Scottish Waste Environmental Footprint Tool

2022 Household Waste Results Summary

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ZERO WASTE SCOTLAND

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Contents

1 Executive Summary

1.1 Introduction

The Scottish Waste Environmental Footprint Tool (SWEFT) has been developed to provide a holistic understanding of the life-cycle impacts of our household waste and the environmental damage it can cause. It is an evolution of the Carbon Metric, a pioneering development in the monitoring of waste impacts.

SWEFT has been developed in response to the widening environmental crisis: it is not just climate change that is on the political agenda, but also biodiversity, air quality, resource consumption, etc. SWEFT covers six impact areas[1] of environmental damage:

- Climate change
- Biodiversity loss
- Air pollution
- Water consumption
- Mineral resource scarcity
- Land use

The model is based on life cycle assessment (LCA) methodology, and covers the impacts during production, transport, recycling, and disposal (e.g. incineration and landfill). It is the first model in a UK and Scottish context to do this, enabling a broader understanding about the environmental impacts of waste.

A key aim of SWEFT is to account for the impacts of the energy, materials, and pollution incurred during waste treatment, as well as the embodied impacts. Embodied impacts refer to the impacts that occur during the production and manufacturing of the materials and products that we ultimately waste. These impacts are important: when we waste products, we are also wasting the energy and materials used to make that product. The use phase (e.g. the cooking of food, the use of a washing machine) is outside the boundaries of SWEFT, since it is independent of these embodied and treatment impacts.

This report covers the environmental impacts of Scotland's household waste in 2022. The waste data is provided by the Scottish Environment Protection Agency (SEPA) [2].

1 Each of these categories are based on the life cycle impact assessment method ReCiPe. More details can be found here: https://www.rivm.nl/en/life-cycle-assessment-lca/recipe

2 Scottish Environment Protection Agency (SEPA) (n.d.). Waste data. [online] www.sepa.org.uk. Available at: https://www.sepa.org.uk/environment/waste/waste-data/ [Accessed 22 Apr. 2024].

1.2 Headline results

- The biggest waste streams by weight are food, paper and cardboard, garden [3], plastics, and glass.
- The waste types that contribute the most to climate change are textiles, food, plastic, paper, and discarded equipment - mainly consisting of waste electronic and electrical equipment (WEEE).
- Food waste is the largest contributor to biodiversity loss.
- Textiles, discarded equipment, and food that we waste are the largest contributors to air pollution.
- Discarded equipment dominates the impacts on mineral resource scarcity, meaning it is the biggest contributor to the depletion of metal resources.
- Impacts across all categories are dominated by the embodied impacts, i.e., the impact of the resources that are used to make materials and products. Note that SWEFT does not include any impacts incurred during the use phase.
- Recycling waste can help to offset some of the embodied impacts by recovering useful materials that avoid some virgin material extraction.

1.3 Conclusions

- The materials and products that households waste in Scotland have adverse environmental impacts, with different waste streams having different relative impacts across the environmental indicators considered. SWEFT allows us to quantify this for the very first time.
- To reach climate goals, such as net-zero, we should aim to reduce how much textiles, food, plastics, paper, and WEEE we waste. Recycling is a valuable step, but reducing how much we waste, e.g. by reusing, sharing, or eliminating avoidable waste, will help to reduce impacts the most.
- In terms of household waste, we contribute to global biodiversity loss mainly through wasting food and textiles. If we waste less, we can help to reduce our impact on biodiversity loss.
- Textiles, food, WEEE, plastic, paper and cardboard are the most problematic waste streams from the perspective of climate change, biodiversity loss, air pollution, mineral resource scarcity, water consumption, and land use.
- SWEFT emphasises the contribution of embodied impacts of waste. Although these embodied impacts are proxies for consumption, household waste does not represent everything that Scottish households consume. A similar tool oriented towards household consumption is recommended to highlight these impacts.

3 Garden waste ("Vegetal waste" under SEPA's categorisation) does not have any impacts associated with its generation. In other words, there are no production impacts. Therefore, despite the large weight of vegetal waste, the environmental impacts are lower relative to other waste categories.

2 Household waste statistics

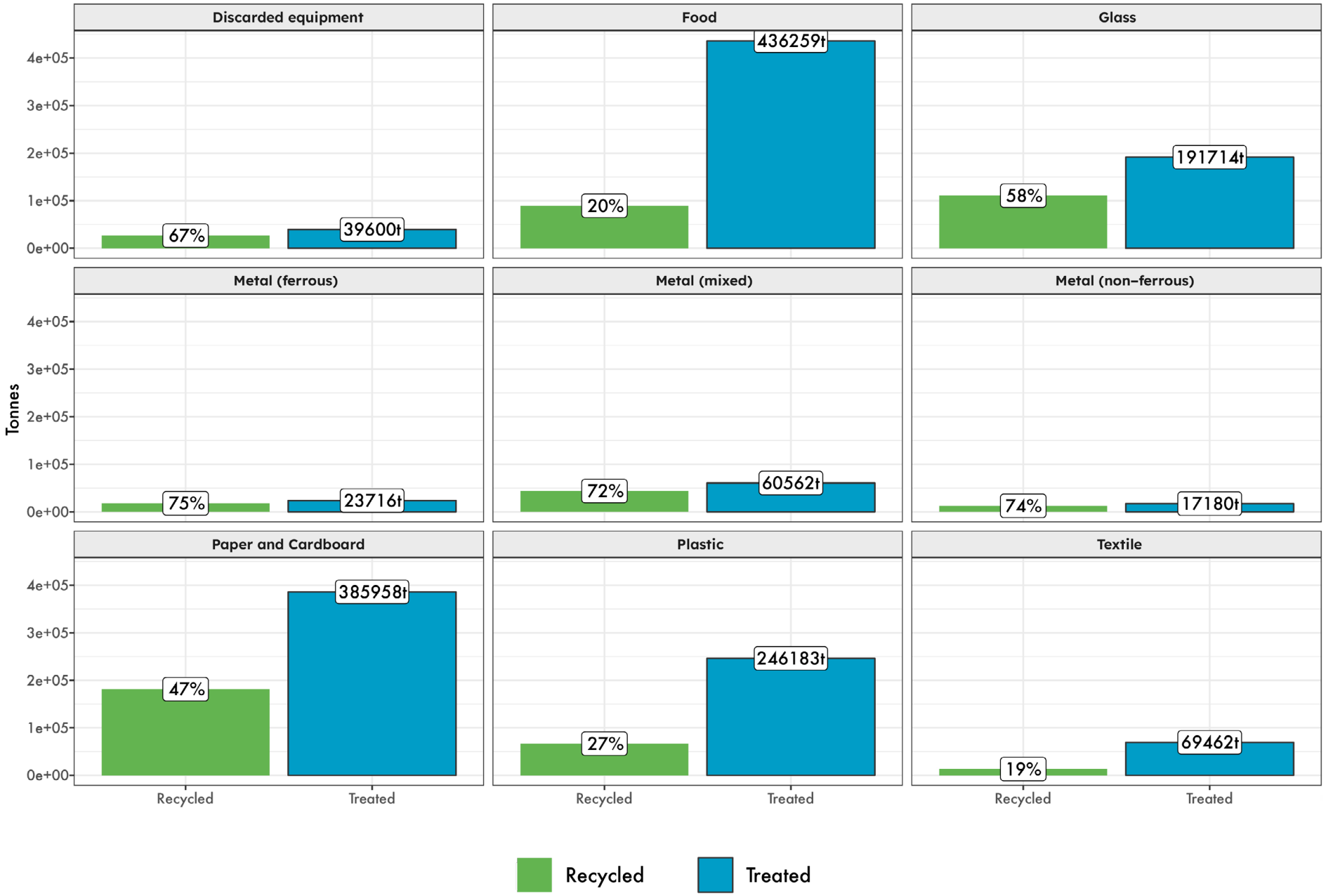
Figure 1 (page 6) shows the tonnes of material treated (that is, recycled, landfilled, incinerated or treated by other methods) for the most important waste categories. The number of tonnes recycled is also reported separately [4], with the recycling rate expressed as a percentage. The categories represented are the most impactful categories, as well as those that are typically collected at the kerbside [5].

The biggest waste stream by weight is food, followed by paper and cardboard, and then plastics. Despite these large tonnages, the recycling rates for these waste streams are all less than 50%.

4 The tonnages reported here include disaggregation of some waste categories reported by SEPA into more specific waste categories. More details are given in the appendix.

5 The waste streams typically collected at the kerbside in Scotland are: food, glass, metals, paper and cardboard, plastic, and garden (vegetal). Discarded equipment and textiles are also included as they have some of the highest impacts on the environment. Garden waste is not included (see footnote above).

Figure 1: Tonnes of waste treated (recycled, incinerated, landfilled or disposed by other methods) and recycling rates for major waste categories



3 Environmental impacts

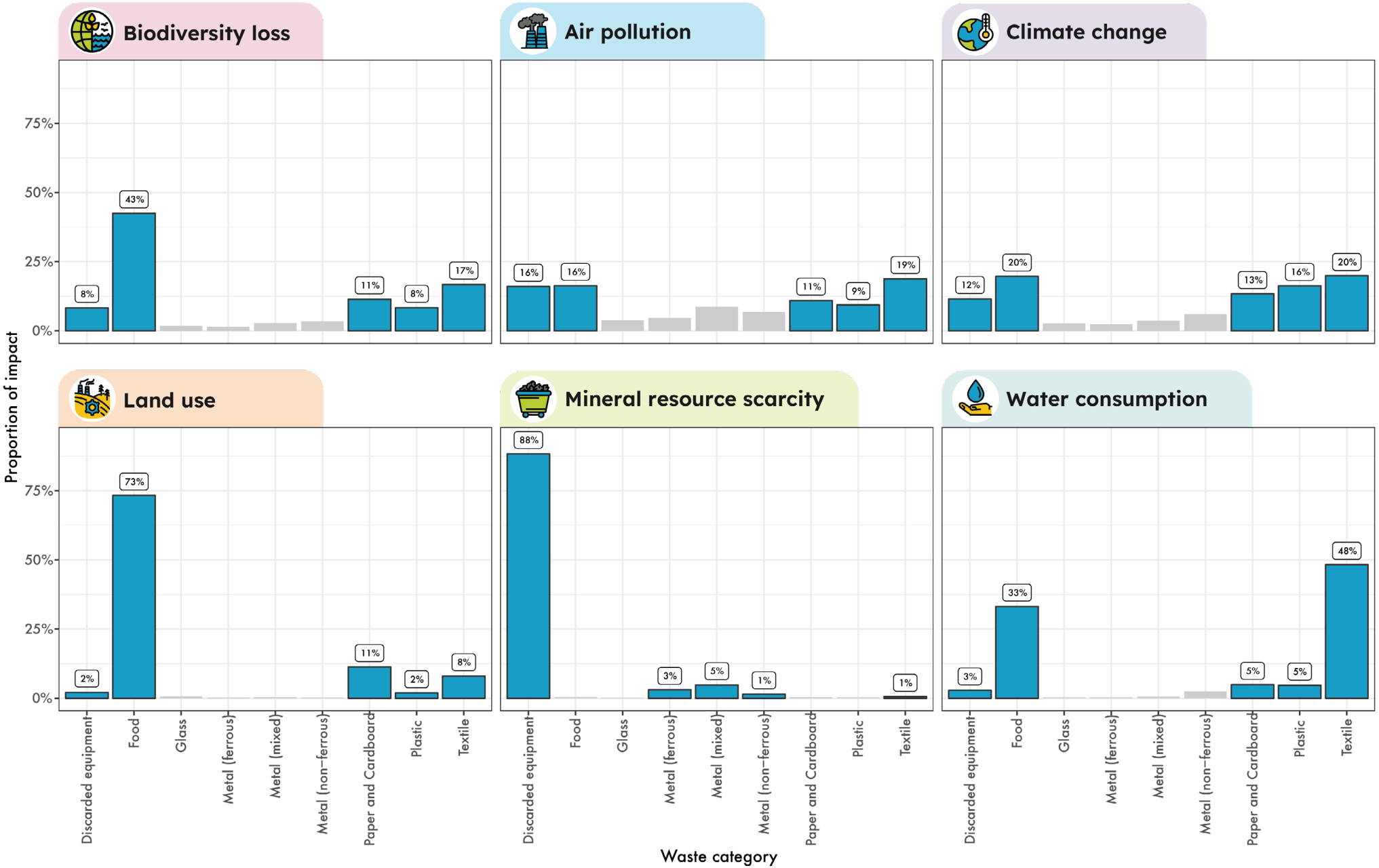
The total impacts for each waste category are given in Table 1. Figure 2 shows the contribution of the most important waste categories to the environmental impacts. Textiles and discarded equipment are ranked in the top five for each impact category. Food, plastic, and paper and cardboard are in the top five for all impact categories except mineral resource scarcity.

The five largest contributors to global warming impacts are textiles, food, plastic, paper and cardboard, and WEEE. In the context of Scotland's household waste, the largest contributor to biodiversity loss is food waste, contributing 43% of all biodiversity loss impacts, with textile waste the second largest contributor (17%); in both cases, it is the embodied impacts that dominate, rather than impacts from waste management. Impacts on mineral resource scarcity are dominated by discarded equipment (88% of total impacts), which consists of various household appliances and other waste electronic and electrical equipment (WEEE). Textile and food waste together account for 81% of water consumption impacts.

Table 1: Total impacts of Scotland's household waste in 2022.

Impact category	Total impact	Units
Climate change	6.2	Mt CO_2 eq.
Biodiversity loss	52	species
Air pollution	10.2	kt PM2.5 eq.
Water consumption	280	Million m^3
Mineral resource scarcity	428	kt Cu eq.
Land use	2,312	Million m^2 ann. crop eq.

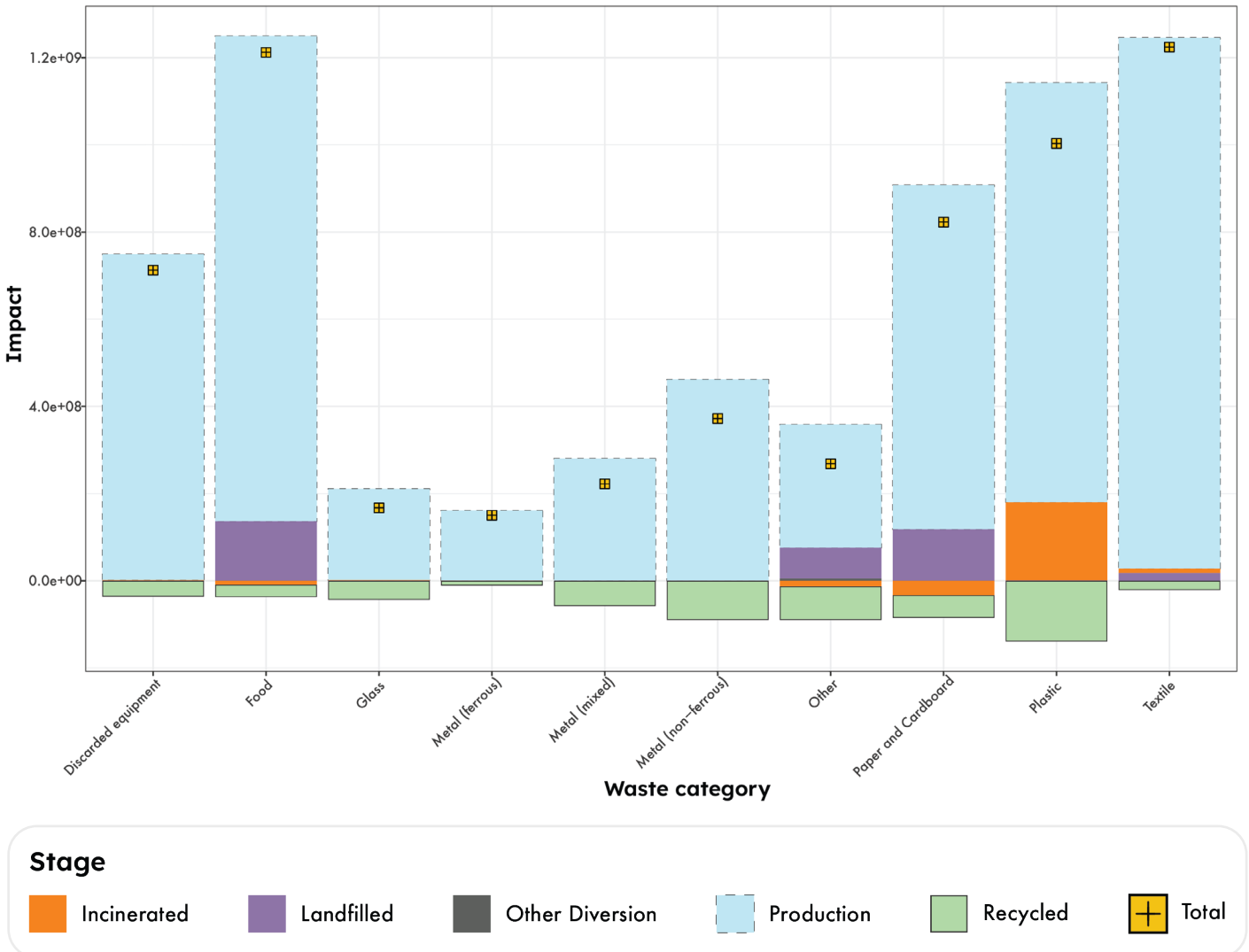
Figure 2: The contribution of major waste streams to impacts. Waste streams ranked in top five for each impact category are shaded blue.



3.1 Climate change

Climate change impacts are based on the global warming potential of different emissions (expressed in kg CO_2 eq). Figure 3 shows the total impacts of household waste on climate change, and the contribution of each stage. The dominant impacts on climate change occur during production and manufacturing. Recycling reduces some of these impacts, most notably for plastic and non-ferrous metals. Incinerating some waste produces energy (electricity and heat) that avoids the need for some energy production.

Figure 3: Impact of Scotland's household waste in 2022 on climate change (kg CO_2 eq) by life-cycle stage. Total impacts are given for each waste category by the crosses in yellow squares.

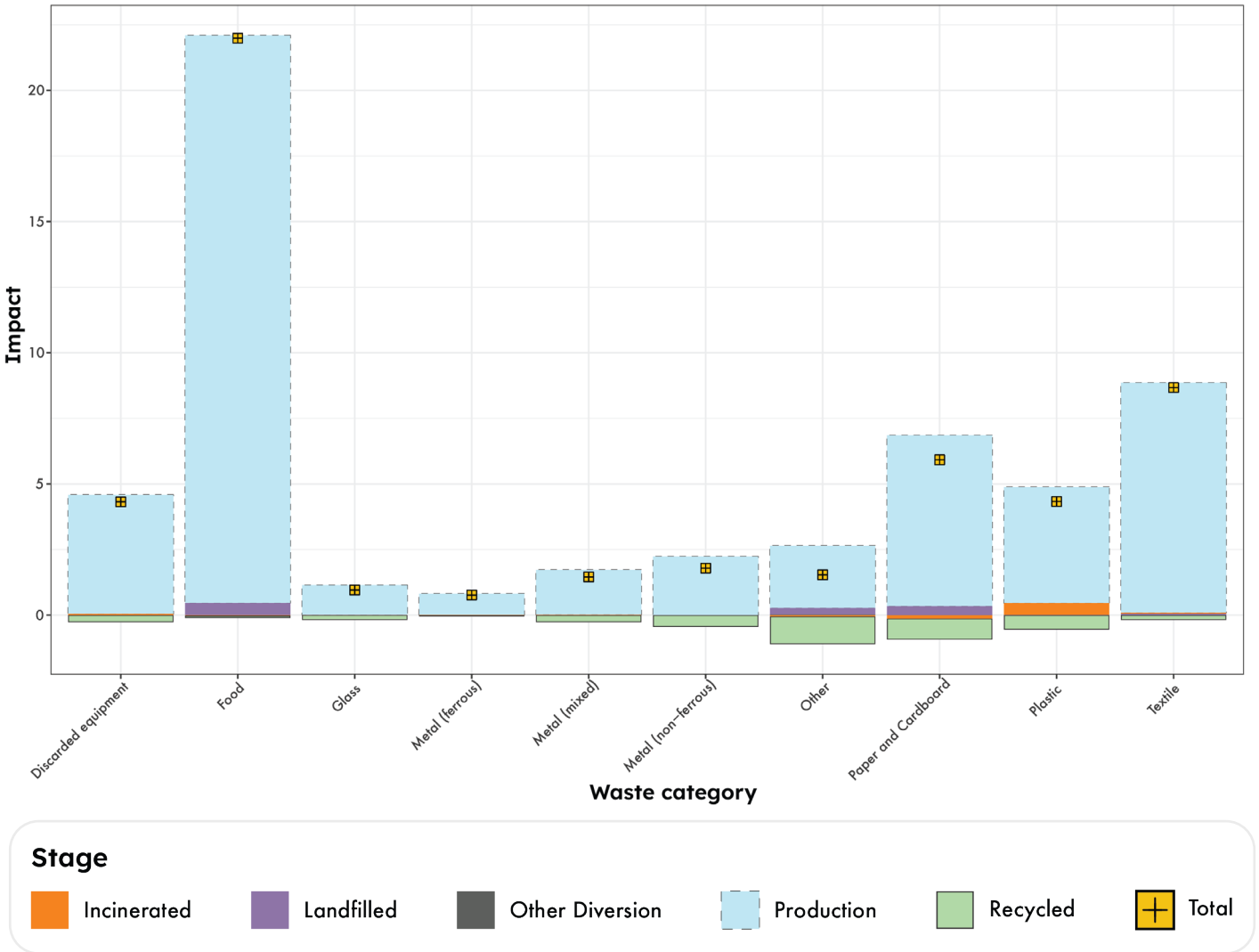


3.2 Biodiversity loss

Human activities can have negative effects on terrestrial, marine, and freshwater species. Impacts are caused by climate change, acidification of soils, increasing levels of nitrogen and phosphorus in water (eutrophication), the emissions of harmful chemicals (ecotoxicity), land-use change, and water consumption. The unit used for the biodiversity loss indicator is the equivalent number of species temporarily lost in one year, i.e. species at risk.

The impact of waste on biodiversity loss is dominated by the embodied impacts of food that is wasted. According to the latest food waste data for Scotland, approximately 60% of food waste is avoidable [6]. If we reduce avoidable food waste, much of these embodied impacts could also be avoided. Recycling food waste has little effect in offsetting the biodiversity loss, this is because food waste is not recycled into new food, but instead used for energy or as compost/ fertiliser.

Figure 4: Impacts on biodiversity loss (species) for key waste categories, by life-cycle stage. Total impacts are given for each waste category by the crosses in yellow squares.

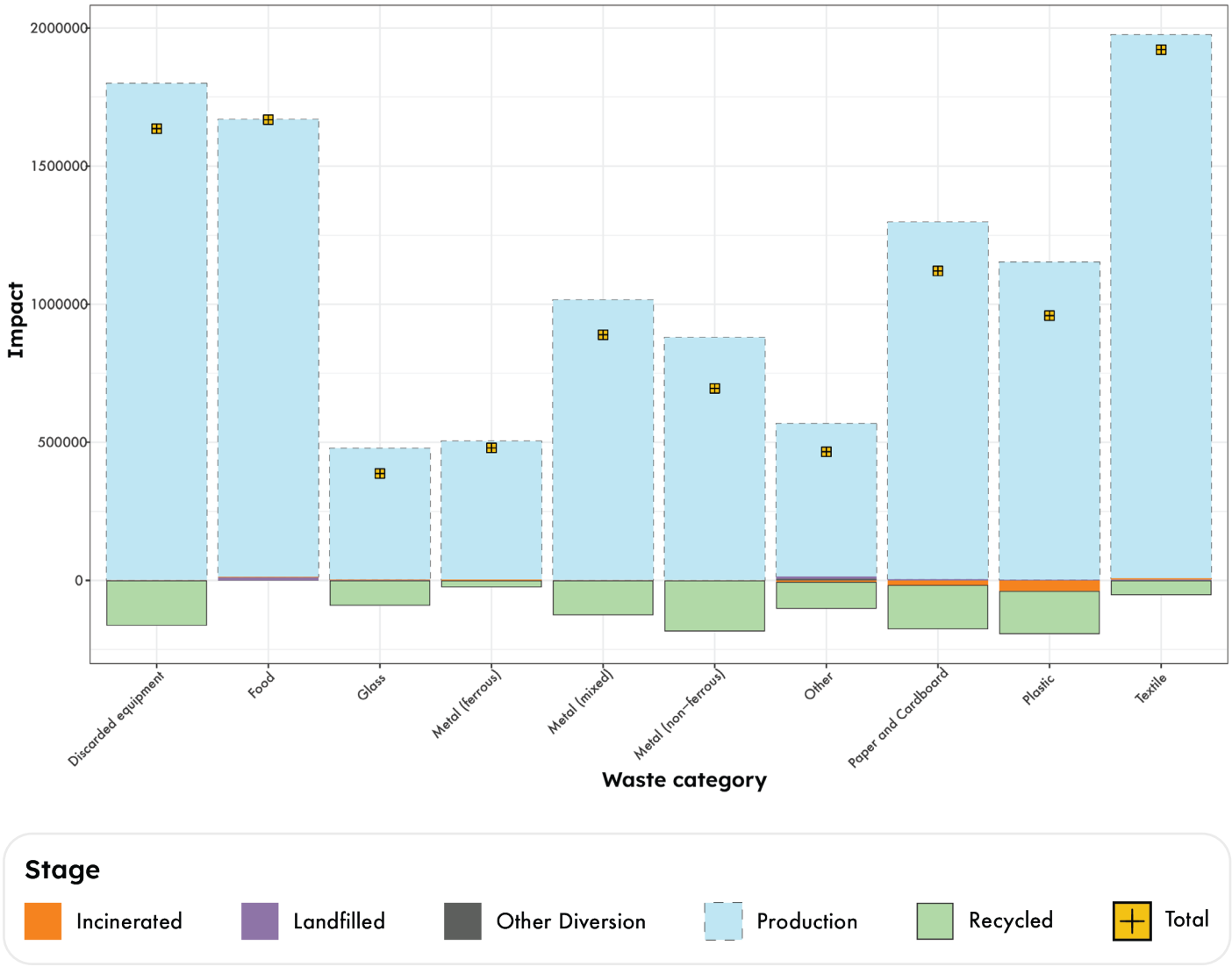


6 Reid, C. (2024). 2021 Scottish Food Waste Estimate. [online] Zero Waste Scotland. Available at: https://cdn.zerowastescotland.org.uk/managed-downloads/mf-cdtg7vnr-1696942041d [Accessed 23 Apr. 2024].

3.3 Air pollution

Air pollution, when inhaled by humans, can damage health (impacts are expressed in kg PM2.5 eq [7]). There are several waste categories that contribute significantly to air pollution, including textiles, discarded equipment, food, plastic, and paper and cardboard. In each case, it is the embodied impacts that dominate. Some impacts are avoided with recycling, since the recovered materials from recycling can offset the need for virgin material, therefore avoiding any associated air pollution from its production.

Figure 5: Impacts on Air pollution (kg PM2.5 eq) for key waste categories, by life-cycle stage. Total impacts are given for each waste category by the crosses in yellow squares.

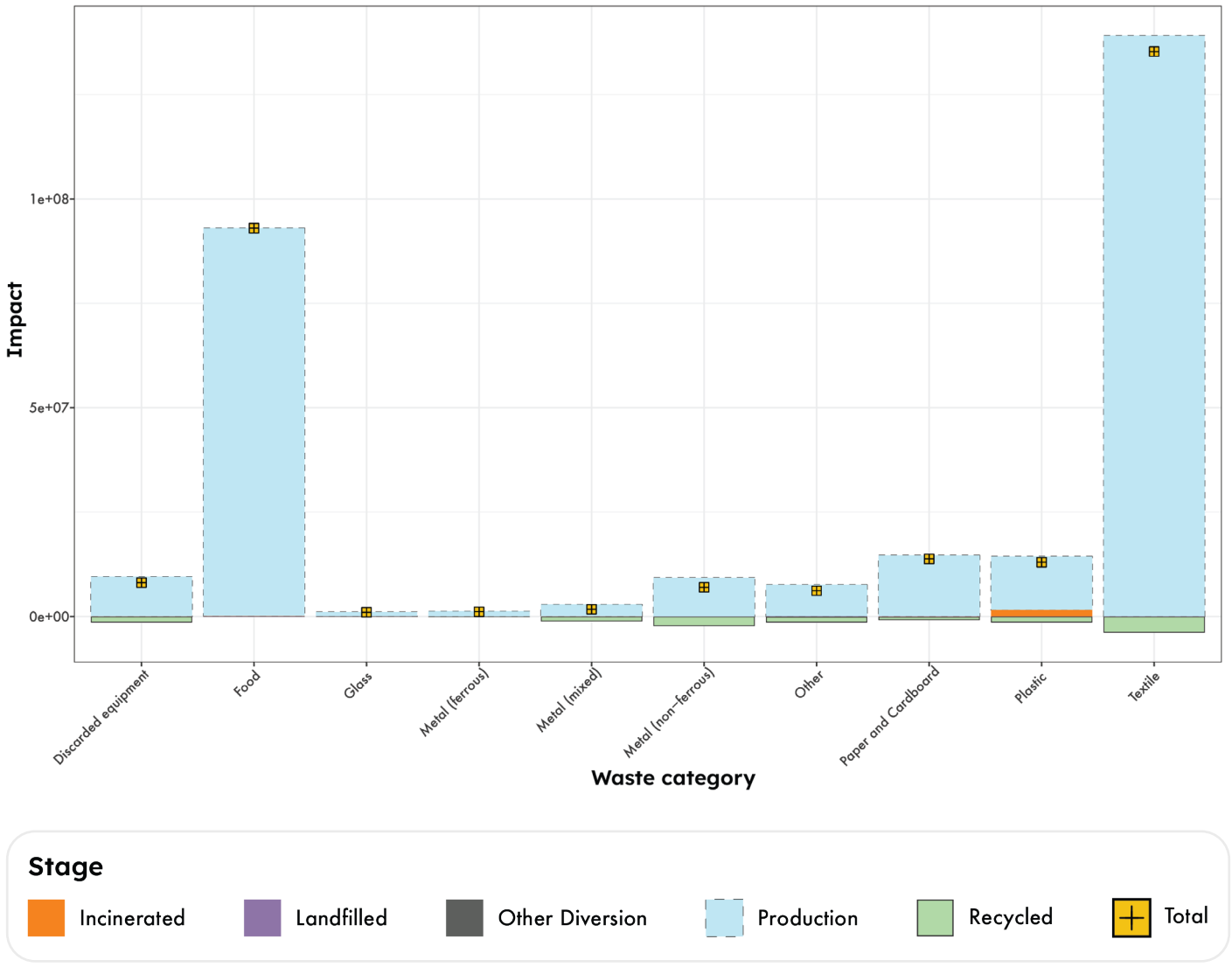


7 PM2.5 are fine particulates less than 2.5µm in diameter. PM2.5 causes damage to human respiratory systems and can lead to increased mortality (ReCiPe, 2016).

3.4 Water consumption

The consumption of water can increase water scarcity, consequently harming human health (through malnutrition) and biodiversity. Water consumption impacts are based on the withdrawal and subsequent use of water, expressed in cubic metre (m^3). Water consumption impacts are dominated by textile waste and food waste. Recycling (and reuse) help to offset some of the impacts of textiles.

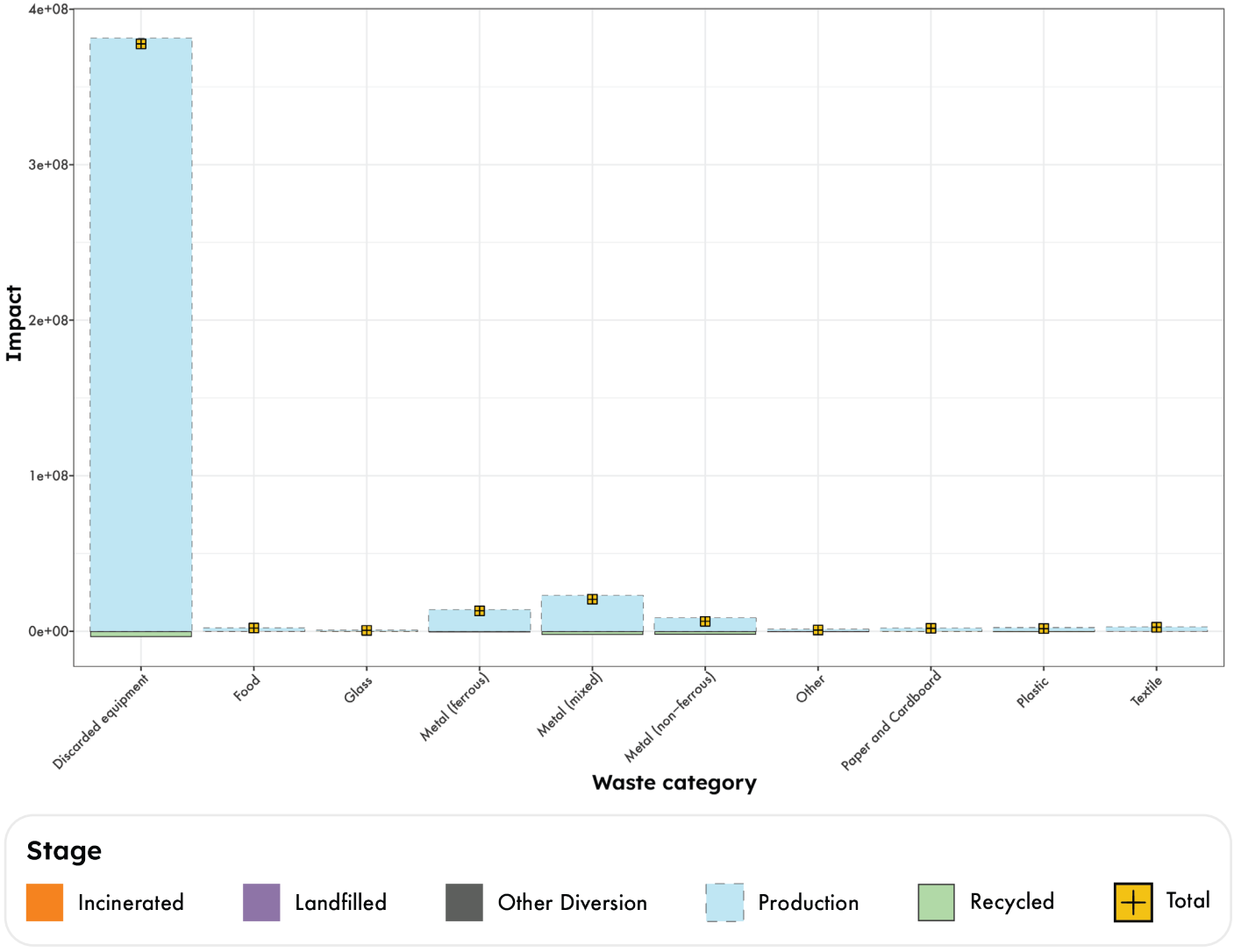
Figure 6: Impacts on water consumption (m^3) for key waste categories, by life-cycle stage. Total impacts are given for each waste category by the crosses in yellow squares.



3.5 Mineral resource scarcity

The extraction of resources in the present makes them more difficult to extract in the future due to declining concentration of metal ores [8]. Mineral resource scarcity is a measure of the increase in ore required to mine a resource in the future given expected future production (measured in kg of copper equivalent – kg Cu eq.). Mineral resource scarcity is dominated by discarded equipment. The only other waste categories that contribute significantly to this are metals.

Figure 7: Impacts on mineral resource scarcity (kgCu eq.) for key waste categories, by life-cycle stage. Total impacts are given for each waste category by the crosses in yellow squares.



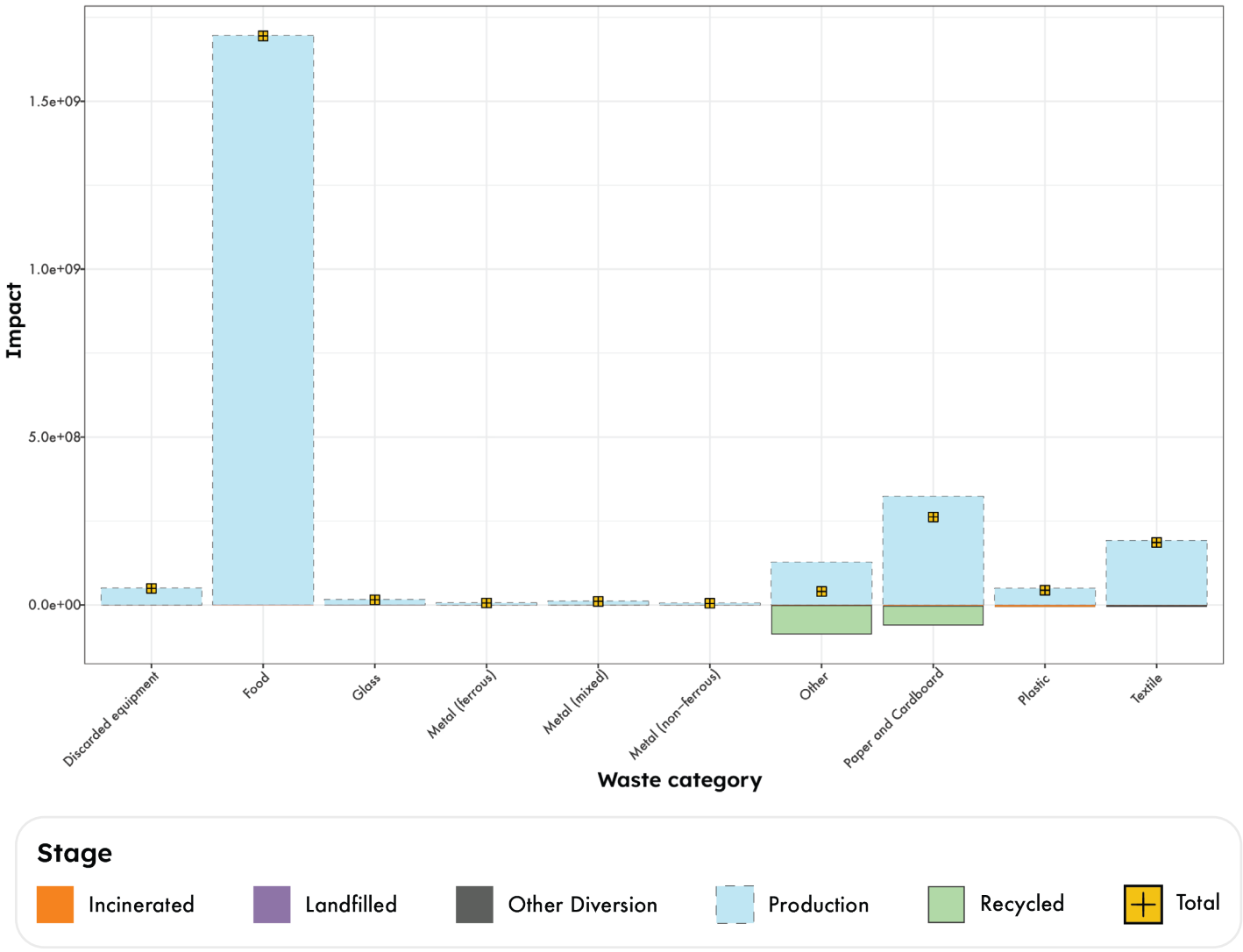
8 The life cycle impact assessment methodology (ReCiPe 2016) assumes that the most concentrated ores of minerals are mined first. Over time, therefore, the concentration of minerals in ores declines, meaning more of the ore is needed to extract the required mineral.

3.6 Land use

The impact on land use is measured in terms of species lost due to loss of habitat and soil disturbance; it is therefore correlated with biodiversity loss. The unit of measurement is the equivalent loss in species as would typically occur in 1m² of crop production. Food waste dominates this impact category; as with biodiversity loss, recycling does not contribute to reduction in land use impacts.

The recycling of paper and cardboard and wood waste (aggregated under "Other"), in contrast, does help to offset some of the negative impacts on land use, since these recycling processes produce a secondary material that avoids the need for some virgin materials.

Figure 8: Impact on land use (m² annual crop eq) for key waste categories, by life-cycle stage. Total impacts are given for each waste category by the crosses in yellow squares.



4 Recommendations for future research

The climate and environmental crises that we face mean more evidence of our impact and how to change it is required. The following issues are limitations of SWEFT at the time of publication, and recommended areas for future research:

- SWEFT should be used to monitor the footprint of Scotland's household waste. It is not recommended to use it to forecast the impacts of changing waste management practices. In order to make accurate forecasts, a new model utilising different data and based on different modelling assumptions must be developed.
- SWEFT relies on a number of secondary data sources, some of which are proxies (e.g., using UK wide data rather than Scotland specific data). To accurately monitor progress towards targets, Scotland-specific data would be needed, which may require primary data collection.
- SWEFT emphasises the contribution of embodied impacts of waste. Although these embodied impacts are proxies for consumption, household waste does not represent everything that Scottish households consume. A similar tool oriented towards household consumption is recommended to highlight these impacts.

5 Appendix

5.1 Life cycle assessment

The SWEFT model has been developed using life cycle assessment (LCA) methodology. The system boundaries for SWEFT include all production and manufacturing processes, transport to retail, waste management collection, recycling, and disposal. The use phase is not considered. This means that the impacts calculated are not of the whole life-cycle, but instead focus on the energy and materials used, and the pollutants emitted, to produce the products that eventually become waste, and that are used to treat the waste at end-of-life (i.e., recycling, landfilling, incineration, and other disposal methods). The use phase is outside the boundaries of SWEFT since the object is to account for the impacts of the materials and products that we ultimately waste; the use-phase is generally independent of these embodied material impacts.
For recycling, material that is recovered is assumed to avoid the additional production of material. For example, any aluminium that is recovered from the recycling of drinks cans avoids the production of aluminium. The exact amount of material recovered is dependent on recycling processes.

For incineration, material that is burned is recovered for energy (electricity and heat). The energy recovered is assumed to avoid the production of energy. The exact amount of energy avoided is dependent on the waste being incinerated and the average efficiency of UK incinerators.

The majority of data used are from the LCA database EcoInvent, version 3.7.1. Occasionally, data has been used from literature either where there are no data in EcoInvent for particular materials or processes, or where there is a more representative process available.

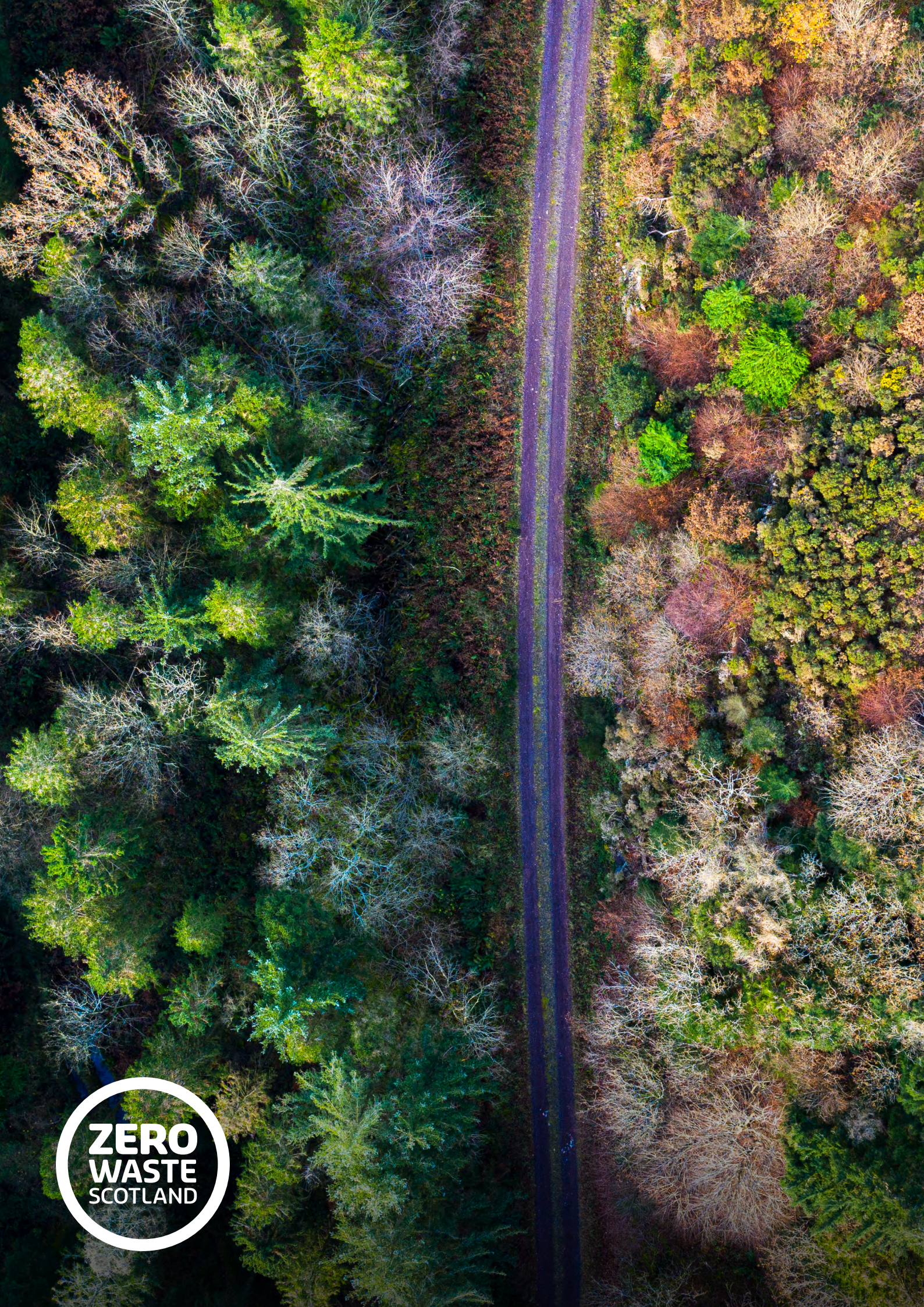
The life cycle impact assessment (LCIA) method used is ReCiPe 2016 (Hierarchical). Due to software limitations, results are only available for 16 midpoint indicators. The biodiversity indicator is calculated using ReCiPe's midpoint to endpoint conversion for damage to ecosystems.

5.2 Waste category disaggregation

Household waste data is collected annually by local authorities and released by SEPA. It covers all household waste that is collected either at the kerbside or through household waste recycling centres. Household waste is separated into several categories based on a standardised methodology. For the purposes of SWEFT, some of this waste has been disaggregated; for example, the category "Household and similar wastes" is mostly made up of residual waste, typical household waste that is collected at the kerbside but that is generally not recycled. This has been disaggregated using the most recent waste composition analysis [9].

A second aggregated category that has been disaggregated is "Mixed and undifferentiated materials". According to SEPA guidelines, this consists of co-mingled recycling (typically what goes into mixed recycling bins), and other materials. We have disaggregated this data using raw data from waste data flow, provided by SEPA.

9 Zero Waste Scotland (2023). Household Waste Composition Analysis. [online] www.zerowastescotland.org.uk. Available at: https://www.zerowastescotland.org.uk/resources/household-waste-composition-analysis [Accessed 22 Apr. 2024].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