and rather than considering a single nations' economy it treats the entire global economy as a single system. The MRIO table is constructed by placing the domestic IO tables from every region along the diagonal of a large composite matrix and filling in the off diagonal matrices to show the sectoral requirements from non-domestic regions in the production of domestic products. This assumes IO tables are available for all nations, there is a degree of harmonisation in sectors described and trade linked data can be determined.

The methodology employed in this study is consistent with the approach adopted by both the UK and Scottish Government that employs an EE-MRIO model. For more details on the model please refer to Barrett et al (2013) or the official Defra site where the national CBA results are available (https://www.gov.uk/government/statistics/uks-carbon-footprint).

4.2. National to sub-national accounts

The methodology described above allows national consumption-based accounts to be produced. Additional steps are required to produce CBA at the sub-national level (for example the City of Bristol level).

We use a hierarchical hybrid methodology for estimating final consumption of the City of Bristol (Minx et al, 2013). Essentially, we need to calculate what proportion of the total UK spend for which the City of Bristol is responsible for each consumption item contained in the database. For example, if the City of Bristol spends 5% of the total UK spend on clothing, it receives 5% of the total UK footprint associated with clothing demand. To understand the portion of UK spend attributed to the City of Bristol, we need an average expenditure profile

[2] Represented as Households, Government, Non-Profit Institutions and Capital Investment in IO tables

for the city and multiply this up by the number of residents. For this particular version of the City of Bristol footprint, we use estimates of household spend profiles generated by the credit reference company TransUnion. TransUnion develop spend profiles for over 60 different household 'types' and also provide the number of different household types living in local authority areas.

Household consumption contributes 70% of the UK's carbon footprint (Minx, Wiedmann et al. 2009). The remainder is attributable to government services and capital investments. We downscale the national accounts for those to the local level on an equal per capita basis. This means we assume that every citizen in the UK enjoys the benefits from government expenditures and capital investments in the same way.

5. Results

5.1. Overall results

Figure 1 shows the consumption-based greenhouse gas (GHG) emissions for City of Bristol in 2016 on an absolute basis. This is broken down by the high level categories of government, capital, households and other. It is important to note that "Government" is not the scope 1, 2 and 3 emissions of the City of Bristol[3]. It is the average per capita emissions of all UK Government (national and local).

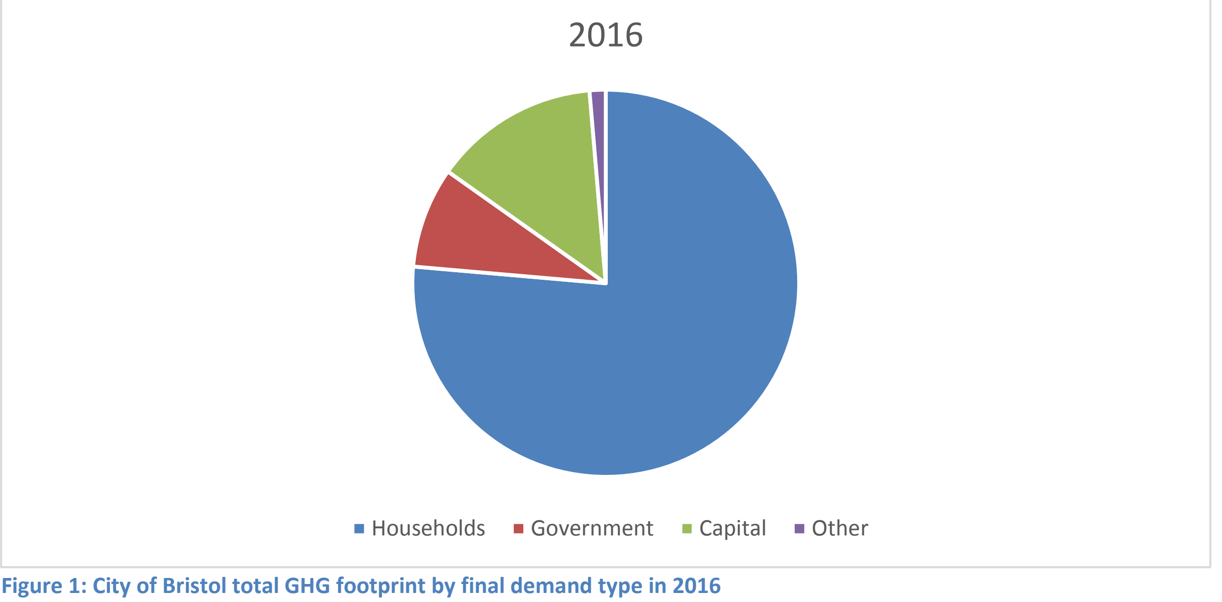

Figure 1: City of Bristol total GHG footprint by final demand type in 2016

Households represent 76% of the footprint of the City of Bristol in 2016 (Figure 1).

The following analysis provides a high-level breakdown of the GHG footprint by consumption categories. The three categories of Food and non-alcoholic drinks, Housing and Transport

[3] Scope 1, 2, and 3 emissions refer to an organisation's direct emissions, indirect emissions from electricity, heating, and cooling, and other indirect emissions, respectively (Greenhouse Gas Protocol, 2011). More detail can be found in Appendix A.

are responsible for 74% of the footprint in the City of Bristol in 2016 associated with household consumption (with households being responsible for 76% of the total footprint). The remaining 26% of the household footprint relates to goods and services. The most notable absolute decline has been the GHG emissions from housing.

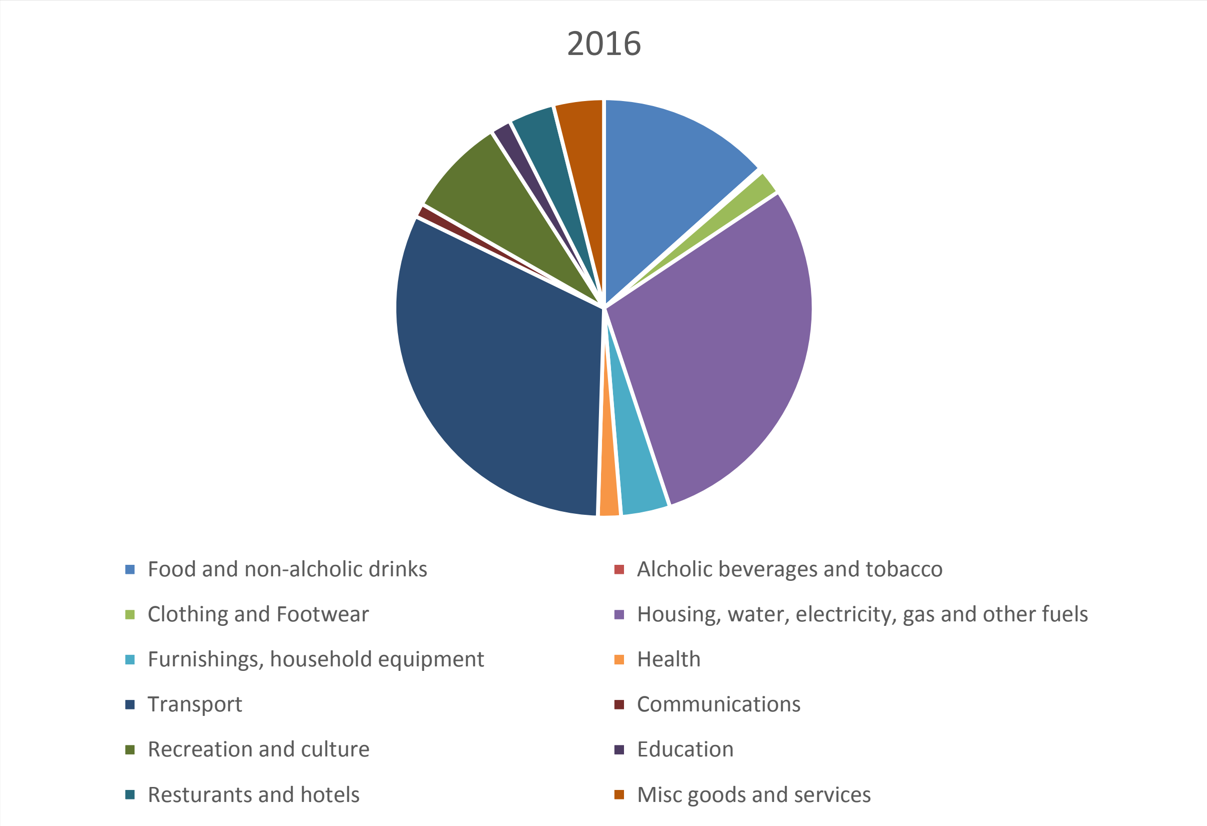

Figure 2: City of Bristol average household footprint broken down by product type

Figure 2 shows that in 2016, Food and non-alcoholic drinks made up 13% of the average City of Bristol household footprint. Housing, water, electricity gas and other fuels made up 29% with emissions associated with transport the highest proportion at 32%.

5.2. Sectoral comparisons with the UK

This section compares the average per capita footprint of a City of Bristol resident with the per capita footprint of the average UK resident for a number of different consumption items.

In the following sectors Bristol's footprint is very similar to, and just lower than, the national average:

- **Food and non-alcoholic drinks** which includes all spend on food consumed in the home.
- **Alcoholic drinks and tobacco** which includes all spend on alcohol and tobacco consumed in the home.

- **Clothing and footwear** which includes all spend on adult and childrens clothes and shoes.

- **Housing, water, electricity, gas and other fuels** which includes all spend on home repairs, heating, water and power.

- **Furnishings and household equipment** which includes all spend on furniture, carpets, kitchen equipment and kitchen appliances.

- **Health** which includes all spend on pharmaceutical products and hospital services.

- **Transport** which includes all spend on vehicles, operating private transport, public transport and air fares.

- **Communication** which includes all spend on post, mobile phones, internet and telephone services.

There were greater emission differences in the following areas:

- **Recreation and culture** which includes all spend on books, games, sports, cinema, pets, gardening and theatre. The average City of Bristol resident had a slightly higher than average impact associated with spend on this category in 2016.

- **Education** which includes all spend on primary to university education. The average City of Bristol resident has a much higher (400% greater) than average impact for spends on this category in 2016.

- **Restaurants and hotels** which includes all spend on catered food and drinks including canteens and pubs and accommodation services. The average City of Bristol resident had a 25% lower than average impact associated with spend on this category in 2016.

- **The miscellaneous other services** which includes all spend on hairdressing, babysitting, business and financial services. The average City of Bristol resident had a 15% higher than average impact associated with spend on this category in 2016.

6. Conclusions and research gaps

University of Leeds will continue to improve the underlying data. Improvements include:

- Capital and infrastructure – national averages are applied and a detailed assessment of the embodied emissions of national infrastructure would help identify additional mitigation options.
- Government – instead of proportioning the national average, an additional study could consider the GHG emissions of the City Council.

- Find better sources of data to estimate how consumption of Bristol residents differs to that of the whole country. Lena Kilian, a PhD student at the University of Leeds is aiming to determine open source, freely available and robust sources of data that may allow for the calculation of local authority level footprints on an annual basis.
- Attempts to disaggregate the footprint to ward level to better understand differences between neighbourhoods in Bristol.
- Further disaggregation at the product level to understand the impact of diets, public transport choices etc.

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8. Appendix A: Scope 1, 2, and 3 emissions

An organisation's emissions are categorised into scope 1, 2, and 3 emissions (Figure 3). Scope 1 emissions capture an organisation's direct emissions, those produced on-site and by transport. Scope 2 and 3 emissions, on the other hand, refer to indirect emissions, where scope 2 emissions are all indirect emissions related to the production of electricity, heat and steam used and purchased by the organization, while scope 3 emissions include all other indirect emissions.

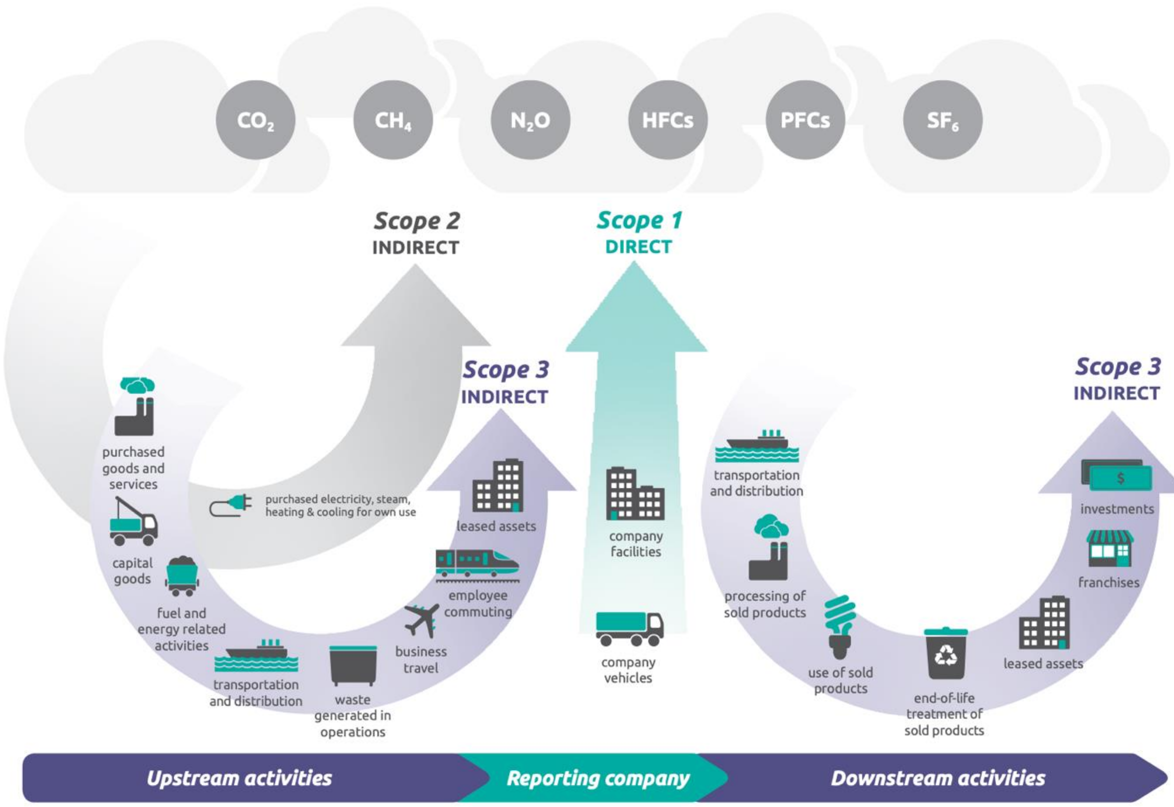

Figure 3: Scope 1, 2, and 3 emissions and their origins. Source: Greenhouse Gas Protocol (2011)