UNEP FOOD WASTE INDEX REPORT 2021

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EXECUTIVE SUMMARY

Food waste reduction offers multi-faceted wins for people and planet, improving food security, addressing climate change, saving money and reducing pressures on land, water, biodiversity and waste management systems. Yet this potential has until now been woefully under-exploited.

This potential may have been overlooked because the true scale of food waste and its impacts have not been well understood. Global estimates of food waste have relied on extrapolation of data from a small number of countries, often using old data. Few governments have robust data on food waste to make the case to act and prioritize their efforts.

Sustainable Development Goal 12.3 (SDG 12.3) captures a commitment to halve food waste at the retail and consumer level and to reduce food loss across supply chains. This *Food Waste Index Report* aims to advance progress on SDG 12.3 in two ways:

- Firstly, it presents the most comprehensive food waste data collection, analysis and modelling to date, generating a new estimate of global food waste. Country-level food waste estimates have been calculated, and while confidence intervals for estimates vary by region and by sector, they offer new insight into the scale of the problem and into the substantial prevention potential in low-, middle- and high-income countries.

- Secondly, this report publishes a methodology for countries to measure food waste, at household, food service and retail level, in order to track national progress towards 2030 and to report on SDG 12.3. Countries using this methodology will generate strong evidence to guide a national strategy on food waste prevention, food waste estimates that are sufficiently sensitive to pick up changes in food waste over two- or four-year intervals, and that enables meaningful comparisons among countries globally.

In complement to the Food Loss Index, developed by the Food and Agriculture Organization of the United Nations (FAO), the Food Waste Index covers the later stages of food's journey – food waste – occurring at household, food service and retail level.

KEY FINDINGS

This report estimates that around 931 million tons of food waste was generated in 2019, 61 per cent of which came from households, 26 per cent from food service and 13 per cent from retail. This suggests that 17 per cent of total global food production may be wasted (11 per cent in households, 5 per cent in food service and 2 per cent in retail)[1].

Household per capita food waste generation is found to be broadly similar across country income groups, suggesting that action on food waste is equally relevant in high, upper-middle and lower-middle income countries. This diverges from earlier narratives concentrating consumer food waste in developed countries, and food production, storage and transportation losses in developing countries.

Previous estimates of consumer food waste significantly underestimated its scale. While data doesn't permit a robust comparison across time, food waste at consumer level (household and food service) appears to be more than twice the previous FAO estimate (Gustavsson et al., 2011).

There is insufficient data on the edible fraction of food waste to allow comparative analysis across country income groups, but **even if inedible parts (bones, pits, eggshells, etc.) predominate in lower-**

[1] The apparent discrepancy between the sum of the percentages for each sector and the total is due to rounding.

income countries, there is sufficient total food waste in these areas for circular approaches or other food waste diversion strategies to be important.

Table 1: Average food waste (kg/capita/year) by World Bank income classification, averaging medium and high confidence estimates for countries

Income group	Average food waste (kg/capita/year)		
	Household	Food service	Retail
High-income countries	79	26	13
Upper middle-income countries	76	Insufficient data	
Lower middle-income countries	91	Insufficient data	
Low-income countries	Insufficient data		

Global food waste data availability is currently low, and measurement approaches have been highly variable. The report identifies 17 countries with high-quality data compatible with SDG 12.3.1(b) reporting in at least one sector: Australia, Austria, Canada, China, Denmark, Estonia, Germany, Ghana, Italy, Malta, the Netherlands, New Zealand, Norway, the Kingdom of Saudi Arabia, Sweden, the United Kingdom and the United States. A further 42 countries have data assigned a *medium confidence*[2] level in this report for at least one sector, meaning that small updates in methodology, geographical coverage or sample size would allow these countries to create an SDG 12.3-compatible estimation. This report provides a framework that supports countries in transitioning to a common global measurement approach that allows for consistent reporting under SDG 12.3.

Scope and definition of food waste

For the purposes of the Food Waste Index, "food waste" is defined as food (see below) and the associated inedible parts removed from the human food supply chain in the following sectors:

- Retail
- Food service
- Households

"Removed from the human food supply chain" means one of the following end destinations: landfill; controlled combustion; sewer; litter/discards/refuse; co/anaerobic digestion; compost / aerobic digestion; or land application.

Food is defined as any substance – whether processed, semi-processed or raw – that is intended for human consumption. "Food" includes drink, and any substance that has been used in the manufacture, preparation or treatment of food. Therefore, food waste includes both:

- "edible parts": i.e., the parts of food that were intended for human consumption, and
- "inedible parts": components associated with a food that are not intended to be consumed by humans. Examples of inedible parts associated with food could include bones, rinds and pits/stones.

[2] The confidence rating is not a judgement on the quality of the study undertaken. It is an assessment – based on the reviewers' understanding of the study – of how robust the estimate of food waste is for *tracking* food waste in the given country. In many cases, this was not an aim of the original study.

SDG 12.3 Indicators

SDG 12.3[3] covers food and inedible parts that exit the supply chain and thus are lost or wasted, and is tracked through two indicators:

- Indicator 12.3.1(a), the Food Loss Index, measures losses for key commodities in a country across the supply chain, up to but not including retail. FAO is its custodian.
- Indicator 12.3.1(b), the Food Waste Index, measures food waste at retail and consumer level (households and food service). The United Nations Environment Programme (UNEP) is its custodian. In contrast to the Food Loss Index, the Food Waste Index measures total food waste (rather than loss or waste associated with specific commodities).

The Food Waste Index also allows countries to measure and report on food loss generated in manufacturing processes, which would not be captured under key commodity losses by the Food Loss Index.

THE FOOD WASTE INDEX MEASUREMENT APPROACH

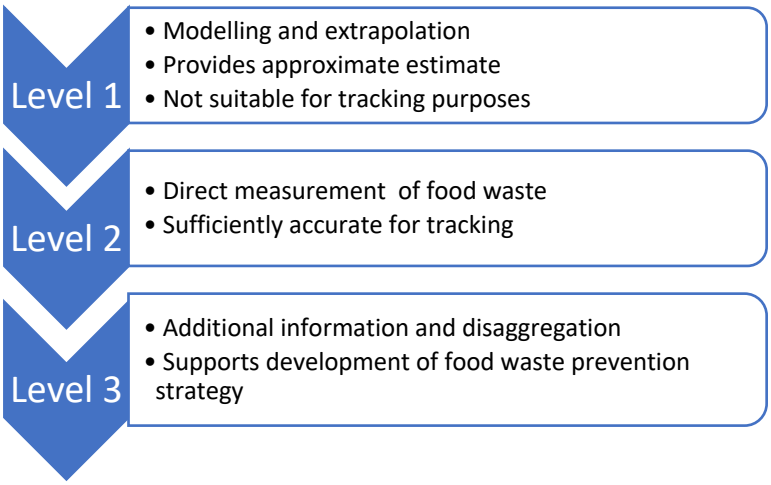
The Food Waste Index has a three-level methodology, increasing in accuracy and usefulness of data, but also increasing in the resources required to undertake them:

Level 1 uses modelling to estimate food waste, for Member States that have not yet undertaken their own measurement. Level 1 involves extrapolating data from other countries to estimate food waste in each sector for a given country. The estimates for these countries are approximate: they are sufficient to provide insight into the scale of the problem and to make a case for action, but inadequate to track changes in food waste over time. They are intended as a short-term support while governments develop capacity for national measurement (consistent with Level 2). Calculated Level 1 estimates are presented in this report for all countries.

Level 2 is the recommended approach. It involves measurement of food waste in countries. The nature of the measurement will vary according to sector and circumstances. It will be either undertaken by national governments or derived from other national studies undertaken in line with the framework described below. Level 2 generates primary data on actual food waste generation and fulfils the requirement for tracking food waste at a national level, in line with the SDG 12.3 target.

Level 3 provides additional information to inform policy and other interventions designed to reduce food waste generation. This includes the disaggregation of data by destination, edible/inedible parts, gender; reporting of manufacturing food waste not covered by the Food Loss Index (for example, where more than one commodity is combined to produce complex food products); and additional destinations such as sewer, home composting and (non-waste) animal feed.

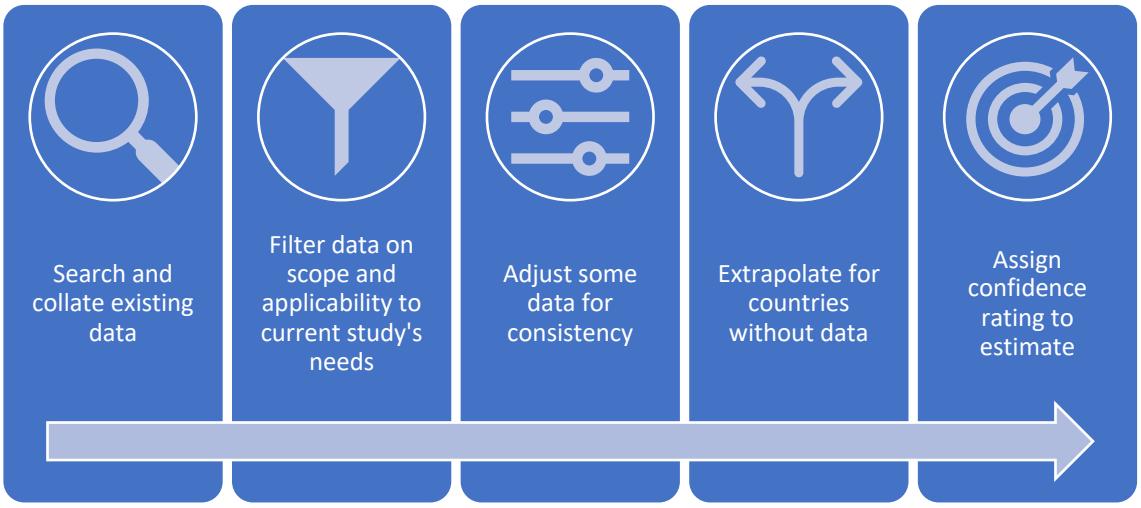
[3] SDG 12 https://sdgs.un.org/goals/goal12



LEVEL 1 MODELLING APPROACH AND OUTCOMES

While the availability of food waste data remains limited, there have been a growing number of national estimates of food waste from countries around the world in recent years.

A new global food waste baseline was developed using both existing *data points* from studies measuring food waste inside a Member State (where available) and *extrapolations* based on the estimates observed in other countries (where no estimate was identified for the Member State).



More relevant data was uncovered than expected, with 152 food waste data points identified in 54 countries. While the majority of studies come from high-income countries, especially in the food service and retail sectors (78 per cent of countries with a food service estimate and 87 per cent of countries with a retail estimate are high-income countries), data at the household level has a more even distribution across income groups, with 54 per cent of the 52 countries that have existing estimates being high-income countries, 23 per cent being upper middle-income countries and 19 per cent being lower middle-income countries. Only two low-income countries have household food waste estimates, representing 4 per cent of the global estimates.

Table 2: Number of countries with measured data points, by sector and World Bank income classification

World Bank income group	Household	Food service	Retail
High-income countries	28	18	20
Upper middle-income countries	12	3	2
Lower middle-income countries	10	2	1
Low-income countries	2	0	0
Total	**52**	**23**	**23**

There is an uneven distribution of data between regions as well as country income groups. Key data gaps exist at the household level in low-income countries, small island states, Central Asia and Northern Africa, and at the food service and retail levels more broadly (in low-income, lower middle-income and upper middle-income countries). Extrapolation to provide an approximate estimate of food waste in countries without data will have greater uncertainty for these areas (see confidence classifications below).

Multiple studies were found at the household level in all European regions, the Americas, most Asian regions, Australia and New Zealand, and Sub-Saharan Africa. Therefore, for most regions, estimating household food waste in countries without data can be based on extrapolation of nearby countries.

Food waste data points that were used in this study, for an individual country and for extrapolation purposes, were classified as:

1) **High confidence estimates:** likely to be suitable for tracking national levels of food waste – i.e., developed using a robust methodology, covering a substantial part of the country and with no adjustment of the data required to align it with the current studies' purposes; or

2) **Medium confidence estimates:** measured using methodologies that may be suitable for detecting larger changes in food waste, e.g., data points from cities used to represent a country, data points requiring adjustment to align with the current studies' purposes.

Extrapolations based on good regional data have been marked as *low confidence* estimates, and extrapolations where regional data was limited are considered *very low confidence* estimates.

Rich sub-national data has greatly improved household food waste estimates. Household food waste data is more widely available than previously expected, in particular due to the inclusion of a large number of studies conducted at the city or municipality level. Sub-national studies outnumber nationwide studies at household level. In most cases, these studies were not focused specifically on food waste but rather were related to general waste planning in an area, and total waste was collected from households and disaggregated to include a food-specific estimate. Food waste is a significant waste material that local authorities collect, and robust food waste data can guide both prevention and circular food strategies, alleviating pressure on local waste management systems.

Fourteen countries have household food waste data compatible with the Food Waste Index. These countries have measured food waste in a way that is broadly consistent with the methods suggested in this report. As a result, the estimates are likely to be suitable for tracking changes over time and for reporting progress on the food waste component of SDG 12.3. Nine countries have measured food waste in the food service sector and ten countries in the retail sector in this way. A further 42 countries have *medium confidence* data in one or more sectors where the scope or parameters could be expanded to align with SDG 12.3 reporting.

Table 3: Countries with high confidence food waste estimates, by sector

Household	Food service	Retail
Australia	Australia	Australia
Austria	Austria	Austria
Canada	China	Denmark
Denmark	Denmark	Germany
Germany	Estonia	Italy
Ghana	Germany	New Zealand
Malta	Sweden	Saudi Arabia
Netherlands	United Kingdom	Sweden
New Zealand	United States	United Kingdom
Norway		United States
Saudi Arabia		
Sweden		
United Kingdom		
United States		

The household food waste estimate is the most robust among the three sectors, based on nearly 100 data points across a range of countries representing 75 per cent of the world's population. In contrast, the estimates for the retail and food service sectors are based on around 30 data points for each, with the majority coming from high-income countries. Countries with measured data points represented 32 per cent of the world's population for food service and 14 per cent for retail. In addition, many of the food service estimates are incomplete, not covering the range of settings outside the home in which food is served and consumed.

Much more measurement is needed to spur action, following the 'Target – Measure – Act' approach promoted by high level food loss and waste coalition Champions 12.3. Even though household data coverage is good, the estimates in many countries come from small, limited samples or required adjustment for comparability. Only 9 per cent of the global population lives in a country with a *high confidence* household food waste estimate, and rates are similarly low for retail (8 per cent), but higher for food service (25 per cent). To improve food waste responses, more countries need to measure food waste, using accurate methods on significant sample sizes.

Similarly, further research to quantify the environmental, economic and social impacts and to understand the causes of this food waste is needed. Some countries now have data and research on the types of food that are wasted and why; increasing this understanding to a wider range of countries would allow stronger strategies and programmes of work to minimize waste of valuable food resources in these sectors. Increased reporting of food waste in the coming years will make it possible to track progress over time and better support Member States in delivering SDG 12.3 and a world in which less food is wasted. The measurement methodology presented in this report offers a common approach to data collection.

LEVELS 2 AND 3: NATIONAL FOOD WASTE MEASUREMENT METHODOLOGY

Modelling and extrapolation are a first step, but direct measurement of food waste is what is ultimately needed for a country to track its food waste over time, and to enable policymakers to make key strategic decisions about how to prevent food waste.

Level 2 and Level 3 of the Food Waste Index provide the framework for countries to measure and report food waste, in a way that is sensitive enough to track progress towards the SDG 12.3 target. Levels 2 and 3 use data from measurements of food waste in the relevant country and time frame, rather than proxy data (Level 1).

The Level 2 approach requires a reporting country to:

- Define a scope – i.e. select the sector(s) they are going to report
- Select suitable methods to measure food waste
- Conduct studies using the chosen method(s)
- Report food waste for the Food Waste Index
- Repeat studies regularly using a consistent methodology.

Figure 1 illustrates the scope of the Food Waste Index, and Table 4 illustrates suitable methods for food waste measurement by sector.

Figure 1: Food Waste Index Inventory Scope, using Food Loss and Waste Standard

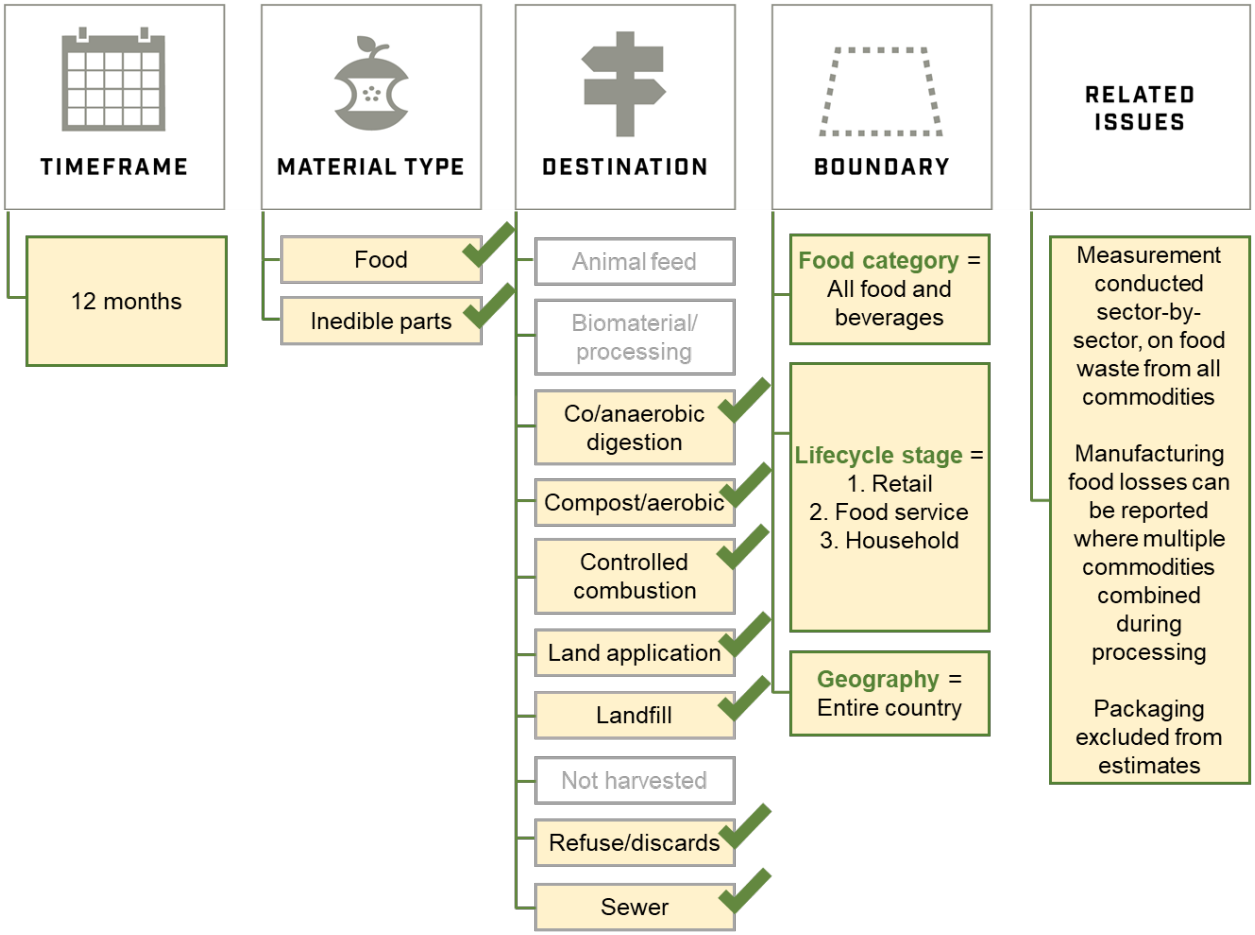


Table 4: Appropriate methods of measurement for different sectors

<table>
<tr><th>Sector</th><th colspan="6">Methods of measurement</th></tr>
<tr><td>Manufacturing (if included)</td><td rowspan="4">Direct measurement (for food-only waste streams)</td><td rowspan="4">Waste composition analysis (for waste streams in which food is mixed with non-food)</td><td rowspan="4">Volumetric assessment</td><td rowspan="2">Mass balance</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Retail</td></tr>
<tr><td>Food service</td><td rowspan="2"></td><td rowspan="3">Counting/ scanning</td><td rowspan="3">Diaries (for material going down sewer, home composted or fed to animals)</td></tr>
<tr><td>Household</td></tr>
</table>

Level 3 comprises supplementary indicators relating to food waste. These are:

- Disaggregation of total food waste reported in the Level 2 indicators by destination.
- Inclusion of additional destinations not included in Level 2: sewer, home composting and food 'surplus' (i.e. food redistributed for consumption by people, used for animal feed or used for bio-based materials / biochemical processing).
- Disaggregation of total food waste by edible parts (intended for human consumption) and their associated inedible parts (e.g., banana skins, bones, eggshells) and by gender.
- Reporting of manufacturing food waste where it is not covered by the Food Loss Index, e.g. where more than one commodity is combined to produce processed/complex food products.

The disaggregation by edible and inedible parts is valuable to policymakers in guiding policy interventions to make the best possible use of food resources, supporting a circular food system and the application of the waste hierarchy. In order to simplify Level 2 processes for the vast majority of countries that will be developing a food waste baseline for the first time, and to improve data comparability in a context of diverse, culturally sensitive interpretations of inedibility (e.g. chicken feet, many skins and peels), this disaggregation is proposed as a Level 3 advanced reporting option.

HOW TO REPORT ON SDG 12.3

Food waste data in relation to SDG 12.3 will be collected using the United Nations Statistics Division (UNSD) / UNEP Questionnaire on Environment Statistics (Waste Section). The questionnaire is sent out every two years to National Statistical Offices and Ministries of Environment, which will nominate a single food waste focal point in the country to coordinate data collection and reporting. The data will be made publicly available in the SDG Global Database and in UNEP's *Food Waste Index Report*, which will be published at regular intervals up to 2030. **The next questionnaire will be sent to Member States in September 2022**, and results will be reported to the SDG Global Database by February 2023.

Countries do not need to conduct new measurements every two years, or to measure every sector simultaneously. Measuring each sector at least once every four years is recommended.

Recognizing the efforts and leadership of countries that already measure and report on food waste, with variances in scope or methodology, (gradual) alignment with the Food Waste Index approach is

appreciated. This enables consistency between nations and supports a common interpretation of SDG 12.3.

HOW THE FOOD WASTE INDEX IS CALCULATED

For each sector within a country, the level of food waste will be expressed as an index relative to the level of food waste in the baseline year. A value of:

- 100 would indicate the same level of food waste in that sector as the baseline year; and
- 50 would indicate that food waste in that sector had halved since the baseline year, consistent with the target of SDG 12.3

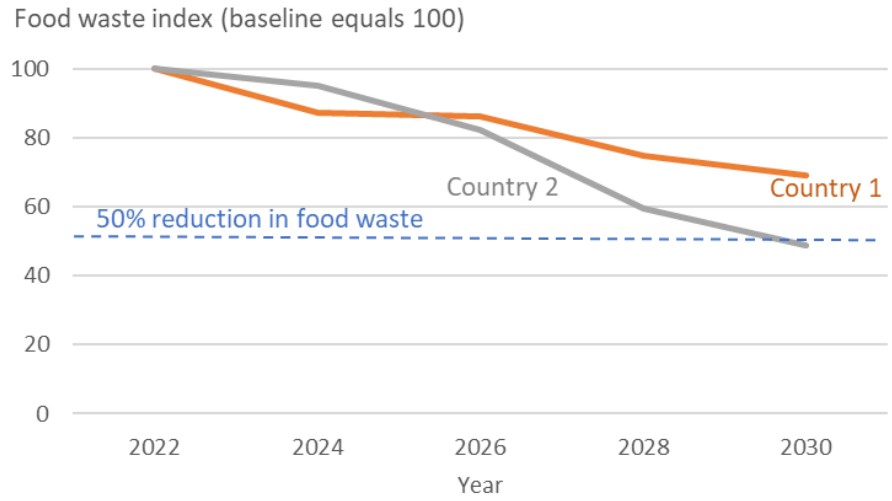
The indices for each sector will **not** be combined into a single Food Waste Index. This will allow the granular data for individual sectors to be more easily communicated; it will also alleviate issues if a country is unable to report all sectors in one reporting cycle.

Example: Food Waste Indices for two hypothetical countries

Figure 6 provides a worked example of the household Food Waste Index for two hypothetical countries. In both cases, the baseline year is 2022. Country 1 has 87 kg/capita/year of household food waste in 2022 and – as this is the first year of measurement – this is defined as 100 in the Food Waste Index. By 2030, this has reduced to 60 kg/capita/year: a value of 69 in the Food Waste Index. This represents a reduction of 31 per cent: good progress, but insufficient to meet the 50 per cent reduction for SDG 12.3(b), represented by the blue dotted line.

Country 2 has a baseline value of 84 kg/capita/year, which is defined as 100 in the Food Waste Index for this country. By 2030, this country has achieved SDG 12.3(b) for this sector, with food waste less than half the baseline level (41 kg/capita/year). Therefore, the final Food Waste Index value for Country 2 is a value less than 50.

Figure 2: Food Waste Indices for two hypothetical countries



WHAT HAPPENS NEXT?

This report, aimed primarily at national governments, is a stepping stone to the delivery of SDG 12.3.

The following are some key next steps in that journey:

- **Use the Target Measure Act approach** developed by Champions 12.3 to organize action, use 'Enhancing NDCs for Food Systems' to **raise ambition in national climate strategies by integrating food loss and waste**, and strengthen food security and cut costs to households by integrating food waste prevention in COVID-19 recovery policy approaches.

- **Co-create and adopt game-changing solutions to food waste through the UN Food Systems Summit.** Member States and a wide range of other actors are heartily encouraged to join Action Track 2's Food Waste workstream, and to prioritize, lead and engage in game-changers that will transform the scale of global action and set us on a path to deliver SDG 12.3.

- **Participate in a Regional Food Waste Working Group.** UNEP will convene Regional Food Waste Working Groups in Asia Pacific, West Asia, Africa, and Latin America and the Caribbean, to be launched in 2021, together with technical partner WRAP. These Working Groups will provide capacity building and training to participating Member States in measuring food waste, developing a national baseline and designing national strategies for food waste prevention. They are intended to bring to life the methodology presented here, creating opportunities for Member States to ask technical questions, work through problems, and learn from and support their peers in the development of food waste measurement processes.

- **Report on food waste in 2022,** using the methodology in this report via the UNSD/UNEP Questionnaire on Environment Statistics (Waste Section).

A few countries are making good progress on SDG 12.3, but most countries are just getting started. It is an ambitious target, with important impacts, on hunger, economies, climate, nature, and pollution. This report and these next steps will equip member states and other entities to manage what they measure.

DEFINITIONS

Food: Any substance – whether processed, semi-processed or raw – that is intended for human consumption. "Food" includes drink, and any substance that has been used in the manufacture, preparation or treatment of food. "Food" also includes material that has spoiled and is therefore no longer fit for human consumption. It does not include cosmetics, tobacco or substances used only as drugs. It does not include processing agents used along the food supply chain, for example water to clean or cook raw materials in factories or at home.

Food loss: Food losses are all the crop and livestock human-edible commodity quantities that, directly or indirectly, completely exit the post-harvest/slaughter production/supply chain by being discarded, incinerated or otherwise, and do not re-enter in any other utilization (such as animal feed, industrial use, etc.), up to, and excluding, the retail level. Losses that occur during storage, transport and processing, also of imported quantities, are therefore all included. Losses include the commodity as a whole with its non-edible parts.

Food surplus: For the purposes of the Food Waste Index, food surplus refers to food that is redistributed for consumption by people, used for animal feed or used for bio-based materials / biochemical processing.

Food waste: For the purposes of the Food Waste Index, "food waste" is defined as food (see definition, including drink) and associated inedible parts removed from the human food supply chain in the following sectors: manufacturing of food products (under certain circumstances); food/grocery retail; food service; and households. "Removed from the human food supply chain" means one of the following end destinations: landfill, controlled combustion, sewer, litter/discards/refuse, co/anaerobic digestion, compost / aerobic digestion or land application.

Inedible (or non-edible) parts: Components associated with a food that, in a particular food supply chain, are not intended to be consumed by humans. Examples of inedible parts associated with food could include bones, rinds and pits/stones. "Inedible parts" do not include packaging. What is considered inedible varies among users (e.g., chicken feet are consumed in some food supply chains but not others), changes over time, and is influenced by a range of variables including culture, socio-economic factors, availability, price, technological advances, international trade and geography. See also "edible parts".

Edible parts of food waste: "Food" (see definition, including drink) that is removed from the human food supply chain (i.e., to end up at the following destinations: landfill, controlled combustion, sewer, co/anaerobic digestion, compost / aerobic digestion or land application). See also "inedible parts".

Municipal solid waste (MSW): Includes waste originating from households, commerce and trade, small businesses, office buildings and institutions (schools, hospitals, government buildings). It also includes bulky waste (e.g., old furniture, mattresses) and waste from selected municipal services, for example waste from park and garden maintenance, waste from street cleaning services (street sweepings, the content of litter containers, market cleansing waste), if managed as waste. Further information on municipal solid waste is defined in the SDG indicator methodology for SDG 11.6.1.

1 INTRODUCTION

This report sheds new light on the magnitude of food waste, and on the prevalence of household food waste on all continents, irrespective of country income levels. By throwing away 17 per cent of food available at retail, food service and consumer level, the impacts of food systems on climate, nature and pollution are generated needlessly. An estimated 8-10 per cent of global greenhouse gas emissions are associated with food that is not consumed (Mbow et al., 2019, p. 200) – and yet none of the Nationally Determined Contributions to the Paris Agreement mention food waste (and only 11 mention food loss) (Schulte et al., 2020).

As environmental impacts accrue across the life cycle of food products, food waste at the consumer level presents the highest burden. The Food and Agriculture Organization of the United Nations (FAO) estimates that 690 million people were hungry in 2019, a number that is expected to rise sharply during and post-COVID-19. With a staggering 3 billion people that cannot afford a healthy diet (FAO, 2020), the message of this report is clear: citizens need help to reduce food waste at home.

The scale of the food waste challenge has not been fully understood. In 2011, a report by the FAO estimated that around one-third of food produced globally was lost or wasted, a total of 1.3 billion tonnes each year (Gustavsson et al., 2011, p. 56); however, the authors acknowledged a lack of household food waste data outside of Europe and North America (Gustavsson et al., 2013). Differences in definitions of food loss and waste and diverse quantification methods used have added to data ambiguity. Xue et al. (2017) noted that there are still large gaps in national estimates of food loss and waste. Of the estimates they analysed, many did not involve new measurement but relied on proxy data often from other countries or that is outdated.

The lack of data is not just an issue at a global level: most countries do not have robust data on food waste. How much food is wasted or lost? In which sectors (parts of the supply chain) is the most waste being created? What types of food have the largest impact? Without this information, governments, businesses and other organizations struggle to make a case to take action, and lack the information to prioritize their efforts. To track progress towards the Sustainable Development Goal on food loss and waste (SDG 12.3), better data is needed. Fortunately, this situation can change.

1.1 THE FOOD WASTE INDEX AND SUSTAINABLE DEVELOPMENT GOAL 12.3

SDG 12.3 focuses on food and its inedible parts that exit the supply chain and thus are lost or wasted. This is split into two indicators:

- Indicator 12.3.1(a), the Food Loss Index, measures losses for key commodities in a country across the supply chain, up to and not including retail. The FAO is its custodian. This indicator is not discussed in detail in this paper, except to describe its boundary with the Food Waste Index.

- Indicator 12.3.1(b), the Food Waste Index, measures food and inedible parts wasted at the retail and consumer levels (household and food service). UNEP is its custodian. In contrast to the Food Loss Index, the Food Waste Index measures total food waste (rather than specific commodities).

For this reason, the three sectors covered by the Food Waste Index are:

  - Food retail
  - Households
  - Food service.

The Food Waste Index also allows countries to report on manufacturing food loss not captured by the Food Loss Index (for example where more than one commodity is combined to produce complex food

products). This is an optional supplementary reporting area, a 'Level 3' methodology as explained below. Wholesale remains under the Food Loss Index and therefore should not be reported under the Food Waste Index.

The Food Waste Index has a three-level methodology, increasing in accuracy and usefulness of data, but also increasing in the resources required to undertake them:

Level 1 uses modelling to estimate food waste, for Member States that have not yet undertaken their own measurement. Level 1 involves extrapolating data from other countries to estimate food waste in each sector for a given country. The estimates for these countries are approximate: sufficient to provide insight into the scale of the problem and make a case for action, but inadequate to track changes in food waste over time. They are intended as a short-term support while governments develop capacity for national measurement (consistent with Level 2). UNEP has calculated Level 1 estimates on behalf of countries, and they are presented in this report.

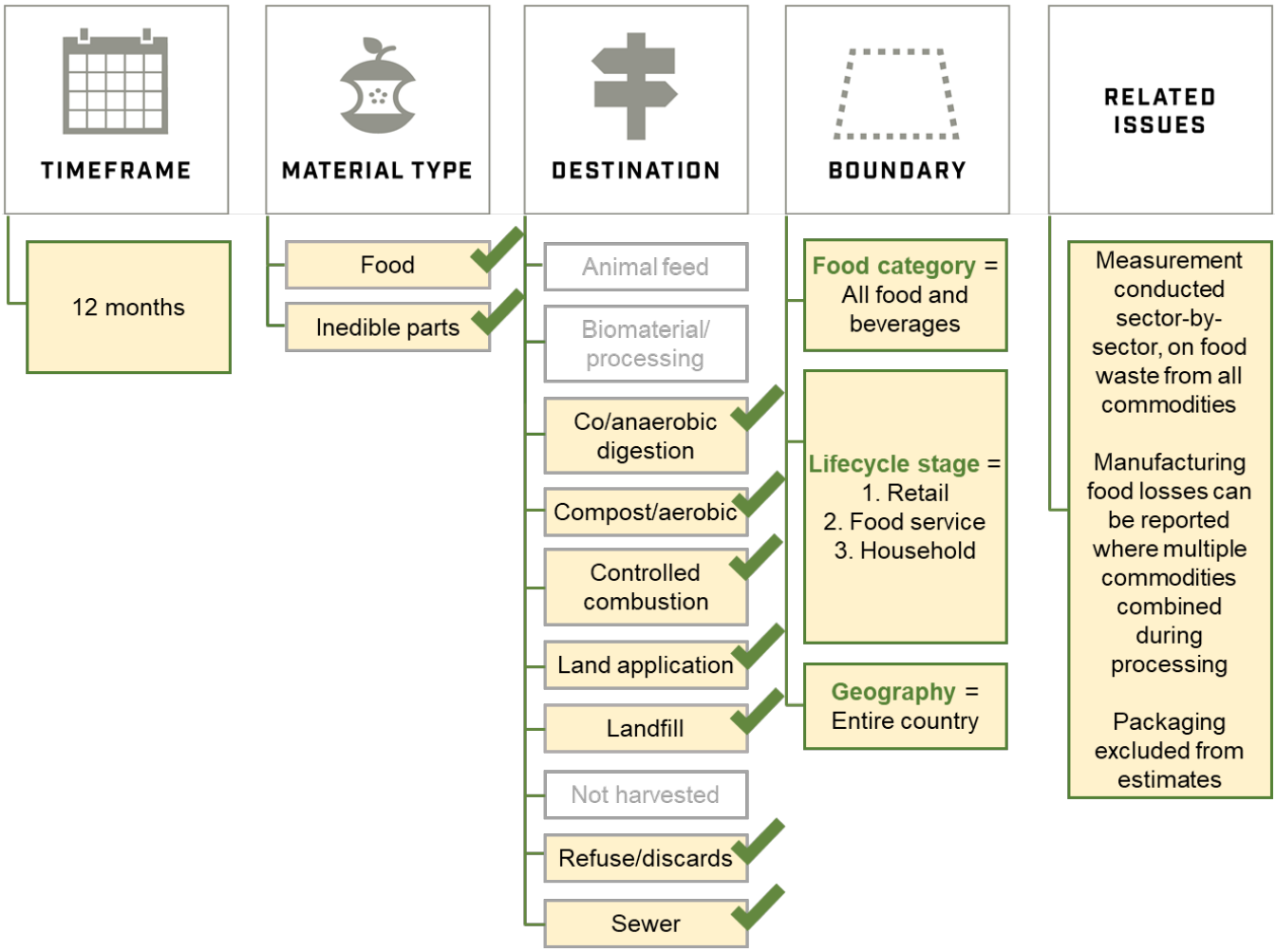
Level 2 is the recommended approach for countries. It involves measurement of food waste. The nature of the measurement will vary according to sector and circumstance. It will be either undertaken by national governments or derived from other national studies undertaken in line with the framework described below. Level 2 generates primary data on actual food waste generation and fulfils the requirement for tracking food waste at a national level, in line with the SDG 12.3 target.

Level 3 provides additional information to inform policy and other interventions designed to reduce food waste generation. This includes the disaggregation of data by destination, edible/inedible parts, gender; reporting of manufacturing food loss not covered by the Food Loss Index (e.g. where more than one commodity is combined to produce complex food products); and additional destinations such as sewer, home composting and (non-waste) animal feed.

This three-level approach endeavours to balance fitness for purpose with feasibility of implementation in as many UN Member States as possible. The approach is designed to enable a country to measure food waste, and to assess the impact of interventions, ideally coinciding with a national strategy on food waste reduction.

The scope of the Food Waste Index is illustrated in Figure 4. It includes both food waste and associated inedible parts that end up in one of the destinations listed. It includes both the recommended (Level 2) and the additional (Level 3) destinations. Animal feed and bioprocessed materials are not classified as food waste, as the material is deemed not to have been removed from the human food supply chain. Definitions of the destinations can be found in Appendix 5.

Figure 4: Scope of the Food Waste Index (Levels 2 and 3) using the Food Loss and Waste Accounting and Reporting Standard



The coverage and quality of existing food waste data for countries around the world is collated and presented in section 2. This highlights where there is a growing amount of evidence on the amounts of food waste. It also identifies the data gaps around the world.

The methodology described in section 3 provides guidance on how countries can measure their food waste (one part of SDG 12.3). The guidance provides clear advice on what to measure, supporting the use of consistent terminology to describe what is being measured. It also provides clear instructions on how to measure and report food waste.

By implementing this guidance, a greater number of countries can measure food waste in a consistent way. This allows them to track food waste over time and to make meaningful comparisons with other countries. It also provides some of the data to support change – to help countries demonstrate the current impact of food waste, and information that prioritizes their efforts to tackle food waste.

2 INDEX LEVEL 1: EXISTING DATA AND EXTRAPOLATION TO OTHER COUNTRIES

2.1 LEVEL 1 ESTIMATES OF FOOD WASTE

While the availability of food waste data remains limited, there have been a growing number of national estimates of food waste from countries around the world in recent years. This section identifies these estimates, assesses whether the measurement methodologies being used are suitable for tracking food waste over time as part of SDG 12.3, and evaluates the coverage of food waste estimates globally.

This section:

1) Assesses the availability of national food waste estimates in the following three sectors:

    a) Households
    b) Food service
    c) Retail.

2) Calculates approximate estimates of food waste for each sector for countries without an estimate (for 2019), alongside an indication of uncertainty (**Level 1** estimates).

3) Develops an approximate estimate for food waste globally.

A Level 1 estimate has been calculated for all Member States of the United Nations and will be used for those states that have not measured food waste (i.e., in line with the **Level 2** or **Level 3** frameworks, as described in section 0). Level 1 estimates are derived either from:

- existing *data points* from studies carried out inside a Member State (where available) or
- *extrapolations* based upon the estimates observed in other countries, where no estimate is available from a given Member State.

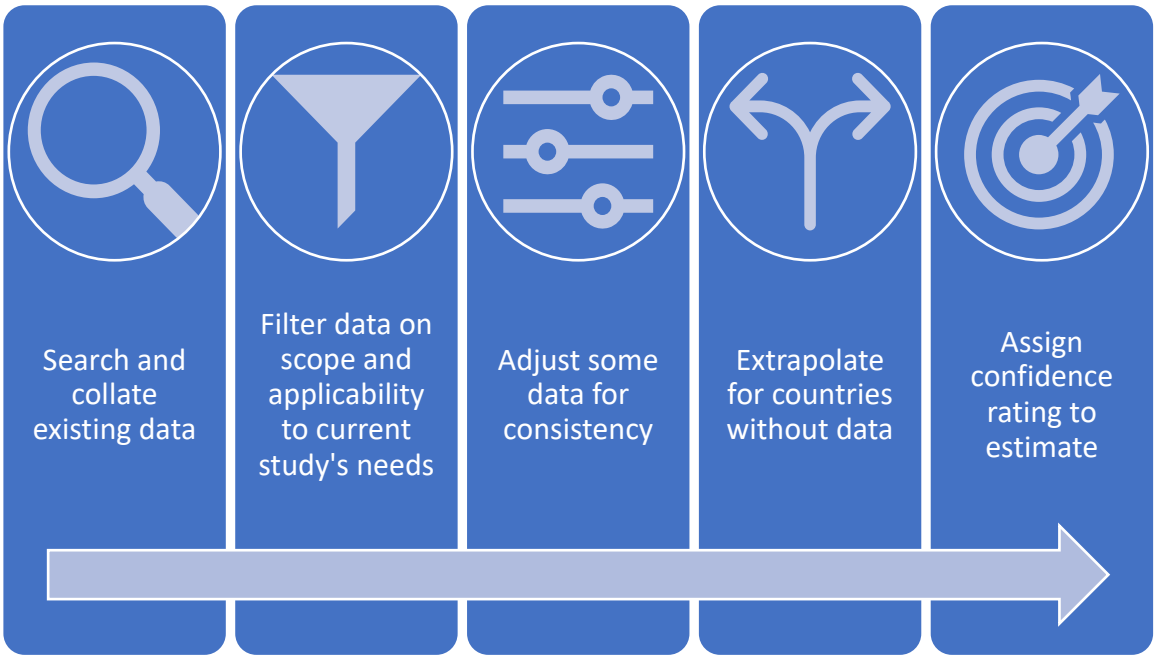
Most Level 1 estimates are not sufficiently accurate for tracking changes over time and reporting progress on SDG 12.3. They are indicative estimates, which provide a sense of scale of the issue. They support a country's case for action to tackle food waste and to prioritize different sectors, while the government works towards more accurate measurement (consistent with Level 2 or Level 3).

This section contains:

- An overview of the methodology used (section 0), with full detail given in the Appendix (section 1)
- The coverage of food waste data globally (section 0), with information on the sector and on the income level of a country and region. Information is also provided on the level of confidence in data points obtained.
- Deep dives into data coverage for each UNEP regional group: Africa, Latin America and the Caribbean, Asia and the Pacific, West Asia, North America and Europe (section 0).
- Estimates of individual countries, whether these are data points from existing studies or extrapolations from other countries' data (section 0).
- Global estimates of food waste in the three sectors (section 0).

2.2 SUMMARY OF THE METHODOLOGY

There are five stages to the method used to obtain Level 1 estimates of food waste:



A summary of the methodology is given below. Full details of the methodology are provided in the appendix (Appendix 1).

Search and collate existing data: An online literature review was performed to collect recent estimates of food waste across the world. Existing meta-analyses and online databases, both academic and non-academic, were used to search for possibly relevant published estimates of food waste at a sectoral level (household, food service, retail), with boundaries comparable to the definitions of the Food Waste Index. Studies carried out both at the national level and at the sub-national level were included. The research and practitioner communities were engaged to identify further useful studies. Estimates of food waste were extracted from relevant studies.

Filter data: Only studies that involved *direct measurement* of food waste or using data from other studies that involved direct measurement were considered. This is in line with the aim to track levels of food waste over time, which requires reasonably accurate data while avoiding methodologies with substantial biases. Other food waste measurement methodologies may be useful for other applications and policy questions, but direct measurement was considered the most accurate and robust for estimating waste amounts. As a result, studies that formed estimates based on proxy data or waste factors not derived from direct measurement were not included.

Adjust some data: Some data points were adjusted to make them comparable with the majority of studies. Household food waste studies that relied on measurements from food diaries were adjusted to account for underestimation known to occur with the diary methodology. Studies that presented only the edible share of food waste were adjusted; the inedible share was estimated based on data from other studies that included this disaggregation.

Extrapolate for countries without data: All estimates were normalized to give the amount of food waste per capita per year. The adjusted, normalized (per capita) estimates were used for the calculation of regional, income group and global averages. With these figures, it was possible to extrapolate estimates to countries with no relevant study. A hierarchical approach was taken, which

prioritized data from the country. In the absence of this, data from nearby countries and those of a similar income level[4] were used. If neither were available, global data were used.

For the purposes of national and global estimates, these per capita waste estimates were scaled by 2019 population data by country, forming Level 1 estimates of food waste in 2019.

Assign confidence rating: Each Level 1 estimate was assigned a confidence rating. This rating indicates the degree to which the estimate is suitable for tracking national food waste over time.

High confidence indicates that the estimate is highly likely to be suitable for tracking. *Medium confidence* estimates have the possibility for identifying larger trends in food waste but may miss smaller changes. The distinction between *high* and *medium* confidence is based on methodological details, such as geographic coverage, sample size and whether the figure required adjustment.

Estimates with *low* and *very low* confidence ratings are based on extrapolation from other countries; they are therefore not suitable for assessing trends in the country in question. Nevertheless, they provide approximate information that may be useful to inform food waste prevention strategies.

It cannot be stressed enough that the confidence rating is not a judgement on the quality of the study undertaken. It is an assessment – based on the reviewers' understanding of the study – of how robust the estimate of food waste is for tracking food waste in the given country. In many cases, this was not an aim of the original study. Hence many good studies will be classified at a *medium confidence* level (or even excluded from consideration altogether) because the aims of the paper did not include national food waste tracking.

Additional resources: Based on the above methodology, a database of food waste estimates was created and is available to download as supplementary information to this report. This is not an exhaustive list of studies that were considered, and, in the cases of *high confidence* estimates, only the latest data are included (see Appendix 1.1 and 1.2).

2.3 RESULTS: DATA COVERAGE

This section describes the extent and coverage of studies containing relevant estimates of food waste. Information is presented by sector, by the income group of the country and by region.

A total of 152 data points[5] were used in this analysis (see Table). A greater number of data points were found during the search process, but many were not used as either they did not fit the filtering criteria (e.g., the sample size was too small) or there were multiple data points from a single country and older / less relevant estimates were not used.

Table 5: Coverage of relevant food waste data points globally, by sector

	Household	Food service	Retail	Total
Number of data points	91	32	29	152
Number of countries	52	23	23	54

[4] 'Income groups' refer to World Bank classification, for the 2021 fiscal year. There are four categories: Low-income countries (LIC), defined as those with Gross National Income (GNI) per capita of $1,035 or less; lower middle-income economies (LMC), with GNI per capita between $1,036 and $4,045; upper middle-income economies (UMC) with a GNI per capita between $4,046 and $12,535; high-income economies (HIC), those with GNI per capita of $12,536 or more

[5] 'Data point' refers to an individual estimate in a study. Some countries have multiple data points due to studies from different time periods or different sub-national areas.

A full list of the data points can be found in the appendix (Appendix 2). This describes the countries in which the studies were conducted, methodological details and the confidence level assigned to each data point.

Subsequent discussion will focus on the number of countries with measured data points. Table presents estimates based on countries' World Bank income groupings. For all sectors, the majority of studies come from high-income countries. This is particularly pronounced for the food service and retail sectors, where respectively 78 per cent and 87 per cent of studies come from high-income countries.

The household sector has a more even distribution across income groups, with 54 per cent of the 52 countries that have estimates being high-income countries, 23 per cent being upper middle-income countries and 19 per cent being lower middle-income countries. Only two low-income countries have household food waste estimates, representing 4 per cent of the global estimates.

Table 6: Number of countries with measured data points, by World Bank income classification

World Bank income group	Household	Food service	Retail	Total no. of countries in classification
High-income countries	28	18	20	81
Upper middle-income countries	12	3	2	55
Lower middle-income countries	10	2	1	50
Low-income countries	2	0	0	29
Total	**52**	**23**	**23**	**215**

Table 7 presents the same data points according to regional distribution[6]. As with income group, there is an uneven distribution of studies among regions. Areas with higher coverage include Europe (especially northern, western and southern Europe), North America, and Australia and New Zealand.

In contrast, a number of areas of the world have no available estimates, namely Northern Africa, Central Asia, Melanesia, Micronesia and Polynesia. Extrapolations made for countries in these regions are therefore highly uncertain. In addition, estimates for Latin America and the Caribbean all come from mainland Latin America, with none from Caribbean islands. As a result, it can be said that food waste in small island states is a particular area of uncertainty.

Table 7: Number of countries with measured data points, by region (UNEP classification)

	Household	Food service	Retail
Northern Africa	0	0	0
Sub-Saharan Africa	8	1	1
Latin America and the Caribbean	4	0	0
North America	2	1	1
Central Asia	0	0	0
Eastern Asia	2	2	1
South-eastern Asia	3	1	1

[6] For the purposes of this report, the regional disaggregation used was the sub-regions as per UNSD classification.

Southern Asia	4	1	0
West Asia	6	1	2
Eastern Europe	3	0	1
Northern Europe	7	7	5
Southern Europe	5	2	3
Western Europe	6	6	6
Australia and New Zealand	2	1	2
Melanesia	0	0	0
Micronesia	0	0	0
Polynesia	0	0	0
Total	**52**	**23**	**23**

For the household sector, multiple studies were found in all sub-regions in Europe, the Americas, Australia and New Zealand, and Sub-Saharan Africa, and in most sub-regions in Asia. Therefore, for most regions, estimating household food waste in countries without data can be based on extrapolation of nearby countries.

The regional distribution is more heavily pronounced for non-household sectors, with studies concentrated in Europe. In both the retail and food service sectors, 15 out of the 23 countries with estimates (65 per cent) are in Europe.

These differences in regional and economic coverage of food waste studies have implications:

- **Data gap**: Much less is known about the amounts of food waste in certain areas:
    - For the household sector: countries in Central Asia and Northern Africa, and small island states; additionally, low-income countries as a whole;
    - For the food service and retail sectors: low-income countries, lower middle-income countries and upper middle-income countries.
- **Inferring food waste levels from other countries' data:** Using extrapolation to provide an approximate estimate of food waste in countries without data will have greater uncertainty for these areas, leading to estimates being classified as *very low confidence* (Appendix 1.2.3).

The proportion of countries with an estimate is relatively low, approximately one-quarter of countries for household (Table 7). However, the estimates found are generally concentrated in more populous countries. As a result, when expressed as a share of global population residing in a country with a food waste estimate, data coverage is quite extensive: for households, it is three-quarters of the global population (Table 8). This demonstrates the importance of large regional actors measuring their waste: food waste estimates from Brazil, China and India have a large impact on the regional coverage, as assessed by population.

Table 8: Share of population residing in countries with existing estimates, by region

	Household	Food service	Retail
Northern Africa	*0%*	*0%*	*0%*
Sub-Saharan Africa	51%	5%	5%
Latin America and the Caribbean	60%	*0%*	*0%*
North America	100%	90%	90%
Central Asia	*0%*	*0%*	*0%*

Eastern Asia	95%	95%	8%
South-eastern Asia	60%	5%	5%
Southern Asia	92%	8%	*0%*
West Asia	34%	3%	16%
Eastern Europe	66%	*0%*	50%
Northern Europe	95%	95%	85%
Southern Europe	79%	7%	48%
Western Europe	96%	91%	96%
Australia and New Zealand	100%	84%	100%
Melanesia	*0%*	*0%*	*0%*
Micronesia	*0%*	*0%*	*0%*
Polynesia	*0%*	*0%*	*0%*
Total	**75%**	**32%**	**14%**

When interpreting Table , it should be noted that, for a country to be considered to have an estimate, there merely needs to be one study meeting the requirements for inclusion (Appendix 1.1.1). In many cases, a large country has a single, geographically focused study (e.g., focusing on a city) that has been included but may not provide an estimate sufficiently accurate for the country to allow tracking of food waste over time.

The tables above include data points used in this study for an individual country and for extrapolation purposes. These data points were subdivided into:

- ***High confidence*** **estimates:** likely to be suitable for tracking national levels of food waste – i.e., developed using a robust methodology, covering a substantial part of the country and with no adjustment of the data required to align it with the current studies' purposes; and

- ***Medium confidence*** **estimates:** measured using methodologies that may be suitable for detecting larger changes in food waste, e.g., data points from cities used to represent a country, data points requiring adjustment to align with the current studies' purposes.

Splitting the global coverage of data points by these confidence levels is instructive (see Table). For the household sector, 75 per cent of the world's population lives in a country with either a *high* or *medium* confidence estimate and therefore have some form of data point used for Level 1 modelling. However, only 9 per cent of the global population lives in a country with a *high confidence* estimate for the household sector (probably accurate enough for tracking purposes). The percentage of the global population covered by a *high confidence* estimate is similarly low for retail (8 per cent) but higher for food service (25 per cent). The relatively high share of population with *high confidence* food service estimates is driven by the inclusion of China.

To track progress on SDG 12.3, there is a need not only to start measuring food waste in countries without any estimate, but also to increase the accuracy and regularity of data being collected in many other countries that have already measured food waste at least once and in some way (i.e., those with *medium confidence*).

Table 9: Share of global population residing in countries with existing estimates

Sector	**Percentage of global population with…**

	… at least one data point used in current study (*medium* or *high* confidence)	… a *high confidence* estimate
Household	75%	9%
Food service	32%	25%
Retail	14%	8%

Some key narratives can be drawn from this preliminary exploration of the available data.

Firstly, household food waste data are more widely available than previously identified. This is particularly due to the inclusion of sub-national studies. A large number of the studies included here were conducted at a city or municipality level (see Table). In the household sector, sub-national studies outnumber nationwide studies. In most cases, these studies were *not* focused on food waste; instead, they were largely studies relating to more general waste planning in an area, and total waste was collected from households and disaggregated to include a food-specific estimate. While many studies of this nature only disaggregate "organic" waste (and were consequently not used in the current analysis), a substantial number included here present specific "food" or "kitchen waste" categories in their disaggregation. More determined searches for these types of sub-national waste composition papers could return even more estimates of food waste than those gathered here.

Table 10: Number of data points, by geographical scope of study

	Household	**Food service**	**Retail**
Nationwide	38	24	27
Municipality and sub-national region	53	8	2

A second narrative is the sharp divide between high-income countries and other income countries (upper-middle, lower-middle and low-income countries) when it comes to existing food service and retail estimates. Estimates for these sectors are concentrated in high-income nations; China is the exception to this with sufficiently robust food service estimates to inform a country-level aggregation (Zhang et al., 2020). There are numerous possible reasons for this: research funding and availability, the degree to which the sector is formalized and the availability of data to scale audits. The strategic importance of food waste in middle- and low-income countries may also be a factor: a global narrative of the past decade has been that food waste is a rich-country problem. These challenges are explored in more detail in Box 4 for food service and Box 2 for retail.

The challenge of data for scaling is particularly important: many of the municipality-level waste audits that captured household data and are included here *also* carried out audits of retailers or markets. These data were usually presented in terms of waste per restaurant, per shop, per member of staff or per meal. Where household data can be easily scaled by population figures, scaling such food service and retail estimates requires extensive additional data such as the number of food service institutions in a country, number of staff members, market share of retailers, etc., which was beyond the scope of this project. The gathering and sharing of such data that would allow for better scaling of food service and retail audits and address this information gap.

A third narrative relates to the importance of tackling data gaps. At present, a number of sub-regions have no identified estimates of their food waste for any sector. Without any knowledge of the scale of the problem, it becomes difficult to prescribe action. Northern Africa, Central Asia and the Pacific

islands of Melanesia, Micronesia and Polynesia have substantial data gaps. In addition, while a number of middle-income countries were discovered to have estimates, low-income countries are heavily underrepresented. It is in low-income countries that food security concerns are particularly pronounced; and understanding the scale of and addressing the causes of food waste is crucial for tackling hunger, improving food security and delivering on SDG 2 ("zero hunger").

Finally, this research underlines the very broad absence of national data collection processes and systems for tracking food waste. Data have been collated from a wide variety of sources, often *ad hoc* academic studies and seldom from national waste statistics. Where national waste statistics are available, the methodology for data collection is not always clear, reducing confidence in comparability between countries. Food waste is not something that has been habitually measured by most countries, although the increase in published data points across time (Appendix 1, Table 1). suggests a recent surge in attention to the issue. Clear, consistent measurement in line with Levels 2 and 3 of the Food Waste Index across a broader range of countries is required.

2.4 REGION-SPECIFIC DATA

World regions are considered in more depth to offer an insight into the types of available data and studies forming estimates. These are grouped by the UNEP regional classification, as a basis for the Regional Food Waste Working Groups that are to be launched by UNEP in four regions in 2021.

AFRICA

In Africa, a total of 14 data points from 12 studies were included, measuring food waste in 8 countries. All of these studies covered the household sector, with one study also providing estimates for food service and retail waste.

For the African region, two sub-regions were examined further. All of the identified studies came from Sub-Saharan African countries. Northern Africa has no identified food waste estimates usable for Level 1 purposes (as per the methodology); this presents a substantial data gap. All extrapolations made for Northern Africa (section 0) are therefore *very low confidence* extrapolations.

Two countries have multiple studies informing the household estimate: South Africa and Kenya. The remaining six countries are each based on a single source paper. The majority of these papers were estimates at the sub-national level, conducted in a particular, often urban, area. The focus on urban areas and extrapolation of food waste estimates from urban areas for rural population is a limitation of this approach (discussed further in Box 1). Only two studies were conducted at a nationwide level, accounting for the whole population: one in South Africa, which combines literature-derived waste generation rates to national statistics (Nahman et al., 2012), and one in Ghana (Miezah et al., 2015).

The study by Miezah et al. (2015) in Ghana is notable as being the only African household estimate judged as *high confidence* for the purposes of the Food Waste Index. The researchers sampled more than 1,000 households across three socioeconomic groups in ten different districts across Ghana for a period of three to five weeks. The waste was sorted and disaggregated into 23 sub-fractions of waste, including a food-specific category. This thorough undertaking offers Ghana a strong evidence base for action on food waste and other forms of household waste. One notable finding was the similarity in food waste generation across all income groups: the averages of low-, medium- and high-income daily food waste generation were 80, 86 and 86 kg/capita/year, respectively. Within-country variation is discussed further in Box 1.

A summary of the African household data is presented in Table 11. South Africa is particularly notable for the substantial range observed. From a methodological perspective, only one paper required adjustment, due to being a diary methodology (Chakona & Shackleton, 2017). The other three South

African data points involved compositional analyses: one applied literature data to national income group statistics (Nahman et al., 2012), one involved measurement of random samples from waste collection trucks in residential areas (Oelofse et al., 2018), and the third was a direct audit of 123 households across three weeks (Ramukhwatho, 2016).

Each study has limitations and may be impacted by bias, but there is no obvious explanation for the wide variation observed. South Africa has substantial domestic income inequality, which may contribute to varied results based on the socioeconomic profile of participants included or excluded in each study (see Box 1 for further discussion of within-country heterogeneity). The experience here encourages caution against putting too much weight on a single data point, as other countries may experience such variation with more studies conducted.

Notably, the household per capita food waste estimates observed here are much higher than expected, given previous assumptions that household food waste is only a high-income country issue. The estimates are broadly similar to the rates observed elsewhere, including in countries in Europe and North America. This is caveated by the fact that the Food Waste Index covers edible and inedible parts of food; there is insufficient data to say with confidence how this composition varies among regions. Edible and inedible parts are discussed further in Box 3.

Table 1: Data points relating to households from African studies

Country name	Reference	Study area	Food waste estimate (kg/capita)
Ethiopia	(Assefa, 2017)	Laga Tafo Laga Dadi town, Oromia	92
Ghana	(Miezah et al., 2015)	Nationwide	84
Kenya	(JICA, 2010)	Nairobi	100
Kenya	(Takeuchi, 2019)	Nairobi	99
Nigeria	(Orhorhoro et al., 2017)	Sapele	189
Rwanda	(Mucyo, 2013)	Kigali	164
South Africa	(Chakona & Shackleton, 2017)	Richards Bay, Dundee and Harrismith	18
	(Nahman et al., 2012)	Johannesburg and Ekurhuleni	8-12
	(Oelofse et al., 2018)	Johannesburg	12
	(Ramukhwatho, 2016)	Nationwide	134
United Republic of Tanzania	(Oberlin, 2013)	Kinondoni municipality, Dar es Salaam	119
Zambia	(Edema et al., 2012)	Ndola	78

Only one study identified covered non-household sectors. The Japan International Cooperation Agency (JICA) study in Nairobi (JICA, 2010) audited waste from 90 food service and retail institutions for one week. In the retail sector, the researchers disaggregated between shops and markets and found that shops generated far less food waste than markets. Adjusting the Nairobi total retail food waste (91,252 kg/day) to yearly per capita figures, shops and markets generated respectively 1.3 kg and 9.6 kg. This lends some support to the suggestion that outdoor markets, especially in urban

settings within low- and middle-income countries, could be an important under-studied data gap (see Box 2).

For food service, the JICA study in Nairobi also estimated the combined waste from restaurants, hotels and public facilities as 31.1 kg/capita/year. While one data point should not be read into too deeply, this result is slightly above the average food service waste from all countries identified here (28 kg/capita), suggesting that more work should be done to identify the possible scale of African food service waste.

Box 1: Within-country variation

As has been highlighted by the experiences of South Africa and China (see section **Error! Reference source not found.**), determining single estimates for countries with high heterogeneity may risk masking highly varied experiences and levels of food waste generation. In these countries, multiple studies in different areas have demonstrated that food waste may vary substantially. In particular, China and South Africa are two of the only middle-income countries with studies explicitly targeting smaller towns or rural areas (see (Li et al., 2021) for China and (Chakona & Shackleton, 2017) for South Africa). Alongside these, the study from Gujranwala, Pakistan (JICA, 2015) sheds some light on the urban-rural divide with 60 kg/capita/year observed in the rural sample compared to 88 kg/capita/year in the urban samples. The small sample sizes, particularly in the rural area, mean this variation cannot be taken to represent urban-rural waste differences with any confidence. How food waste differs in rural areas – particularly in middle- and lower-income countries – remains a substantial data gap, and more research is needed.

With the surprisingly high levels of household food waste identified here, it may be reasonable to question to what extent samples were representative of the diversity of a population. Indeed, in few cases was a sample described as being explicitly representative of the national population, and it is likely that the very poorest were inadequately accounted when sampling. Nevertheless, in many studies the authors explicitly mentioned sampling from a range of income groups, and in nine studies from low- and middle-income countries, sufficient information about the results was available to observe the differences in food waste generation between income groups (see **Error! Reference source not found.**).

Table 2: Findings of studies providing results, by income group

Reference	Country	Area	Methodological notes	Food waste by income group (kg/capita/year)		
				Low	Medium	High
(JICA, 2015)	Pakistan	Gujranwala	60 urban households sampled in total. One week's waste collected in each of three seasons.	93	74	118
(Grover & Singh, 2014)	India	Dehradun	144 households sampled in total. Unclear sample length.	63	68	90
(Yasir & Abudi, 2009)	Iraq	Nassiriya	65 households sampled in total. Waste collected over a period of seven months.	155	168	169
(Sulaymon et al., 2010)	Iraq	Al-Kut City	80 households sampled in total. One week's waste collected each month for seven months.	111	161	166
(Nahman et al., 2012)	South Africa	Nationwide	Income group waste rates derived from secondary literature observations, combined with national waste statistics.	27	30	45
(Oberlin, 2013)	United Republic of	Kinondoni municipality	75 households sampled in total, only in middle and low income settlements, primarily high	98	142	

	Tanzania	, Dar es Salaam	population density informal settlements. Three days' waste collected.			
(JICA, 2010)	Kenya	Nairobi	150 households sampled in total. One week's waste collected.	78	114	151
(Takeuchi, 2019)	Kenya	Nairobi	90 households sampled in total. One week's waste collected.	40	176	125
(Miezah et al., 2015)	Ghana	Nationwide	1 014 households sampled in total across 10 districts nationwide, sampled for a period of 3-5 weeks.	80	86	86

This data present a mixed image, which is to be expected. In places where a trend is observed, generally high-income households have higher food waste than low-income households. However, in some places (Nassiriya, (Yasir & Abudi, 2009) Ghana (Miezah et al., 2015)) no meaningful trend is distinguishable, and in others (Nairobi (Takeuchi, 2019), Gujranwala (JICA, 2015)) a straightforward trend is less clear.

Some important caveats are necessary: firstly, while all of these studies used three income groups ("low", "medium" and "high", these are not necessarily comparable across studies. In each case, this was defined contextually. It was primarily determined by the area rather than by household income level, and in few cases did the studies make clear exactly how this was determined (e.g., author's judgement, an existing municipal classification, based on income data, based on housing types, etc.). As a result, "high-income" areas in Nairobi and Al-Kut will not necessarily be comparable.

Secondly, due to the total sample sizes being quite small, when divided into three the samples for specific income groups become often very small, roughly 20-50 households. Due to these very small samples, in most cases the differences cannot be said to be statistically significant, and the variation observed may reflect natural scatter in samples. One notable exception to the small samples is that in Ghana, where over 1,000 households were sampled in total. Interestingly, this is the example with the *least* variation between income groups.

As a result of these caveats, too much should not be read into this information; more, better measurement is required to say with any confidence how income groups and food waste relate. It is likely that this relationship will vary substantially between countries and places based on a range of national factors. Nonetheless, an important observation is that even in the low-income samples presented here, food waste can be substantial. As with other conclusions of this report, it must be borne in mind that *total* food waste, including inedible parts, is being measured here (see Box 3 for discussion). As a result, the suggestion is not that low-income populations, possibly in food insecurity, are wasting calories that they could have consumed; there is insufficient evidence to either support or refute that claim. What is clear, however, is that food waste in low- and middle-income countries, and in low-income populations within those countries, merits far more research.

LATIN AMERICA AND THE CARIBBEAN

In Latin America and the Caribbean, seven data points were identified in four countries. All of these countries were in mainland Latin America (South and Central America), with no estimates from Caribbean islands. This represents a major data gap. Four of the identified data points come from a single study in Belize, the only country to have multiple estimates. All of the usable estimates relate to the household sector, meaning that food service and retail waste in Latin America and the Caribbean remains a substantial data gap. All studies were classified as *medium confidence.*

Two papers were conducted on a nationwide level, in Brazil and Mexico. The Brazilian study (Araujo et al., 2018) is a diary study, and therefore required adjustment to account for diary underestimation. (The figure in Table is the adjusted figure.) The Mexican figure is taken from a report (Kemper et al., 2019) that

combined waste compositional analyses measured directly at households across three states and five municipalities, scaled using national urban solid waste figures. The authors signal that food waste may be exaggerated due to small businesses and illegal dumping by larger businesses in the household municipal waste, but the scale of this contamination is not known. The limitations with each nationwide study mean they are both classified as *medium confidence.*

The Belize study (Inter-American Development Bank, 2011) conducted waste compositional analyses in four areas, with samples between 130-183 households in each area, sampled for the duration of eight days. As the paper presents four different areas independently, a specific scaling exercise accounting for national demographics would be required to form a *high confidence* estimate. Instead, the average is taken of these four areas and is coded as *medium confidence.*

The study in Bogota, Colombia (JICA, 2013) was conducted by JICA, sampling more than 3,000 households over a 24-hour period. The disaggregation of food into prepared and unprepared offers some insight into edible waste, but this is not directly comparable to studies that disaggregate the edible or avoidable waste (see Box 3). In this study, JICA also audited waste from "small commercial producers" and "institutional, small producers." These were considered for retail and food service estimates; however, the focus on small producers was incomparable with other studies and would have led to a downward bias in results; they were therefore not included.

Table 3: Data points relating to households from studies in Latin America and the Caribbean

Country name	Reference	Study area	Food waste estimate (kg/capita)
Belize	(Inter-American Development Bank, 2011)	Belize City	34
		Caye Caulker	45
		San Ignacio / Santa Elena	95
		San Pedro	36
Brazil	(Araujo et al., 2018)	Nationwide	60
Colombia	(JICA, 2013)	Bogota	70
Mexico	(Kemper et al., 2019)	Nationwide	94

Box 2: Retail challenges

Retail has challenges similar to those experienced in the food service sector: as commercially sensitive information, retailers may be unwilling to share waste data even when they have it and may be resistant to researchers carrying out audits. While supermarkets are increasingly publishing their food waste data publicly, a sufficient number of retailers in a given country would need to do so to enable accurate scaling to national estimates.

A particular challenge in retail relates to the role of non-supermarket retailers, especially informal ones such as street markets. Depending on the national circumstances, supermarkets may not play a central role, as wholesale markets may supply direct to consumers; the importance of specialist retailers such as bakers or butchers will vary based on the national context, and outdoor farmers markets can be particularly important. In Mexico, for example, up to an estimated 50 per cent of food retail is informal (Kemper et al., 2019).

As this activity is often informal and *ad hoc*, gathering accurate estimates on food waste from street markets in particular can be difficult. Many outdoor markets will straddle definitions, offering both fresh produce (retail) and prepared, ready-to-eat "street food" (food service). Very few estimates considered here contain farmers markets, and none are known to consider street food. The scale of waste in these sub-sectors is therefore a substantial data gap, one that could be of particular importance in some countries.

ASIA AND THE PACIFIC

The Asia and the Pacific region, as containing multiple sub-regions (Australasia, Southern Asia, Southeast Asia, Eastern Asia, Central Asia), has a large number of data points. Across all sectors, 45 data points were identified in 11 countries. The majority (32) of these data points were in the household sector, with 9 in the food service sector and 4 in retail.

High-income and high-population countries are the most represented: countries in the Organisation for Economic Co-operation and Development (OECD) – Australia, New Zealand and Japan – all have nationwide estimates across multiple sectors.

Southeast Asia has household estimates identified in sub-national territories in Indonesia, Malaysia and Viet Nam. Only Malaysia has estimates in this region for food service and retail; these estimates come from a secondary reference of a governmental source that could not be found and further verified, leading to a *medium confidence* classification. The other household estimates in Southeast Asia all come from specific municipalities or areas, with direct measurement and composition of household waste from samples of at least 100 households.

In South Asia, multiple small-scale studies across Bangladesh, India, Pakistan and Sri Lanka were identified. JICA was responsible for studies in Bangladesh, Pakistan and Sri Lanka. Through the JICA study in Dhaka, Bangladesh (JICA, 2005), the only food service estimate in South Asia can be derived. This is, however, a paper published in 2005, making it at the very beginning of the publication time frame considered. Its relevance to current waste levels is highly uncertain. Both household estimates for Bangladesh come from studies in Chittagong, both studies having small samples of households measured for an unclear duration.

Three Indian studies were identified, two of which were carried out in Dehradun. In all three, the sample size or length is either small or unclear. The Pakistan estimate comes from a JICA study in Gujranwala that had a small sample size but long duration, repeating the week-long audit across three seasons. This study is one of the few that audited both urban and rural households, these have been separated into two data points for comparison. The samples informing the Sri Lanka estimates are not known and combine generation data from households with compositional data from waste sites, reducing their accuracy. However, samples were taken from 10 different localities, making it one of the most geographically dispersed estimates in the region.

No estimates were identified in Central Asia or in the Pacific island regions of Melanesia, Micronesia and Polynesia. These areas remain substantial data gaps.

Table 4: Data points relating to households from studies in Asia and the Pacific

Country name	Reference	Study area	Food waste estimate (kg/capita)
Australia	(Arcadis, 2019)	Nationwide	102
Bangladesh	(Salam et al., 2012)	Chittagong	74
Bangladesh	(Sujauddin et al., 2008)	Chittagong	57
China	(Gao et al., 2013)	Beijing	26
China	(Gu et al., 2015)	Suzhou	67
China	(Li et al., 2021)	Shandong	21

China	(Lo & Woon, 2016)	Hong Kong	101
China	(Qu et al., 2009)	Beijing	59
China	(Song et al., 2015)	Nationwide	23
China	(Zhang et al., 2020)	Urban China Total	150
India	(Grover & Singh, 2014)	Dehradun	73
India	(Ramakrishna, 2016)	Rajam, Andhra Pradesh	58
India	(Suthar & Singh, 2015)	Dehradun	20
Indonesia	(Dhokhikah et al., 2015)	Surabaya	77
Japan	(Food Industry Policy Office, 2017)	Nationwide	64
Malaysia	(Jereme et al., 2013)	Nationwide	112
Malaysia	(Watanabe, 2012)	Bandar Baru Bangi	71
New Zealand	(Sunshine Yates Consulting, 2018)	Nationwide	61
Pakistan	(JICA, 2015)	Gujranwala (urban)	88
Pakistan		Gujranwala (rural)	60
Sri Lanka	(JICA, 2016)	Jaffna	118
Sri Lanka		Nuwara Eliya	95
Sri Lanka		Kataragama	95
Sri Lanka		Thamankaduwa	79
Sri Lanka		Katunayake	78
Sri Lanka		Moratuwa	75
Sri Lanka		Kesbewa	75
Sri Lanka		Dehiwala Mt Lavinia	75
Sri Lanka		Kurunegala	47
Sri Lanka		Trincomalee	21
Viet Nam	(Thanh et al., 2010)	Mekong Delta	85
Viet Nam	(Vetter-Gindele et al., 2019)	Da Nang	67

China is particularly noteworthy: as a very large country and population with substantial internal variation, it is unsurprising that a wide range of food waste estimates are identified within its borders. Due to its rapid income growth and urbanisation, it is likely to be particularly sensitive to the exact location of the estimates and how recently the studies were conducted, highlighting the importance of regular, accurate measurement.

For household waste, seven data points were identified, with a range of methods and scopes. Two of these took a national approach: one (Song et al., 2015) uses information from the China Health Nutrition Survey diary dataset, grouped from samples across the years 2004, 2006 and 2009, therefore

only narrowly being included in this review due to being a relatively old sample. A second (Zhang et al., 2020) combines localized studies of municipal solid waste with the household generation rate in urban areas in order to form a nationwide estimate for urban China. Even accounting for diary bias, the more than five-fold difference (23-150 kg/capita/year) in these estimates is striking.

Of the sub-national estimates, a substantial variation is observed both in results and methodology. Studies in Beijing (Gao et al., 2013) and Hong Kong (Lo & Woon, 2016) come from statistics with unclear methodological origins, making confidence in them limited. Compositional analysis of waste collected directly from households were conducted in Suzhou (Gu et al., 2015) and Beijing(Qu et al., 2009), with measured waste observed as 67 and 59 kg/capita/year respectively. One recent study is notable for targeting households in villages in Shandong in order to improve the estimate for rural China (Li et al., 2021). This study used diary methodology and only measured edible waste; even after accounting for methodological biases it returns the smallest waste estimate in China (21 kg/capita/year). This low result – and the stark contrast to the 150 kg/capita observed in urban China – suggests that the rural-urban divide and within-country heterogeneity could be particularly important, an observation that may be relevant for other rapidly developing countries around the world.

Appropriate and representative sampling is required to develop a clearer understanding of how food waste may vary within a country. On the recommendation of a food waste researcher with specialist knowledge of China, all of the identified household estimates are considered in forming China's estimate, until a Level 2 baseline is published.

China is unique in Asia for its wealth of food service estimates. One recent paper (Zhang et al., 2020) aggregated 47 studies of food service waste from a range of sources to create regional estimates on food waste, normalised to a 2019 baseline. This was treated as an authoritative estimate and therefore assigned *high confidence*, but the regional estimates were considered as separate data points for forming an estimate.

WEST ASIA

In West Asia, 14 data points were found across 11 studies in 6 countries (see Table). Eleven of these data points were household estimates, with two retail and one food service estimates identified. Other than the household estimate for Saudi Arabia, all data points are classified as *medium confidence*.

In the household sector, there is more information than has previously been identified: nationwide studies have been undertaken in Israel, Saudi Arabia and Bahrain. In Israel and Bahrain, the accessible published methodological detail is insufficiently clear to make a judgement about its robustness: the Israeli study refers to a "bottom-up" value chain model, and the original Bahraini waste composition report could not be identified, only a summary of its results. These are therefore classified as *medium confidence* but could be revised in the future with more methodological information.

The baseline study of the Kingdom of Saudi Arabia is based on information from waste compositional analysis. The report does not clearly present the household sample size but does present the information that 21,730 consumption-stage foodstuff samples across 35 cities or governates were taken. From this it was inferred that a sufficiently large sample of households was taken to offer *high confidence* in the result, although clearer methodological documentation would increase the confidence in this claim.

Sub-national studies on household food waste were identified in Georgia, Iraq, Israel and Lebanon. These were varied in their methodologies: the estimate for Georgia comes from a sample of residual

waste[7] from a residential area; those from Lebanon and Baghdad, Iraq, come from food waste diaries (which have therefore been adjusted to account for bias, see section Appendix 1.2.2.3), and additional studies in Israel and Iraq come from direct measurement through weighing of household waste. In all cases, the sample size was under 100 households.

Iraq is notable for having five identified sub-national studies. Whilst independently they are limited in their robustness, together they give insight into the possible range of household food waste, from 75 to 163 kg/capita/year. What is notable across the region as a whole is the convergence of household food waste estimates: in Israel, Lebanon and Saudi Arabia, values around 105 kg/capita/year were observed. More transparent, robust measurement is needed to increase confidence in the results, but the preliminary picture is of substantial household food waste in the region, similar to levels in Western Europe and North America.

Israel and Saudi Arabia are the two countries for which non-household studies were identified: in Israel, the food rescue organisation Leket produced a whole "value chain model" that is built from a "bottom-up" approach with estimates at both the retail and food service levels. The exact methodology and data sources are not sufficiently clear in the documentation identified, so this estimate is considered *medium confidence*. Saudi Arabia's baseline similarly estimates retail food waste as part of a baseline study conducted by the Saudi Grains Organisation (SAGO). The published documentation does not provide all relevant methodological detail, but extensive direct measurement was undertaken over a range of geographical locations and stores.

Table 5: Data points relating to households from studies in West Asia

Country name	Reference	Study area	Food waste estimate (kg/capita)
Bahrain	(Alayam, 2018)	Nationwide	132
Georgia	(Denafas et al., 2014)	Kutaisi	101
Iraq	(Al-Maliky & ElKhayat, 2012)	Baghdad	75
	(Al-Rawi & Al-Tayyar, 2013)	Mosul	85
	(Al-Mas'udi & Al-Haydari, 2015)	Karbala	142
	(Sulaymon et al., 2010)	Al-Kut City	138
	(Yasir & Abudi, 2009)	Nassiriya	163
Israel	(Elimelech et al., 2018)	Haifa	94
	(Leket Israel, 2019)	Nationwide	105
Lebanon	(Chalak et al., 2019)	Beirut	105
Saudi Arabia	(SAGO, 2019)	Nationwide	105

[7] For the purposes of this report, residual waste is defined as waste contained within waste streams that are not recycled or reused, usually destined for landfill or incineration.

Box 3: Edible and inedible parts

The Food Waste Index considers total food waste, meaning both the edible and inedible share of food items. A country having high household food waste does not, therefore, necessarily mean that a high amount of *edible* food that is suitable for human consumption is being wasted. This is particularly the case for low- and middle-income countries, where no estimates of the extent of edible food waste were identified. It could be the case that the large household food waste estimates are a consequence of home cooking, which may generate more unavoidable food scraps. Certainly, one of the studies in Sub-Saharan Africa (Mucyo, 2013, in Rwanda) described, but did not quantify, that household waste "is generally composed of leftover food and fruit, inedible parts of vegetables, and peels of fruits, potato and cooking bananas *with large quantities of the latter and vegetable wastes*" (emphasis added), suggesting that inedible waste was prominent.

Two other studies may help illuminate this issue: one from Malaysia (Watanabe, 2012), and one from Colombia (JICA, 2013). In a 2010 household waste composition analysis in Bandar Baru Bangi, Malaysia, food waste was split into three categories: "Unused food", "General kitchen waste" and "big fruit peels." The latter category is particularly relevant to Southeast Asia, where large fruits such as durian or jackfruit will lead to substantial inedible waste. "General kitchen waste" is a bit ambiguous and accounted for 58 per cent of the household food waste. This does not allow for any conclusions to be drawn. What is more notable is that "Unused food" accounted for some 18 per cent of total food waste in those households, a substantial minimum share of food waste that was edible.

Similarly, a waste compositional analysis carried out in Bogota by JICA disaggregated food into "prepared" and "not prepared." We can say with some confidence that the "prepared" food represents food intended to be eaten and leftovers that could have been avoided; this amounted to 14 per cent of total food waste in those households. The "not prepared" category would likely include a mixture of inedible cooking scraps and unprepared food uneaten and allowed to go bad, so it is not possible to say with confidence the true extent of edible food waste, but here again the evidence of a minimum bound suggests it is far from negligible.

Understanding the split between edible and inedible food waste is not a requirement for reporting on SDG 12.3 using the Food Waste Index, and SDG 12.3 is a target to halve total consumer food waste, including inedible parts. Understanding the composition and causes of food waste does, however, help design better policy interventions, so it should be considered by countries where feasible. In both cases, understanding the nature of the problem will help in designing solutions: whether reducing edible food waste or finding sustainable, circular food systems solutions to unavoidable waste.

NORTH AMERICA

North America has a total of four data points from two studies in two countries. In Canada, an estimate for household was identified. In the United States, all three sectors had identified estimates from a single source paper (U.S. Environmental Protection Agency, 2020a). Both of these studies generated national-level figures by aggregating other, localized studies and scaling by national data.

The Canadian household paper (Environment and Climate Change Canada, 2019) is a recent analysis that aggregates 56 waste compositional analyses of household waste to form a national average. The studies included involved a mixture of curbside analysis and analyses conducted at sorting facilities. The share of food waste was multiplied by the total residential waste to form an estimate.

The U.S. estimates all come from a recent paper by the Environmental Protection Agency (U.S. EPA 2020a) that was published to improve upon methodology and calculate sector-specific generation of surplus food and understand waste management pathways, aligning this measurement with the Food Loss and Waste Accounting and Reporting Standard. These measurements are also in line with the Food Waste Index. For each sector, studies were identified that directly measured food waste and provided a waste generation factor, such as food waste per household, per employee or per U.S. dollar revenue. These generation factors have been scaled by up-to-date information to form an estimate of

total U.S. waste. To compare these published figures with other Level 1 studies in this report, the weight was adjusted (U.S. tons to metric tons) and normalized to provide a per capita estimate. The U.S. and Canadian estimates are displayed in Table .

Table 6: Data points from studies in North America

Country name	Reference	Sector	Food waste estimate (kg/capita)
Canada	(Environment and Climate Change Canada, 2019)	Household	79
United States of America	(U.S. Environmental Protection Agency, 2020a)	Household	59
		Food service	64
		Retail	16

The U.S. estimate for household waste is notable for how low it is: some past estimates, such as Buzby et al. (2014), and common assumptions have held that U.S. household waste is very high, whereas these data suggest it is below the global average. There are some possible reasons for this divergence:

Past U.S. estimates have differed in methodology and in scope. For example, Buzby et al. (2014) estimated food waste (or, using their terminology, food loss) in the consumption stages of the supply chain (including both household and food service) by comparing the amount of food going into this stage (Loss-Adjusted Food Availability data) with the amount that is consumed. While this and similar methods have many strengths, they are not designed with tracking food waste over time. Therefore, they do not meet the criteria set out for inclusion in the current study:

- There is no direct measurement of food waste, rather it is inferred via a mass-balance approach.
- The household and food service sectors are effectively combined.
- Inedible parts of food waste are not measured.

Secondly, the high food service waste is important to factor in to understand U.S. food waste. While the country's household waste is below the average, its food service waste is the highest of any *high confidence* food service estimates. This high waste generation may reflect that the U.S. study covers the entirety of the food service sector more thoroughly than other studies (see Box 4 for a discussion of some of the challenges in measuring food service sector food waste). It may also reflect a higher proportion of meals being consumed out of the home, which would be expected to both increase food service waste and decrease household waste, all other things being equal. While U.S. household waste alone is below the average, U.S. household and food service combined waste (123 kg/capita/year) is comparable to or exceeds other countries of similar levels of economic development for which estimates exist, such as Australia (124 kg/capita/year) and the United Kingdom (94 kg/capita/year).

Thirdly, due to the detailed information on waste destinations, it was possible to appropriately scale the U.S. data and remove non-waste management destinations for surplus food. Food donated to humans and fed to animals was removed from retail (35 per cent of the total waste reported in the study), and donation was removed from the hospitality parts of food service (14 per cent of waste

from those sources). In addition, as detailed in the appendix (Appendix 1.2.2.7), in order to improve comparability with studies of residual waste in Level 1, food waste disposed in the sink/sewer was removed. Sewer waste is included in Level 3 of the Food Waste Index. In-sink disposal is an important waste route in the United States and if included, would increase U.S. household food waste by around 10 kg/capita/year.

Box 4: Food service challenges

Food service is a particularly problematic sector for measurement. Many studies exist providing robust measurement of a single establishment or sub-sector of establishments, such as hotels or university canteens. However, the food service sector involves a very wide range of different sub-sectors, meaning that studies with a limited scope may be difficult to accurately scale and extrapolate to form a nationwide estimate. As a result, the overall level of confidence in food service estimates is reduced.

Measuring food service waste presents challenges. As commercially sensitive waste, many authors identified resistance or hostility to conducting a waste audit. Secondly, scaling information from audits or surveys to a national estimate requires robust national data on metrics such as the number of restaurants, number of meals consumed in out-of-home settings such as schools or workplace canteens, and so on. For many countries, it is unclear if such data exist. As a result, a number of robust studies that presented food waste in this manner (per meal, per restaurant, etc.) were not usable for the purposes of forming national estimates. Scaling by population allows for readily available data to be used, but may overlook nuances related to national specificities such as the share of meals consumed out of the home. Appropriate scaling data would allow more food waste factors from existing studies to be used for the purposes of forming Level 1 estimates and could also form the basis of Level 2 estimates.

A further challenge relates to the heterogeneity of the sector. Section 0 demonstrates the wide range of establishments that could be considered under food service. Measuring waste in all of these locations presents practical challenges, and the relative importance of each sub-sector will vary significantly based on national context. (Hotels, for example, will be much more prominent in countries where tourism plays a larger part in gross domestic product (GDP).) This can lead to an inconsistency in scopes: for example, sports stadia appear to be included only in the UK (WRAP, 2020b) and U.S. (U.S. Environmental Protection Agency, 2020a) baselines. Balancing an accurate estimate of food service waste with practical resource limitations remains a challenge.

EUROPE

Europe is the most well-documented region, with a large number of data points across all sectors. A number of published meta-analyses of European data points exist, notably BIO Intelligence Service (2010) , Stenmarck et al. (2016) and, more recently, Caldeira et al. (2019). These formed the basis of the European data search. As a result, a large share of Europe's data points were from secondary literature that detailed the methodology of the studies sufficiently to have confidence in the methodological criteria being met.

Within Europe's four sub-regions there is an uneven spread of data points, with Northern and Western Europe having both the highest number of data points and the highest number of countries represented across all sectors. Eastern Europe has the least coverage, with no estimates for retail (see Table).

Table 7: Data coverage in Europe, by sector and sub-region

	Data points			Number of countries		
Subregion	**Household**	**Retail**	**Food service**	**Household**	**Retail**	**Food service**
Northern Europe	9	9	9	7	7	5
Western Europe	7	8	8	6	6	6

Southern Europe	7	3	3	5	2	3
Eastern Europe	3	1	0	3	0	1

The data point tables (sections 0, Appendix 2.2 and 2.3) show more detail of the methodology. On a broad level, what is notable is that a large number of countries have estimates for all sectors, often conducted or compiled as part of a single study in order to generate a food waste baseline. In a number of countries, such as Norway or Slovenia, there are repeated data gathering efforts for tracking food waste over time.

Between countries, however, there is a substantial variation in methodology and assigned confidence level. A large number of European studies were considered *medium confidence* for this paper due to measuring only edible waste, using food waste diary methodology, or both. This is a contrast to other regions (such as Africa or Asia and the Pacific) where many studies were marked *medium confidence* due to studying at a sub-national or municipal level. Only Belgium (Flemish Food Supply Chain Platform for Food Loss, 2017) and Poland (Steinhoff-Wrześniewska, 2015) were studies of specific sub-national areas. In a number of cases, multiple *medium confidence* estimates for a single sector have been identified and combined in forming that country's estimate.

With regard to food waste measurement, during 2019, the European Commission adopted a common definition for food waste and accepted methodologies for European Union (EU) countries to measure their food waste across the supply chain (European Commission, 2020). These advances are in the context of the revised Waste Framework directive, which calls on EU countries to reduce food waste at each stage of the food supply chain, monitor food waste levels and report back regarding progress made.

The measurement methods specified by the EU are very similar to those specified in the Food Waste Index (section 0), allowing EU countries to meet reporting requirements of the European Commission and SDG 12.3 simultaneously. Furthermore, increased consistency in measurement within EU countries should increase the degree to which levels of food waste can be compared between countries.

Table 18: Data points relating to households from studies in Europe

Country Name	Reference	kg / capita food waste estimate	Confidence level
Austria	(Environment Agency Austria, 2017)	39	High
Belgium	(Flemish Food Supply Chain Platform for Food Loss, 2017)	50	Medium
Denmark	(Danish Environmental Protection Agency, 2018)	79	High
	(Edjabou et al., 2016)	83	High
Estonia	(Moora, Evelin, et al., 2015)	78	Medium
Finland	(Katajajuuri et al., 2014)	67	Medium

	(Stenmarck et al., 2016)	64	Medium
France	(ADEME, 2016)	85	Medium
Germany	(Schmidt et al., 2019)	75	High
Greece	(Abeliotis et al., 2015)	142	Medium
Hungary	(Kasza et al., 2020)	94	Medium
Ireland	(Stenmarck et al., 2016)	55	Medium
Italy	(Giordano et al., 2019)	67	Medium
Luxembourg	(Luxembourg Environment Ministry, 2020)	89	Medium
	(Caldeira et al., 2019)	91	Medium
Malta	(Caldeira et al., 2019)	129	High
Netherlands	(The Netherlands Nutrition Centre Foundation, 2019)	50	High
Norway	(Hanssen et al., 2016)	79	High
Poland	(Steinhoff-Wrześniewska, 2015)	56	Medium
Russian Federation	(Tiarcenter, 2019)	33	Medium
Slovenia	(Republic of Slovenia Statistical Office, 2020)	36	Medium
	(Republic of Slovenia Statistical Office, 2019)	33	Medium
Spain	(Caldeira et al., 2019)	77	Medium
		78	Medium
Sweden	(Swedish Environmental Protection Agency, 2014)	81	High
United Kingdom of Great Britain and Northern Ireland	(WRAP, 2020b)	77	High

Data points relating to food service from studies in Europe

Country Name	Reference	kg / capita food waste estimate	Confidence level
Austria	(Caldeira et al., 2019)	31	High
	(Environment Agency Austria, 2017)	26	High
Belgium	(Flemish Food Supply Chain Platform for Food Loss, 2017)	20	Medium

Denmark	(Danish Environmental Protection Agency, 2014)	21	High
Estonia	(Moora, Piirsalu, et al., 2015)	17	High
Finland	(Katajajuuri et al., 2014)	23	Medium
	(Stenmarck et al., 2016)	24	Medium
France	(BIO Intelligence Service, 2010)	17	Medium
	(ADEME, 2016)	32	Medium
Germany	(Schmidt et al., 2019)	21	High
Ireland	(Stenmarck et al., 2016)	56	Medium
Luxembourg	(Luxembourg Environment Ministry, 2020)	21	Medium
Norway	(Stensgård et al., 2019)	5	Medium
Serbia	(Bogdanović, et al., 2019)	6	Medium
Slovenia	(Republic of Slovenia Statistical Office, 2020)	20	Medium
	(Republic of Slovenia Statistical Office, 2019)	20	Medium
Sweden	(Swedish Environmental Protection Agency, 2014)	20	High
		21	High
Switzerland	(Beretta et al., 2013)	40	Medium
United Kingdom of Great Britain and Northern Ireland	(WRAP, 2020b)	17	High

Data points relating to retail from studies in Europe

Country Name	Reference	kg / capita food waste estimate	Confidence level
Austria	(Environment Agency Austria, 2017)	9	High
Belgium	(Flemish Food Supply Chain Platform for Food Loss, 2017)	10	Medium
Denmark	(Danish Environmental Protection Agency, 2014)	30	High
Estonia	(Moora, Piirsalu, et al., 2015)	5	Medium
	(Caldeira et al., 2019)	5	Medium
France	(ADEME, 2016)	26	Medium
Germany	(Schmidt et al., 2019)	6	High

Greece	(Stenmarck et al., 2016)	7	Medium
Italy	(Cicatiello et al., 2019)	4	High
Luxembourg	(Luxembourg Environment Ministry, 2020)	9	Medium
	(Stenmarck et al., 2016)	4	Medium
	(Caldeira et al., 2019)	9	Medium
Netherlands	(Stenmarck et al., 2016)	11	Medium
Norway	(Stensgård et al., 2019)	14	Medium
	(Stensgård & Hanssen, 2016)	14	Medium
	(Caldeira et al., 2019)	13	Medium
		14	Medium
Russian Federation	(Tiarcenter, 2019)	14	Medium
Slovenia	(Republic of Slovenia Statistical Office, 2020)	7	Medium
Sweden	(Swedish Environmental Protection Agency, 2020)	10	High
United Kingdom of Great Britain and Northern Ireland	(WRAP, 2020b)	4	High

2.5 FOOD WASTE AMOUNTS: MEASURED ESTIMATES AND EXTRAPOLATIONS

Alongside assessing the coverage and quality of national food waste data points, a second aim of the current study was to make country-level estimates for those countries without robust data. These estimates were developed using the data collected and presented in section 0, employing a hierarchical approach:

- For countries with one or more data points of sufficient accuracy, these were used to form an estimate for the country in question;
- For countries without any data points of sufficient accuracy, estimates from other countries in the region and/or similar income classification were used if available;
- Otherwise, global averages were employed.

'Sufficient accuracy' in this context was considered *medium confidence* data or higher. In other words, all data that met the criteria set out in section 0. Data points not meeting this criterion were excluded.

The extrapolation was carried out on the basis of the available data. For household, extrapolations combine the average food waste from a country's region and from the country's World Bank income

grouping. Due to a sample much more concentrated in high-income countries, this method could not be repeated for food service or retail. In these sectors, extrapolations for high-income countries without their own observed estimate are based on the average waste for that sector in the high-income country group. For upper middle-income countries, lower middle-income countries and low-income countries, the global average is used, as there are insufficient data to use group or region-specific data. As a result, the confidence in these results is lower; without further robust estimates, it cannot be said with confidence whether the extrapolations overestimate or underestimate the true extent of food waste. Full details of this extrapolation methodology are presented in Appendix 1.3).

Every estimate was given a confidence rating to reflect the differences in methodology of data points and extrapolations. *High* and *medium* confidence were only applied to countries in which data points were identified and correspond to the confidence rating of those estimates. All extrapolations to countries without estimates were rated *low* and *very low* confidence. The *low* or *very low* classification depends on the number of estimates in the same regional and income group informing the extrapolation. The details of confidence classification are elaborated in the appendix (Appendix 1.3.3).

FOOD WASTE ESTIMATES BY COUNTRY INCOME LEVEL

Table 19 presents the average food waste, per capita, per year, in each of the World Bank income classifications for each sector.

Table 19: Average food waste (kg/capita/year) by World Bank income classification, averaging medium and high confidence estimates for countries

Income group	Average food waste (kg/capita/year)		
	Household	Food service	Retail
High-income countries	79	26	13
Upper middle-income countries	76	Insufficient data	
Lower middle-income countries	91	Insufficient data	
Low-income countries	Insufficient data		

For extrapolation purposes at the household level, low-income countries used an average from the two low-income countries with data points in addition to estimates from lower middle-income countries. This combined average of lower middle-income countries and low-income countries was 97 kg/capita/year (see Appendix 1.3.1). for more on the calculation methodology. This surprisingly high estimate makes a strong case for more household food waste data collection in low-income countries, to improve our understanding of the scale of the problem and its possible causes.

For food service and retail, there were sufficient data points to make averages for high-income countries. For the other income groups, global averages were used (see Appendix 1.3.2).

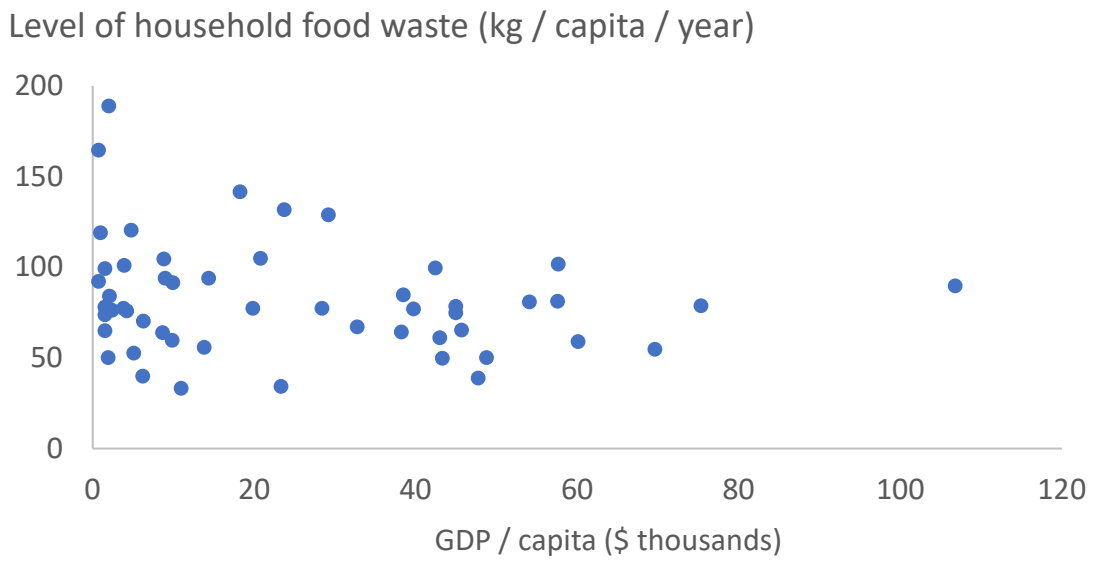
For food waste in households, there are sufficient data for a meaningful average for three of the four income groups. For these three groups, the averages were similar, ranging from 76 to 91 kg/capita/year. Given the number of studies and methodological differences between studies, there is no evidence of markedly different levels of per capita food waste between these three groups.

Key finding: Levels of household food waste (the total of edible and inedible parts) are similar for high-income, upper middle-income and lower middle-income countries.

Further analysis was undertaken to correlate household food waste and GDP per capita (see

Figure). There is negligible correlation between these two factors. However, lower-GDP countries did exhibit a wider range of variation in their food waste estimates compared to countries with higher GDP. This could be due to a genuine wider variation of food waste in lower-income countries, or an artefact of the studies measuring food waste (e.g., smaller sample sizes leading to more variability in the measured value).

Figure 5: Scatter plot of food waste (household) against GDP of county



Recent analysis of similar data by Dou and Toth (2020) also revealed no clear relationship between the level of household food waste per capita and the GDP of a country.

This convergence in household food waste data is a notably different finding to the narrative of the previous decade that food waste is not an issue in low- and middle-income countries. While Table shows that an insufficient number of estimates were identified for the low-income country group, in the case of middle-income countries, there is a sufficient amount of evidence to conclude that there are substantial amounts of food waste, similar to high-income countries.

It is important to note that SDG 12.3 and the Food Waste Index track *total food waste*, i.e., food and its associated inedible parts. It is possible that inedible parts play a larger role in household food waste in middle-income countries, if, for example, more meals are consumed at home and cooked from scratch. While there are a sufficient number of estimates of the split between edible and inedible fractions of food waste in high-income countries, there are too few studies in middle-income countries to make a comparison.

Recent research by van den Bos Verma et al. (2020) used a modelling approach, based on an energy balance, to estimate the amount of food wasted in the consumption stage (focusing on the parts of food generally eaten – i.e., the edible parts). This suggested that low-income countries produced less edible food waste than high-income countries did. The disaggregation of food waste data into edible and inedible parts would provide useful information for policymakers, in terms of the balance of policies focusing on food waste prevention and on circular uses of less commonly eaten and inedible parts.

Key recommendation: Increase measurement efforts globally to disaggregate estimates of food waste into edible and inedible parts.

FOOD WASTE ESTIMATES BY REGION

For the purposes of forming Level 1 estimates, income-group averages were combined with regional averages. These regional averages can be viewed in Table . This is presented alongside the number of countries informing the estimate to help demonstrate the level of robustness.

Comparisons should not be made between regions due to the small number of studies for most regions and methodological differences between studies. However, it is notable that the average level of household food waste is substantial for all regions studied.

Key finding: In all countries where household food waste data was identified, per capita arisings were substantial.

Table 20: Average food waste (kg/capita/year) by region, averaging medium and high confidence estimates for countries

	Average household food waste (kg/capita/year)	No. of countries with estimates informing average
Northern Africa	n/a	0
Sub-Saharan Africa	108	8
Latin America and the Caribbean	69	4
Northern America	69	2
Central Asia	n/a	0
Eastern Asia	64	2
South-eastern Asia	82	3
Southern Asia	66	4
Western Asia	110	6
Eastern Europe	61	3
Northern Europe	74	7
Southern Europe	90	5
Western Europe	65	6
Australia and New Zealand	81	2
Melanesia	n/a	0
Micronesia	n/a	0
Polynesia	n/a	0

Due to the scarcity of data in food service and retail, the averages are not presented. Section 0 contains discussion on the data availability by region.

TABLE OF HOUSEHOLD ESTIMATES

Table 21 provides estimates of household food waste for each country in the world. Similar data for food service and retail can be found in Appendix 3.2 and 3.3 respectively.

To briefly reiterate the methodology: the best available food waste data were collected, adjusted to account for biases and improve comparability, and grouped into confidence ratings. Where available, the average of these data points was applied for a country. Where not available, an extrapolation was made based on the average food waste observed in that country's region and income grouping. The *high* and *medium* confidence refer only to estimates from the data collected. All extrapolations are *low* or *very low* confidence, based on the number of estimates informing the extrapolation. This methodology is detailed in Appendix 1.

Table 8: Household food waste estimates (from measured data points or extrapolation) for each country

Region	M49 code[8]	Country	Household food waste estimate (kg/capita/year)	Household food waste estimate (tonnes/year)	Confidence in estimate
Australia and New Zealand	36	Australia	102	2 563 110	High confidence
Australia and New Zealand	554	New Zealand	61	291 769	High confidence
Central Asia	398	Kazakhstan	76	1 404 584	Very low confidence
Central Asia	417	Kyrgyzstan	91	583 951	Very low confidence
Central Asia	762	Tajikistan	97	906 209	Very low confidence
Central Asia	795	Turkmenistan	76	449 895	Very low confidence
Central Asia	860	Uzbekistan	91	3 001 868	Very low confidence
Eastern Asia	156	China	64	91 646 213	Medium confidence
Eastern Asia	344	China, Hong Kong SAR	71	531 023	Very low confidence
Eastern Asia	446	China, Macao SAR	71	45 731	Very low confidence
Eastern Asia	408	Dem. People's Rep. Korea	81	2 070 528	Very low confidence
Eastern Asia	392	Japan	64	8 159 891	Medium confidence
Eastern Asia	496	Mongolia	78	250 173	Very low confidence
Eastern Asia	410	Republic of Korea	71	3 658 024	Very low confidence
Eastern Europe	112	Belarus	68	646 356	Very low confidence
Eastern Europe	100	Bulgaria	68	478 667	Very low confidence
Eastern Europe	203	Czechia	70	746 894	Very low confidence
Eastern Europe	348	Hungary	94	908 669	Medium confidence
Eastern Europe	616	Poland	56	2 119 455	Medium confidence
Eastern Europe	498	Republic of Moldova	76	307 419	Very low confidence
Eastern Europe	642	Romania	70	1 353 077	Very low confidence
Eastern Europe	643	Russian Federation	33	4 868 564	Medium confidence
Eastern Europe	703	Slovakia	70	381 301	Very low confidence
Eastern Europe	804	Ukraine	76	3 344 904	Very low confidence
Latin America and the Caribbean	660	Anguilla	*	*	No estimate

[8] UNSD Standard Country or Area Codes for Statistical Use.

Latin America and the Caribbean	28	Antigua and Barbuda	74	7 178	Very low confidence
Latin America and the Caribbean	32	Argentina	72	3 243 563	Very low confidence
Latin America and the Caribbean	533	Aruba	74	7 858	Very low confidence
Latin America and the Caribbean	44	Bahamas	74	28 794	Very low confidence
Latin America and the Caribbean	52	Barbados	74	21 217	Very low confidence
Latin America and the Caribbean	84	Belize	53	20 564	Medium confidence
Latin America and the Caribbean	68	Bolivia (Plurin. State of)	80	922 012	Very low confidence
Latin America and the Caribbean	535	Bonaire, St. Eustatius & Saba	*	*	No estimate
Latin America and the Caribbean	76	Brazil	60	12 578 308	Medium confidence
Latin America and the Caribbean	92	British Virgin Islands	74	2 218	Very low confidence
Latin America and the Caribbean	136	Cayman Islands	74	4 798	Very low confidence
Latin America and the Caribbean	152	Chile	74	1 401 043	Very low confidence
Latin America and the Caribbean	170	Colombia	70	3 545 499	Medium confidence
Latin America and the Caribbean	188	Costa Rica	72	365 609	Very low confidence
Latin America and the Caribbean	192	Cuba	72	820 910	Very low confidence
Latin America and the Caribbean	531	Curaçao	74	12 079	Very low confidence
Latin America and the Caribbean	212	Dominica	72	5 201	Very low confidence
Latin America and the Caribbean	214	Dominican Republic	72	777 849	Very low confidence
Latin America and the Caribbean	218	Ecuador	72	1 258 415	Very low confidence
Latin America and the Caribbean	222	El Salvador	80	516 828	Very low confidence
Latin America and the Caribbean	238	Falkland Islands (Malvinas)	*	*	No estimate
Latin America and the Caribbean	254	French Guiana	*	*	No estimate
Latin America and the Caribbean	308	Grenada	72	8 112	Very low confidence
Latin America and the Caribbean	312	Guadeloupe	*	*	No estimate
Latin America and the Caribbean	320	Guatemala	72	1 273 466	Very low confidence
Latin America and the Caribbean	328	Guyana	72	56 700	Very low confidence
Latin America and the Caribbean	332	Haiti	83	936 940	Very low confidence
Latin America and the Caribbean	340	Honduras	80	780 504	Very low confidence

Latin America and the Caribbean	388	Jamaica	72	213 552	Very low confidence
Latin America and the Caribbean	474	Martinique	*	*	No estimate
Latin America and the Caribbean	484	Mexico	94	11 979 364	Medium confidence
Latin America and the Caribbean	500	Montserrat	*	*	No estimate
Latin America and the Caribbean	558	Nicaragua	80	524 188	Very low confidence
Latin America and the Caribbean	591	Panama	74	313 919	Very low confidence
Latin America and the Caribbean	600	Paraguay	72	510 256	Very low confidence
Latin America and the Caribbean	604	Peru	72	2 354 806	Very low confidence
Latin America and the Caribbean	630	Puerto Rico	74	216 854	Very low confidence
Latin America and the Caribbean	652	Saint Barthélemy	*	*	No estimate
Latin America and the Caribbean	659	Saint Kitts and Nevis	74	3 903	Very low confidence
Latin America and the Caribbean	662	Saint Lucia	72	13 241	Very low confidence
Latin America and the Caribbean	663	Saint Martin (French part)	74	2 809	Very low confidence
Latin America and the Caribbean	670	Saint Vincent & Grenadines	72	8 011	Very low confidence
Latin America and the Caribbean	534	Sint Maarten (Dutch part)	74	3 134	Very low confidence
Latin America and the Caribbean	740	Suriname	72	42 112	Very low confidence
Latin America and the Caribbean	780	Trinidad and Tobago	74	103 127	Very low confidence
Latin America and the Caribbean	796	Turks and Caicos Islands	74	2 824	Very low confidence
Latin America and the Caribbean	850	United States Virgin Islands	74	7 733	Very low confidence
Latin America and the Caribbean	858	Uruguay	74	255 909	Very low confidence
Latin America and the Caribbean	862	Venezuela (Boliv. Rep. of)	72	2 065 461	Very low confidence
Melanesia	242	Fiji	76	67 385	Very low confidence
Melanesia	540	New Caledonia	79	22 256	Very low confidence
Melanesia	598	Papua New Guinea	91	798 767	Very low confidence
Melanesia	90	Solomon Islands	91	60 963	Very low confidence
Melanesia	548	Vanuatu	91	27 296	Very low confidence
Micronesia	316	Guam	79	13 167	Very low confidence
Micronesia	296	Kiribati	91	10 704	Very low confidence
Micronesia	584	Marshall Islands	76	4 452	Very low confidence
Micronesia	583	Micronesia (Fed. States of)	91	10 358	Very low confidence
Micronesia	520	Nauru	79	850	Very low confidence

Micronesia	580	Northern Mariana Islands	79	4 502	Very low confidence
Micronesia	585	Palau	79	1 417	Very low confidence
Northern Africa	12	Algeria	91	3 918 529	Very low confidence
Northern Africa	818	Egypt	91	9 136 941	Very low confidence
Northern Africa	434	Libya	76	513 146	Very low confidence
Northern Africa	504	Morocco	91	3 319 524	Very low confidence
Northern Africa	729	Sudan	97	4 162 396	Very low confidence
Northern Africa	788	Tunisia	91	1 064 407	Very low confidence
Northern Africa	732	Western Sahara	*	*	No estimate
Northern America	60	Bermuda	74	4 606	Very low confidence
Northern America	124	Canada	79	2 938 321	High confidence
Northern America	304	Greenland	74	4 178	Very low confidence
Northern America	666	Saint Pierre and Miquelon	*	*	No estimate
Northern America	840	United States of America	59	19 359 951	High confidence
Northern Europe	208	Denmark	81	469 449	High confidence
Northern Europe	233	Estonia	78	102 743	Medium confidence
Northern Europe	234	Faroe Islands	76	3 710	Low confidence
Northern Europe	246	Finland	65	361 937	Medium confidence
Northern Europe	352	Iceland	76	25 829	Low confidence
Northern Europe	372	Ireland	55	267 073	Medium confidence
Northern Europe	833	Isle of Man	76	6 446	Low confidence
Northern Europe	428	Latvia	76	145 273	Low confidence
Northern Europe	440	Lithuania	76	210 255	Low confidence
Northern Europe	578	Norway	79	423 857	High confidence
Northern Europe	752	Sweden	81	812 948	High confidence
Northern Europe	826	United Kingdom	77	5 199 825	High confidence
Polynesia	16	American Samoa	76	4 187	Very low confidence
Polynesia	184	Cook Islands	*	*	No estimate
Polynesia	258	French Polynesia	79	21 981	Very low confidence
Polynesia	570	Niue	*	*	No estimate
Polynesia	882	Samoa	76	14 923	Very low confidence
Polynesia	772	Tokelau	*	*	No estimate
Polynesia	776	Tonga	76	7 912	Very low confidence
Polynesia	798	Tuvalu	76	878	Very low confidence
Polynesia	876	Wallis and Futuna Islands	*	*	No estimate
South-eastern Asia	96	Brunei Darussalam	80	34 742	Very low confidence
South-eastern Asia	116	Cambodia	86	1 423 397	Very low confidence
South-eastern Asia	360	Indonesia	77	20 938 252	Medium confidence
South-eastern Asia	418	Lao People's Dem. Rep.	86	618 994	Very low confidence
South-eastern Asia	458	Malaysia	91	2 921 577	Medium confidence

South-eastern Asia	104	Myanmar	86	4 666 125	Very low confidence
South-eastern Asia	608	Philippines	86	9 334 477	Very low confidence
South-eastern Asia	702	Singapore	80	465 385	Very low confidence
South-eastern Asia	764	Thailand	79	5 478 532	Very low confidence
South-eastern Asia	626	Timor-Leste	86	111 643	Very low confidence
South-eastern Asia	704	Viet Nam	76	7 346 717	Medium confidence
Southern Asia	4	Afghanistan	82	3 109 153	Very low confidence
Southern Asia	50	Bangladesh	65	10 618 233	Medium confidence
Southern Asia	64	Bhutan	79	60 000	Very low confidence
Southern Asia	356	India	50	68 760 163	Medium confidence
Southern Asia	364	Iran (Islamic Republic of)	71	5 884 842	Very low confidence
Southern Asia	462	Maldives	71	37 688	Very low confidence
Southern Asia	524	Nepal	79	2 249 412	Very low confidence
Southern Asia	586	Pakistan	74	15 947 645	Medium confidence
Southern Asia	144	Sri Lanka	76	1 617 738	Medium confidence
Southern Europe	8	Albania	83	238 492	Low confidence
Southern Europe	20	Andorra	84	6 498	Low confidence
Southern Europe	70	Bosnia and Herzegovina	83	273 269	Low confidence
Southern Europe	191	Croatia	84	348 091	Low confidence
Southern Europe	292	Gibraltar	84	2 840	Low confidence
Southern Europe	300	Greece	142	1 483 996	Medium confidence
Southern Europe	336	Holy See	*	*	No estimate
Southern Europe	380	Italy	67	4 059 806	Medium confidence
Southern Europe	470	Malta	129	56 812	High confidence
Southern Europe	499	Montenegro	83	51 988	Low confidence
Southern Europe	807	North Macedonia	83	172 480	Low confidence
Southern Europe	620	Portugal	84	861 838	Low confidence
Southern Europe	674	San Marino	84	2 857	Low confidence
Southern Europe	688	Serbia	83	726 196	Low confidence
Southern Europe	705	Slovenia	34	71 107	Medium confidence
Southern Europe	724	Spain	77	3 613 954	Medium confidence
Sub-Saharan Africa	24	Angola	100	3 169 523	Low confidence
Sub-Saharan Africa	204	Benin	100	1 175 297	Low confidence
Sub-Saharan Africa	72	Botswana	92	211 802	Low confidence
Sub-Saharan Africa	854	Burkina Faso	103	2 086 893	Low confidence
Sub-Saharan Africa	108	Burundi	103	1 184 127	Low confidence
Sub-Saharan Africa	132	Cabo Verde	100	54 765	Low confidence

Sub-Saharan Africa	120	Cameroon	100	2 577 064	Low confidence
Sub-Saharan Africa	140	Central African Republic	103	487 305	Low confidence
Sub-Saharan Africa	148	Chad	103	1 637 656	Low confidence
Sub-Saharan Africa	174	Comoros	100	84 742	Low confidence
Sub-Saharan Africa	178	Congo	100	535 851	Low confidence
Sub-Saharan Africa	384	Côte d'Ivoire	100	2 561 140	Low confidence
Sub-Saharan Africa	180	Dem. Rep. of the Congo	103	8 912 903	Low confidence
Sub-Saharan Africa	262	Djibouti	100	96 962	Low confidence
Sub-Saharan Africa	226	Equatorial Guinea	92	124 670	Low confidence
Sub-Saharan Africa	232	Eritrea	103	359 132	Low confidence
Sub-Saharan Africa	748	Eswatini	100	114 341	Low confidence
Sub-Saharan Africa	231	Ethiopia	92	10 327 236	Medium confidence
Sub-Saharan Africa	266	Gabon	92	199 748	Low confidence
Sub-Saharan Africa	270	Gambia	103	241 095	Low confidence
Sub-Saharan Africa	288	Ghana	84	2 555 332	High confidence
Sub-Saharan Africa	324	Guinea	103	1 311 530	Low confidence
Sub-Saharan Africa	624	Guinea-Bissau	103	197 266	Low confidence
Sub-Saharan Africa	404	Kenya	99	5 217 367	Medium confidence
Sub-Saharan Africa	426	Lesotho	100	211 661	Low confidence
Sub-Saharan Africa	430	Liberia	103	507 043	Low confidence
Sub-Saharan Africa	450	Madagascar	103	2 769 594	Low confidence
Sub-Saharan Africa	454	Malawi	103	1 913 062	Low confidence
Sub-Saharan Africa	466	Mali	103	2 018 765	Low confidence
Sub-Saharan Africa	478	Mauritania	100	450 720	Low confidence
Sub-Saharan Africa	480	Mauritius	93	118 632	Low confidence
Sub-Saharan Africa	175	Mayotte	*	*	No estimate
Sub-Saharan Africa	508	Mozambique	103	3 118 416	Low confidence
Sub-Saharan Africa	516	Namibia	92	229 344	Low confidence

Sub-Saharan Africa	562	Niger	103	2 393 877	Low confidence
Sub-Saharan Africa	566	Nigeria	189	37 941 470	Medium confidence
Sub-Saharan Africa	638	Réunion	*	*	No estimate
Sub-Saharan Africa	646	Rwanda	164	2 075 405	Medium confidence
Sub-Saharan Africa	654	Saint Helena	*	*	No estimate
Sub-Saharan Africa	678	Sao Tome and Principe	100	21 422	Low confidence
Sub-Saharan Africa	686	Senegal	100	1 622 980	Low confidence
Sub-Saharan Africa	690	Seychelles	93	9 128	Low confidence
Sub-Saharan Africa	694	Sierra Leone	103	802 371	Low confidence
Sub-Saharan Africa	706	Somalia	103	1 585 898	Low confidence
Sub-Saharan Africa	710	South Africa	40	2 329 228	Medium confidence
Sub-Saharan Africa	728	South Sudan	103	1 136 015	Low confidence
Sub-Saharan Africa	768	Togo	103	830 017	Low confidence
Sub-Saharan Africa	800	Uganda	103	4 546 237	Low confidence
Sub-Saharan Africa	834	United Rep. of Tanzania	119	6 907 649	Medium confidence
Sub-Saharan Africa	894	Zambia	78	1 391 729	Medium confidence
Sub-Saharan Africa	716	Zimbabwe	100	1 458 564	Low confidence
Western Asia	51	Armenia	93	275 195	Low confidence
Western Asia	31	Azerbaijan	93	934 872	Low confidence
Western Asia	48	Bahrain	132	216 161	Medium confidence
Western Asia	196	Cyprus	95	113 312	Low confidence
Western Asia	268	Georgia	101	403 573	Medium confidence
Western Asia	368	Iraq	120	4 734 434	Medium confidence
Western Asia	376	Israel	100	848 395	Medium confidence
Western Asia	400	Jordan	93	939 897	Low confidence
Western Asia	414	Kuwait	95	397 727	Low confidence
Western Asia	422	Lebanon	105	717 491	Medium confidence
Western Asia	512	Oman	95	470 322	Low confidence
Western Asia	634	Qatar	95	267 739	Low confidence
Western Asia	682	Saudi Arabia	105	3 594 080	High confidence
Western Asia	275	State of Palestine	101	501 602	Low confidence
Western Asia	760	Syrian Arab Republic	104	1 771 842	Very low confidence
Western Asia	792	Turkey	93	7 762 575	Low confidence
Western Asia	784	United Arab Emirates	95	923 675	Low confidence

Western Asia	887	Yemen	104	3 026 946	Very low confidence
Western Europe	40	Austria	39	349 249	High confidence
Western Europe	56	Belgium	50	576 036	Medium confidence
Western Europe	250	France	85	5 522 358	Medium confidence
Western Europe	276	Germany	75	6 263 775	High confidence
Western Europe	438	Liechtenstein	72	2 725	Low confidence
Western Europe	442	Luxembourg	90	55 126	Medium confidence
Western Europe	492	Monaco	72	2 796	Low confidence
Western Europe	528	Netherlands	50	854 855	High confidence
Western Europe	756	Switzerland	72	616 037	Low confidence
	830	Channel Islands	*	*	No estimate
	158	Other non-specified areas	*	*	No estimate

Note: Territories with (*) have no estimates generated. These territories are included in the UN Statistics Division list of countries but are not included in the World Bank's income classification grouping.

GLOBAL ESTIMATES

Given that food waste has been estimated for every country in the world (section 0 and Appendix 3), these can be added together to obtain global estimates of food waste for 2019. This combines data for countries with existing estimates, and estimates based on extrapolations (for countries without primary data).

This suggests a total of around 931 million tons of food waste across these three sectors: 61 per cent from households, 26 per cent from food service and 13 per cent from retail (see Table).

Table 9: Estimates of global food waste by sector

	Global average food waste (kg/capita/year)*	**2019 total (million tons)**
Household	74	569
Food service	32	244
Retail	15	118
Total	**121**	**931**

* The global averages presented in this table differ slightly from those presented earlier in section **Error! Reference source not found.**. Being built up country-by-country, the averages in the current table are population weighted, while those presented earlier are simple, unweighted averages.

The estimate for the household sector is the most robust, based on almost 100 data points across a range of countries around the world representing 75 per cent of the world's population. In contrast, the estimates for the retail and food service sectors are based on smaller sets of data: around 30 data points for each, with the majority coming from high-income countries. Countries with measured data points represented 32 per cent of the world's population for food service and 14 per cent for retail. In addition, many of the food service estimates are incomplete, not covering the range of settings outside the home in which food is served and consumed.

In all cases, however, confidence should not be overstated. Even though household *coverage* is good, the estimates from many countries come from small, limited samples or required adjustment for

comparability. The confidence in the global household estimate should thus be considered *medium-low.*

For food service and retail, the confidence in this estimate is *very low*, for the reasons discussed above.

Key finding: To improve the food waste evidence base – both globally and at a country level – more countries need to measure food waste across the supply chain and in households, using accurate methods on substantial sample sizes.

The results above can be compared to food available at the consumption stage of the supply chain to estimate the proportion of this that becomes waste during retail and consumption[9]. In 2018, the most recent year with data available, 5.3 billion tonnes of food was available globally. Comparing this with the food waste figures (Table 22) suggests that 17 per cent of food available was wasted in the three sectors included in this paper: 11 per cent in household, 5 per cent in food service and 2 per cent in retail[10].

The FAO *State of Agriculture* report (2019) estimates that around 14 per cent of global food production is lost during supply chain stages up to, but not including, retail. On the surface, this percentage could be added to that calculated for the present paper. However, this approach is not advised for two main reasons: firstly, due to the differences in scope. The estimate of food losses is on a commodity-by-commodity basis and includes all quantity losses for multiple utilizations: food, feed, seed and other. This is expressed as a share of all agricultural production, not just food. By contrast, the Food Waste Index looks at consumer *food* waste, i.e. of final food products, not including non-food uses such as animal feed or seed. Secondly, there are differences in the definition between the two estimates: one (the Food Waste Index) includes inedible parts, whereas the other (the loss estimate in FAO (2019)) does not.

Due to these different baselines for the different SDG 12.3 indicators, the two estimates cannot be combined and should be treated separately. FAO and UNEP are collaborating to find ways to combine the two indicators in the future.

Similarly, further research to quantify the environmental, economic and social impacts of this food waste would be important. Many countries now have data and research on the types of food that are wasted and why. Increasing this understanding to a wider range of countries would allow stronger strategies and programmes of work to minimize waste of valuable food resources in these sectors.

There are numerous differences between this estimate and the FAO's 2011 study (Gustavsson et al., 2011). Unlike the FWI, the previous FAO estimate combines loss and waste; relies on waste generation rates applied to food available for each sector and often based on assumptions at household level; and only measures edible parts of food. Figures from that report are not directly comparable with those presented in the FWI. These differences mean it is not possible to do a comparison over time in an attempt to deduce food waste trends.

However, in the technical report appendix to FAO (2013), which builds upon the 2011 data, adjustments are made which do allow a degree of comparability. This technical report estimates 2007

[9] Data from the FAO Food Balance Sheets for 2018. Food availability refers to 'food' in the balance sheets: the total amount of the commodity available as human food. It excludes crops or animal products used for industrial applications or animal feed. It also excludes food losses occurring *before* the retail stage of the supply chain. As it covers food reaching the consumer level, it is therefore a good comparator for the food waste described in the Food Waste Index (FWI), for which retail and consumption stages are the focus. Future work could also allow a comparison with the amount of food *produced* globally.

[10] The apparent discrepancy between the sum of the percentages for each sector and the total is due to rounding.

food loss and waste including inedible parts. When disaggregated by the stage in which waste is generated, it is possible to compare the 'Distribution' – which includes retail – and 'Consumption' stages with the sectors considered in this report (retail, food service and household). Taken as approximate values from a report figure (FAO, 2013, fig. 29), global 'Distribution' waste is estimated to be approximately 195 million tonnes and 'Consumption' waste approximately 340 million tonnes.

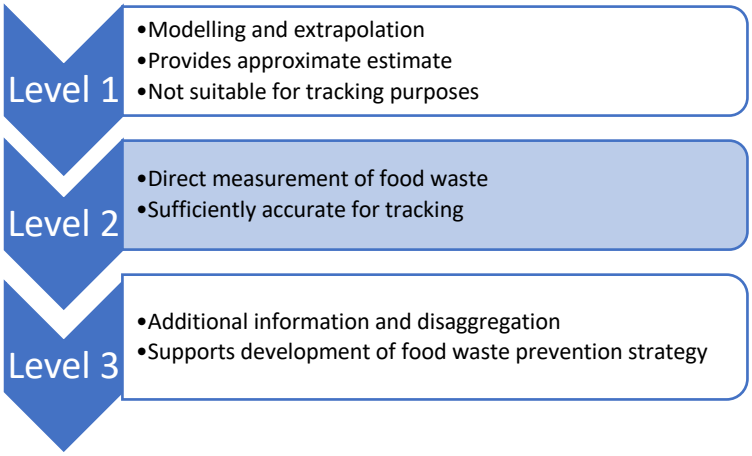
There are two possible ways to make comparisons from these figures. Firstly, using the combined 'Distribution' and 'Consumption' figures compared to the total estimate of the FWI: in this case, the 2007 estimate was of 535 million tonnes. The 931 million tonnes estimated here would therefore be 1.74 times higher than previous estimates.

However, it may not be appropriate to compare what is grouped in FAO (2013) as 'Distribution' with 'retail' as defined in the FWI: the former includes transport to markets and supermarkets. Supply chain logistics and distribution losses are counted under the FLI. It may therefore be more appropriate to compare 'Consumption' as defined in the FAO study with the final consumption stages presented here: household and food service. When doing this, the approximate value of 340 million tonnes in FAO (2013) is compared to 813 million tonnes in the FWI. This would make the FWI estimate of waste at the consumption stage some 2.4 times higher than previous estimates.

Given the substantial differences in methodology and distance between the two datapoints (2007 and 2019), **these comparisons should not be understood as presenting any indication of the change in food waste over time. What they do show, however, is that previous assumptions regarding consumer food waste likely significantly underestimated its scale.** The evidence informing the FWI suggests consumer food waste is a magnitude of two times higher than previous estimates, reinforcing the key conclusion that much more needs to be done to support consumer food waste reduction if SDG 12.3 is to be realized.

3 INDEX LEVELS 2 AND 3: MEASURING FOOD WASTE AT THE NATIONAL LEVEL

3.1 OVERVIEW



Level 1 estimates provide an indication of the scale of food waste in a country and are therefore useful for making the case for action. However, modelling and extrapolation are insufficiently accurate for a country to track their food waste over time, and rarely provide a level of detail sufficient to enable policymakers to make key strategic decisions about how to prevent food waste in that country. Therefore, direct measurement of food waste is required.

Level 2 and Level 3 of the Food Waste Index provide the framework for countries to measure and report food waste, allowing progress to be tracked in line with the SDG 12.3 target. Levels 2 and 3 use data from measurements of food waste in the relevant country and time frame, rather than proxy data (Level 1). This section of the report gives guidance on accepted methodologies for use within Level 2.

The Level 2 approach requires a reporting country to (see section 3.2):

- Define a scope – i.e., select the sector(s) they are going to report;
- Select suitable methods to measure food waste within the above;
- Conduct studies using the chosen method(s);
- Report food waste for the Food Waste Index;
- Repeat studies regularly using a consistent methodology.

3.2 STEPS FOR MEASUREMENT

DEFINE THE SCOPE

For a country to effectively quantify food waste, it needs clarity on what is measured, and over what time period. This section covers:

- The sectors to include
- The destinations to cover and disaggregation between destinations

- Disaggregation between edible and inedible parts
- The time period to cover.

Sectors to include

The Level 2 framework covers food waste generated in the following sectors:

- Retail
- Food service
- Household.

Manufacturing not covered in the Food Loss Index can be measured using Level 3 guidance (section 0).

These sectors are defined according to the International Standard Industrial Classification of all Economic Activities (ISIC), revision 4 (UN, 2008) to comprise the following sub-sectors:

- **Retail:**
  - ISIC 47-11 Retail sale in non-specialized stores with food, beverages or tobacco predominating
  - ISIC 47-2 Retail sale of food, beverages and tobacco in specialized stores
  - ISIC 47-81 Retail sale via stalls and markets of food, beverages and tobacco products
  - (Retail excludes ISIC 46-30, Wholesale of food, beverages and tobacco – this is covered under the Food Loss Index.)
- **Food service** involves food waste generated in settings where food is consumed in substantial quantities outside of the home. This could include all of the classifications below. However, for practical purposes, measurement can focus on those where the majority of meals are eaten within a country, for example ISIC 56 and ISIC 85.
  - ISIC 49-11 Passenger rail transport, interurban
  - ISIC 49-21 Urban and suburban passenger land transport
  - ISIC 50-11 Sea and coastal passenger water transport (from food prepared and consumed on voyages and cruises)
  - ISIC 50-21 Inland passenger water transport (from food prepared and consumed on voyages and cruises)
  - ISIC 51-10 Passenger air transport (from food prepared and consumed on flights)
  - ISIC 52-23 Service activities incidental to air transport (specifically airports)
  - ISIC 55-10 Short term accommodation activities, especially in settings where food is prepared and consumed, e.g., hotels, guesthouses, and bed and breakfasts
  - ISIC 55-90 Other accommodation, especially in settings where food is prepared and consumed, including student residences, school dormitories and workers hostels

- ISIC 56 Food and beverage service activities, including restaurants, cafeterias, fast-food restaurants, delivery and take-out eating places, mobile food carts, food preparation in market stalls, events catering, operation of food concessions at sports and similar facilities, operation of canteens or cafeterias (e.g., for factories, offices, hospitals or schools) on a concession basis, bars, taverns, cocktail lounges, discotheques (with beverage serving predominant), beer parlors and pubs, coffee shops, fruit juice bars and mobile beverage vendors

- ISIC 84-22 Defence activities (specifically canteens and other places for preparation and consumption of food associated with the armed services)

- ISIC 84-23 Public order and safety activities (specifically canteens and other places for preparation and consumption of food associated with prisons)

- ISIC 85 Education (specifically canteens and other places for preparation and consumption of food associated with educational settings)

- **Households** are not defined under the ISIC system (except where people are employed by households or households produce goods and services). The definition of household of the UN Statistics Division is included below. For the purposes of the Food Waste Index, a household is any type of dwelling not covered by the other sectors (e.g., hotels, student residences).

  - A household is classified as either: (a) a one-person household, defined as an arrangement in which one person makes provision for his or her own food or other essentials for living without combining with any other person to form part of a multi-person household or (b) a multi-person household, defined as a group of two or more persons living together who make common provision for food or other essentials for living (UNSD, 2020).

- **Manufacturing** (for Level 3)**:** where manufacturing is included in the Food Waste Index, it should include:

  - ISIC 10 Manufacture of food products

  - ISIC 11 Manufacture of beverages

In situations where food waste is already being measured and that information is shared with governments, the resources required to collate and report this information can be relatively modest. However, where these measurements are not being undertaken or the information is not shared, undertaking new food waste measurement studies for all of the above sectors will require a higher level of resources. Therefore, the indicators are structured so that countries can begin by measuring food waste in one of the relevant sectors (determined according to national priorities) and work to include more sectors over time.

The Level 1 modelling conducted for this report (see section 2) suggests that household food waste is the largest source of food waste in most countries. For this reason, it is recommended that household food waste is measured as a first step. When resources allow, the measurement and reporting of retail and food service food waste will also provide countries with important information to inform policy development and support the achievement of SDG 12.3.

Studies for each of the sectors do not need to be conducted at the same time. They can be staggered between years to avoid spikes in resource levels.

Destinations to cover

The Food Waste Index attempts to quantify the food waste *generated* from each of the above sectors. For the purposes of the Food Waste Index, food waste is defined as edible parts (i.e., wasted food) and associated inedible parts going directly to the following destinations (see also Appendix 5 for further information):

- Landfill (including licenced and unlicensed landfilled)
- Controlled combustion
- Litter discards/refuse
- Compost / aerobic digestion[11]
- Land application
- Co/anaerobic digestion
- Sewer[12].

Only relevant destinations need be included. For example, in some countries, food waste from households will not go to land application or controlled combustion. In such cases, only the destinations where the food waste goes should be quantified.

Disaggregation between edible and inedible parts

The total amount of food waste does not need to be disaggregated into edible and inedible parts for Level 2 reporting. However, as it is useful for understanding the national situation, it is included under Level 3 and discussed in section 0.

Time period

The estimates for the Food Waste Index should cover a one-year period (preferably January to December). These estimates should ideally be produced with data obtained throughout the year to account for variations in food waste generation by season. More information on when data will need to be reported can be found under section 0.

SELECTION OF METHODS

The measurement methods chosen should generate up-to-date data that are sufficiently accurate to allow tracking of food waste over time.

A range of methods are available for measuring food waste, each with its own advantages and disadvantages. These are well documented in the *Food Loss and Waste Accounting and Reporting Standard* (Hanson et al., 2016a, 2016b).

For each sector, a method (or multiple methods) should be chosen to obtain food waste estimates that are sufficiently accurate for tracking over time. Other information could also be obtained at the

[11] For households, food waste composted at home can be omitted from Level 2 due to its low prevalence in most countries where it has been measured. For example, estimates for the European Union suggested home composting accounted for 8 per cent of total household food waste. Other forms of composting from households (i.e., industrial composting of food collected from households) should be included. Household home composting can be included under Level 3.

[12] For Level 2, it is not essential to measure food waste going to the sewer. This is because it requires additional resources to measure, and – for some sectors – can represent a small proportion of total food waste. However, it is included under Level 3, and countries are encouraged to measure it where possible. As an example, the amount of food discarded to sewer was 23 per cent of household food and drink waste in the United Kingdom in 2015 (WRAP, 2018); the amount will vary between countries depending on culture, foods eaten and the prevalence of waste disposal units that discharge to the sewer.

same time to help a country in reducing food waste (e.g., obtaining information on the types of food that are most frequently thrown away and the principal causes can support the development of a food waste prevention strategy).

Table 23 provides appropriate methods for different sectors – countries can use these methods, a combination of them, or any other method equivalent in terms of relevance, representativeness and reliability. More detail on the most appropriate methods for each sector is found in Appendix 4.

Table 10: Appropriate methods of measurement for different sectors

<table>
<tr><th>Sector</th><th colspan="6">Methods of measurement</th></tr>
<tr><td>Manufacturing (if included)</td><td rowspan="4">Direct measurement (for food-only waste streams)</td><td rowspan="4">Waste composition analysis (for waste streams in which food is mixed with non-food)</td><td rowspan="4">Volumetric assessment</td><td rowspan="2">Mass Balance</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Retail</td></tr>
<tr><td>Food service</td><td rowspan="2"></td><td rowspan="3">Diaries (for material going down sewer, home composted or fed to animals)</td></tr>
<tr><td>Households</td><td></td></tr>
</table>

In addition, questionnaires, interviews and forms can be used to collate ***existing*** information, but are not sufficiently accurate for obtaining ***primary*** data in these sectors (see section 0).

An overview of the methods presented in Table are given below, with more detail in the appendix (Appendix 4):

- **Direct measurement:** using a measuring device to determine the mass of food wasted. This could involve weighbridges for collection vehicles or simple scales in a household setting.

- **Waste composition analysis:** physically separating food waste from other material to determine its mass and composition. This can be the most accurate way to gain deeper understanding into the differences in material type (edible and inedible parts) and types or categories of food wasted. Thus, even in a separate food waste stream, this method has some utility to achieve a narrower scope or provide greater detail.

- **Volumetric assessment:** assessing the physical space occupied by the food waste and using the result to determine the mass. In a situation where the entire quantity of food waste is likely to have the same composition, for example a waste stream from commodity processing, the density of that waste is likely to be consistent. Therefore, a value for mass can be determined by applying the density of the waste to the volume it occupies, potentially something like a residue collection vat in the above example.

- **Mass balance:** inferring the amount of food waste (either in total or for one particular destination) by identifying all food-related inputs and all outputs (except for the one being quantified) for a site or sector. The food waste can be calculated by subtracting the outputs from the inputs, adjusting for any changes within the site/sector (e.g., evaporation; dry foods being boiled and absorbing water). Works best in situations requiring minimal adjustment. An example is the

estimation of food waste in retail in the United States by the U.S. Department of Agriculture (Buzby et al., 2009).

- **Counting/scanning**: assessing the number of discrete food items that have been discarded and using the result to determine the mass. This could include scanner data or simply counting bags of waste.

- **Diaries:** a log in which quantities of food waste are recorded on a case-by-case basis as they are becoming waste. This can involve weighing or estimation/approximation by the person filling in the log. For example, in a household setting, the diary keeper could log three tortillas or "a handful" of ugali. The average mass of items for such reported measures would need to be used to convert the measure into grams. Diaries are not particularly accurate (see Quested et al., 2020) and therefore are not recommended for situations in which one of the above quantification methods is available (such as food waste present in solid waste streams). However, in some situations – e.g., food waste from households being home composted or going to the sewer – they are the only tested method available.

The inclusion of more than one sector within the scope's boundaries may necessitate multiple studies and different methods for each sector chosen.

The methods above are appropriate for a government-funded study but could also be used by individual businesses to quantify their own waste, ready for collating using methods in section 0. For example, some countries have voluntary agreements where major retailers are required to measure their own food waste. By applying appropriate methods (those listed above) in a robust manner, the data from these retailers can be collated and used to inform a national estimate.

In some situations, more than one method may be necessary to quantify food waste. For example, some businesses may have food waste in two solid waste streams: one sorted (i.e., food only) and one mixed residual. For the first, direct weighing or volumetric assessment would be appropriate; for the mixed waste stream, waste compositional analysis would be required.

In general, the amount of food waste within a sector shall be established by measuring food waste generated by a sample of businesses or households. These results will require scaling to obtain an estimate for the entirety of that sector in the country. (See section 0 on data for scaling.) Therefore, the sample needs to be adequate in size and representativeness to allow the estimates to be sufficiently accurate for tracking over time.

Relevant measurements may already be taking place in a country for other purposes:

SDG indicator 11.6.1: This indicator tracks the proportion of municipal solid waste (MSW) collected and managed in controlled facilities out of the total municipal waste generated, by cities. To provide the data for this indicator, the amount and composition of urban solid waste can be tracked by compositional analysis of a range of sectors, including households, food retail and food service. This data will include the amount of food waste, which can also be repurposed for the Food Waste Index.

Consideration needs to be given to the difference in geographic bounds between the two indicators: 11.6.1 covers cities while 12.3.1(b) (the Food Waste Index) is for the entirety of a country. This difference could be overcome by including additional studies for rural areas or extending city-based studies to surrounding areas.

Using MSW data as a basis of reporting for 12.3.1(b) may allow two SDG indicators to be reported with one set of fieldwork in certain situations. However, if a substantial amount of food waste is not collected as part of the MSW collection system, then additional measurement is required.

Food waste agreements: Some countries have an agreement (or legislation) that requires businesses to share data on the amount of food waste they generate. If the agreement allows, these data can be used for tracking purposes where the coverage of the relevant sector is high, or the businesses covered are representative of the wider sector. Examples include the Courtauld Commitment in the United Kingdom (WRAP, 2018) and United Against Food Waste in the Netherlands (United Against Food Waste, 2018).

PREPARING FOOD WASTE DATA FOR REPORTING

The reporting of the Food Waste Index from each UN Member State comprises the following elements for each sector:

1) The total mass of food waste generated for that sector in a 12-month period (in metric tons) – including edible and inedible parts and covering the destinations in scope;

2) The mass of food waste (as above) per person per year (in kilograms).

For both indicators, the mass is the fresh mass: i.e., the weight of waste at measurement (rather than the dry weight of the material).

Normalization should be undertaken per capita, as the SDG target is based on reduction in food waste on a per capita basis. Per capita data allows meaningful comparison over time, even in situations where the population of a country is changing rapidly. It also allows comparisons between countries.

Although not necessary for the Food Waste Index, determining the level of food waste as a percentage of food entering each sector would also provide a useful comparison metric, as this takes into account additional differences between countries/trends over time, such as the proportion of food eaten in and out of the home within a country.

Estimates for the Food Waste Index will be requested every two years, in line with data requests from the UN Statistics Division. For countries measuring for the first time, the baseline year will be 2021 (or the first year for which they have measurement if they are not able to report in 2021). For countries with measurements of food waste that pre-date 2021, they can report food waste in every year for which they have data. UNEP will look for ways to capture relevant historic data, as this will be useful for understanding food waste prevention and could be used in illustrative case studies.

There are four indicators under 12.3.1(b). These are defined for each sector as defined below:

$$Food\ waste\ index\ (sector) = \frac{FW\ in\ sector\ /\ capita\ (nonbaseline\ year)}{FW\ in\ sector/\ person\ (baseline)} \times 100$$

where FW denotes food waste.

For example, for household (HH) food waste, this will be:

$$Food\ waste\ index\ (HH) = \frac{HHFW/\ person\ (nonbaseline\ year)}{HHFW/\ person\ (baseline)} \times 100$$

The indices for each sector will **not** be combined into a single Food Waste Index. This will allow the granular data for individual sectors to be more easily communicated; it will also alleviate issues if a country is unable to report all sectors in one reporting cycle.

Example: Food Waste Indices for two hypothetical countries

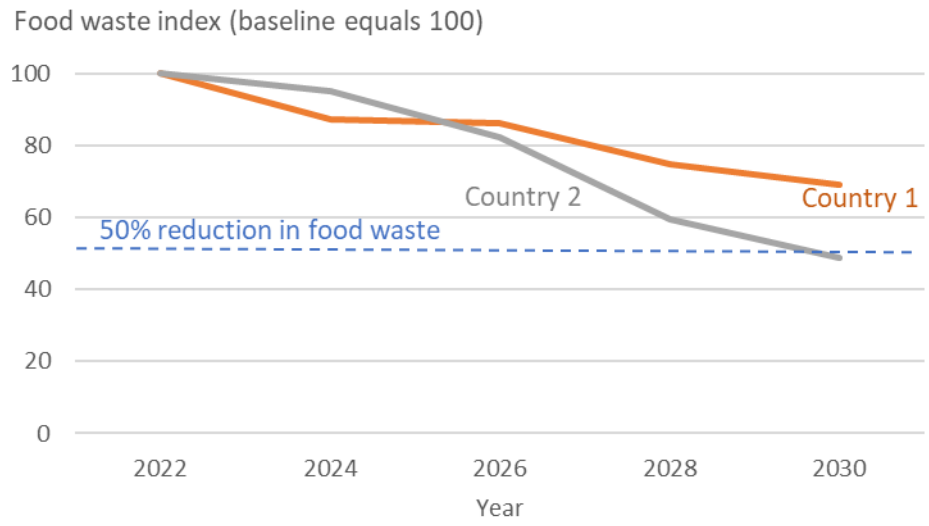
Table and Figure 6 provide a worked example of the household Food Waste Index for two hypothetical countries. In both cases, the baseline year is 2022. Country 1 has 87 kg/capita/year of household food waste in 2022 and – as this is the first year of measurement – this is defined as 100 in the Food Waste Index. By 2030, this has reduced to 60 kg/capita/year: a value of 69 in the Food Waste Index. This represents a reduction of 31 per cent: good progress, but insufficient to meet the 50 per cent reduction for SDG 12.3(b), represented by the blue dotted line.

Country 2 has a baseline value of 84 kg/capita/year, which is defined as 100 in the Food Waste Index for this country. By 2030, this country has achieved SDG 12.3(b) for this sector, with food waste less than half the baseline level (41 kg/capita/year). Therefore, the final Food Waste Index value for Country 2 is a value less than 50.

Table 11: Worked example of Food Waste Indices for household food waste for two hypothetical countries

Year	Country 1		Country 2	
	Household food waste (kg/capita/yr)	Index	Household food waste (kg/capita/yr)	Index
2022	87	100	84	100
2024	76	87	80	95
2026	75	86	69	82
2028	65	75	50	60
2030	60	69	41	49

Figure 6: Food Waste Indices for two hypothetical countries



More details on the practicalities of UN Member States reporting to UNEP are given in the following sub-section.

HOW COUNTRIES SHOULD REPORT FOOD WASTE UNDER SDG 12.3

Food waste data in relation to SDG 12.3 will be collected using the UN Statistics Division-UNEP Questionnaire on Environment Statistics: Waste Section. The questionnaire is sent out every two years to National Statistical Offices and Ministries of Environment, which will nominate a single food waste focal point in the country to coordinate data collection and reporting. The data will be made publicly available in the SDG Global Database and in UNEP's Food Waste Index Report, which will be published at regular intervals up to 2030. **The next questionnaire will be sent to member states in September 2022**, and results will be reported to the SDG Global Database by February 2023.

Countries do not need to conduct new measurements every two years, or measure every sector simultaneously. Measuring each sector at least once every four years is recommended.

3.3 DATA SOURCES, AVAILABILITY AND PRODUCTION

This section provides:

- Sources of existing food waste data;
- Methods for collecting existing data – if data of sufficient coverage and quality are already being collected, these methods allow the data to be collated;
- Data sources for scaling the above two types of data from a sample to the whole country.

These sections apply to indicators under both Level 2 and Level 3.

SOURCES OF EXISTING DATA

Some of the data to estimate the quantity of food waste may already exist, having been generated for reasons other than quantifying food waste. The following should be investigated as potential data sources for building a national estimate of food waste:

- **Manufacturing** (for Level 3 reporting): factory records, stock keeping, purchase and sales ledgers, waste management records/receipts (where charged by volume).
- **Retail:** (formal) company records, stock keeping, purchase and sales records, waste management records/receipts; (informal) government surveys, academic surveys and studies; (both) studies focusing on municipal solid waste (MSW), e.g., those used for other waste-related SDG indicators, such as 12.5.1 and 11.6.1.
- **Food service:** (formal) company records, stock keeping, purchase and sales records, waste management records/receipts; (informal) government surveys, academic surveys and studies; (both) studies focusing on MSW.
- **Households:** data on waste collected (government statistics or from waste management companies), academic studies on generation and composition, studies focusing on MSW.

METHODS FOR COLLATING EXISTING DATA

As mentioned in the previous section, some countries may already have data from which a food waste estimate can be derived. It is generally more cost-effective for a country to use existing data – assuming they are of appropriate quality and coverage – than to undertake new measurement. This section describes methods for collating existing data.

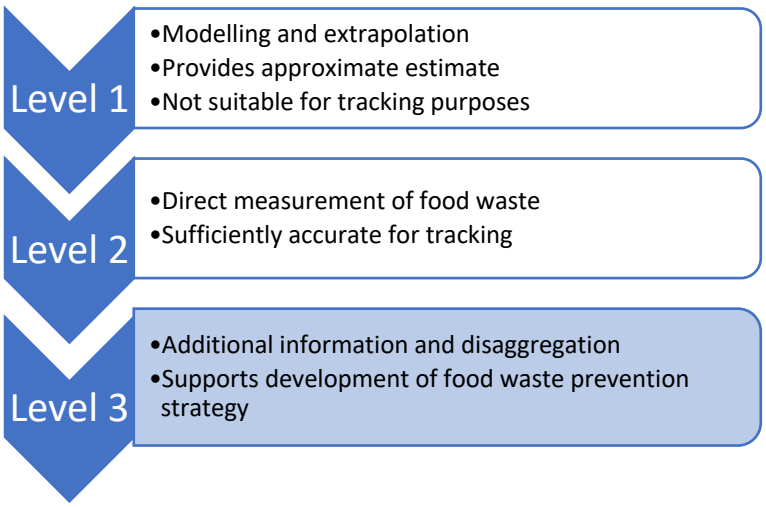
Structured questionnaires or forms to gather information from a large number of individuals or entities. A survey is most appropriate when the commissioner of such a method is confident in the ability of the respondent to accurately provide the data requested. This means that the respondent has already measured food waste in a robust way, rather than asking for a recollection or opinion. This stipulation invalidates surveying as a method for household food waste quantification, as respondents are unlikely to have measured their food waste and remember it accurately at time of asking. Use of surveys is more appropriate for formal retailers, companies providing out-of-home meals (restaurants, etc.) and food manufacturers that are already measuring their food waste (i.e., using methods in section 0).

DATA SOURCES FOR SCALING DATA

Data collected often need scaling to obtain a national estimate. For example, a government register of companies may contain data on the number, size and type of business (e.g., restaurant versus street vendor) to scale other data (e.g., food waste per business) with. This section contains examples of data that facilitate this scaling.

- **Manufacturing** (for Level 3): company registration data, factory records / stock keeping of amount of food processed, purchase and sales ledgers.
- **Retail:** (formal) company registration data, purchase and sales records; (informal) government surveys, academic surveys and studies.
- **Food service:** (formal) company registration data of restaurants, hospitals, schools, etc.; company records of amount of food purchased/sold; (informal) government surveys, academic surveys and studies.
- **Households:** household income and expenditure surveys on purchases, census data for population, number and type of household, waste collection company data (total amount of waste collected).

3.4 SPECIFICS FOR LEVEL 3



Level 3 comprises supplementary indicators relating to food waste. These are:

- Disaggregation of total food waste reported in the Level 2 indicators by destination. This would include any of the following that are used for food waste management from the sector in question within a country:

    - Co-digestion / anaerobic digestion
    - Composting / aerobic process
    - Controlled combustion
    - Land application
    - Landfill
    - Refuse/discards/litter.

- Inclusion of destinations not included in Level 2: sewer, home composted and food "surplus" destinations: i.e., redistributed for consumption by people, used for animal feed or used for bio-based materials / biochemical processing.

- Disaggregation of total food waste by edible parts (intended for human consumption) and their associated inedible parts (e.g., banana skins, bones, eggshells).

- Reporting of manufacturing food waste where it is not covered by the Food Loss Index: e.g., where more than one commodity is combined to produce processed/complex food products.

The disaggregation by edible and inedible parts (e.g., animal bones, eggshells, fruit pits) distinguishes between items/parts of food that are considered edible (and therefore have the potential to have been consumed if better managed within the supply chain or within the home) and parts considered inedible, where there are few opportunities for preventing the item becoming food waste. In the case of inedible parts, attention can be given to incentivize the destination with the greatest environmental, social and economic benefits (and fewest costs): for example, if fresh eggs are purchased, then eggshells will need to be discarded, and the challenge becomes finding a way of obtaining the most value from them in a sustainable way.

Guidance is given on how to quantify and report edible and inedible parts separately in the *Food Loss and Waste Accounting and Reporting Standard* (Hanson et al., 2016a), specifically sections 6.4 and 8.2. However, the Food Loss and Waste Standard does not give clear guidance on how to distinguish these two categories for food waste in the home. However, Nicholes et al. (2019) provide a methodology for making this classification that could be applied in different countries taking into account cultural differences.

In addition to the disaggregation of data within Level 2 and Level 3 indicators, there are several other splits that can be very useful to countries developing food waste prevention strategies:

- The **types of food thrown away** provides useful insight for prioritizing solutions to prevent waste. Data can be obtained for high-level categories (e.g., fruit, vegetables, bakery) or for more detailed categories (e.g., apples, melons, bananas). Either level of detail can be achieved via waste compositional analysis, but the cost will increase with greater detail. In retail and food service settings, the use of scanning systems and/or smart bins can also provide this level of detail.

- Disaggregation may also be useful based **on geography**, e.g., obtaining data for individual states, provinces, cities or other areas within a country. This will help understand where efforts to reduce food waste need to be focused.

- For similar purposes, countries may wish to undertake studies to understand the differences in the amounts and types of food waste between **groups of businesses or types of**

households/people. For household food waste, this may include understanding the variation by age, gender, income levels, region, household composition, employment status, etc.

For both businesses and households, qualitative research (e.g., including interviews and observation) can be useful in understanding how the factors such as gender and income can influence how food is obtained, managed, consumed and wasted in different cultural and geographical contexts.

These additional indicators provide information that creates a fuller picture of the food system within a country, with specific focus on food waste and food surplus. This information will help authorities determine the best way to prevent food waste or divert food waste/surplus to a destination with higher economic, environmental and/or social value. This can feed into a national food waste prevention strategy.

As with Level 2 indicators, Level 3 indicators should be expressed in total and per capita. However, unlike Level 2 indicators, it is not necessary to track these using an index – this may hinder clear interpretation of the data.

3.5 METHODOLOGICAL CHALLENGES AND LIMITATIONS

There are several challenges relating to food waste measurement and the interpretation of the resulting data.

As the measurement of food waste becomes more established within countries, Level 2 and Level 3 data should allow comparison over time for individual countries. With care, Level 2 and Level 3 data should also allow comparison between countries. Similarly, Level 2 and Level 3 data can be aggregated to regional level, where country coverage is good.

Level 1 data should not be compared with Level 2 and 3 data, as methodologies differ substantively. Furthermore, Level 1 data are not designed to (and should not be used to) compare countries or track a country's food waste over time. This is because data often come from other countries or come from more than a few years ago. Therefore, although Level 1 estimates are a rough estimate of how much food waste is generated by a country for a given sector (e.g., for informing a business case to tackle the issue), they are not accurate enough for comparison purposes.

It is good practice for countries to estimate the uncertainty associated with their food waste data and report it alongside the estimate. This can then be used to ensure that comparisons are only made where the degree of uncertainty is sufficiently small to allow it. Therefore, countries should estimate the total uncertainty in their Level 2 and 3 food waste estimates. Uncertainties will come from random errors (e.g., sampling errors) which are relatively easy to estimate, and from systematic errors (e.g., using a measurement method that systematically over- or under-estimates food waste, or sampling only for a portion of the year), which are harder to estimate.

Other relevant challenges to consider:

- Variations in waste over time can have a significant impact on estimated quantities of waste when short studies (e.g., a week) are used to represent a longer time period (a year), either due to:
    - The specific time of year when a study takes place which may affect the waste produced, which can lead to a systematic error. Solutions include sampling throughout the year; or, if a study has been undertaken at one time of year, adjusting to account for known variations, for example, see chapter 11 of WRAP's household food waste report (WRAP, 2013).

- Natural scatter over time in amounts of waste generated by single entities (e.g., households or restaurants), which contributes to the random error associated with sampling. This can be overcome by designing food waste measurement to include a sufficient number of entities and measuring over a sufficient length of time.

These points are discussed further in section 8.1 of the *Food Loss and Waste Accounting and Reporting Standard* (Hanson et al., 2016a).

- Different methods of quantification can also be used for other related purposes, for example, identifying the greatest opportunities for reductions within a sector or a country. Taking households as an example, it is difficult to obtain reasons for discarding food (and therefore the opportunities for influencing citizen behaviour) without the use of diaries or ethnography. These methods provide information on the causes of food waste but do not produce accurate food waste data.

- At a national level, countries may have to rely on other entities (e.g., businesses generating food waste, waste management companies, municipalities) to measure their own waste and report to the government, which would then be collated and analysed to estimate the total amount. How the data is collected by each entity may vary. For example, a government may collate food waste data from grocery retailers; the government is reliant on these retailers measuring their food waste in a sufficiently accurate way for the national estimate to be robust. Establishing clear guidance for these entities can support this effort, for example, WRAP's guidance for signatories to the Courtauld Commitment (WRAP, 2020a).

3.6 BENEFITS OF MEASUREMENT AND EXAMPLES

Accurate food waste measurement requires resources and time to obtain. However, sufficiently accurate data collection is possible and provides the basis to build the case for tackling food waste, to provide an understanding of the nature of food waste in a country, to inform a national food waste strategy based on food waste hotspots and to track food waste over time. Delivering reductions in food waste can be an important avenue for stakeholders to save money, improve food security, reduce environmental impacts and add value to circular economy processes.

To support food waste reduction, collecting additional information is important. For instance, recording the reasons why food is thrown away can provide additional insight and help develop solutions to tackle food waste. Understanding the types of food thrown away in different settings has similar benefits; this can be achieved through detailed waste compositional analysis, use of smart-bin technology, diaries and/or systems that scan food as it becomes waste for a retailer. In addition, observations, interviews and surveys can also increase understanding of why food is wasted and what can be done to minimize the amount wasted. In most situations, this additional information is not required for the purpose of tracking food waste over time but is important in developing an effective strategy to achieve SDG 12.3.

There are several examples of data being collected for tracking purposes from a range of countries around the world. A selection of these have been presented below, by sector. These examples are not exhaustive. Neither should their inclusion be taken to indicate that all elements of the study are consistent with the Food Waste Index. However, they provide information for the reader on how other countries are measuring food waste and how practical problems have been overcome.

RETAIL

Although the majority of studies come from high-income countries, there is an example of a study from a lower middle-income country.

A couple of principal methods have been used to estimate food waste in this sector, including:

- **Use of industry data** by Australia (Arcadis, 2019), Austria (Environment Agency Austria, 2017), Japan (Andrew Parry et al., 2015; Food Industry Policy Office, 2017), the United Kingdom (WRAP, 2020b) and Flanders (part of Belgium) (Flemish Food Supply Chain Platform for Food Loss, 2017); and

- **Waste compositional analysis / waste audit by** Denmark (Danish Environmental Protection Agency, 2014), Kenya (JICA, 2010) and New Zealand (Goodman-Smith et al., 2020).

FOOD SERVICE SETTINGS

The food service sector comprises a number of sub-sectors: for example, restaurants, hotels, education establishments, prisons, etc. Few existing studies collect data from all sub-sectors, and therefore many estimates rely on proxy measures for at least some of the sub-sectors.

Examples of studies include:

- **Waste compositional analysis / waste audit by** Austria (Environment Agency Austria, 2017), Estonia (Moora, Evelin, et al., 2015), Kenya (JICA, 2010) and the United Kingdom (WRAP, 2020b);

- **Direct weighing:** In China, Wang et al. (2017) measured restaurant waste in four cities by weighing the food waste generated by a set number of tables;

- **Data from industry:** In an Australia study (Arcadis, 2019), data were collated via surveys for a range of sectors, and the authors acknowledged a wide confidence interval around the estimate due to small sample sizes.

HOUSEHOLD

There are more national estimates of food waste from households than any of the other sectors covered by the Food Waste Index. Furthermore, the studies are distributed among continents and countries of different income levels to a greater extent than the other sectors.

Waste compositional analyses (WCAs) that have been performed can be split into two groups:

- **General/multi-material WCAs** in which the study is quantifying the amounts of different materials from households (or in municipal waste more widely). These are often designed to support changes to *recycling* infrastructure, rather than being performed to understand food waste. Sometimes with a national focus, many of these studies focus on a city or region within a country. Examples include: China (Gu et al., 2015), Ghana (Miezah et al., 2015), Rwanda (Mucyo, 2013), Sweden (Swedish Environmental Protection Agency, 2014) and Viet Nam (Thanh et al., 2010).

- **Food waste-specific WCAs** designed to understand food waste generation, often not quantifying other materials in the waste streams. Examples include Australia (Arcadis, 2019), Denmark (Edjabou et al., 2016), New Zealand (Sunshine Yates Consulting, 2018) and South Africa (Oelofse et al., 2018).

In addition, studies have taken data from waste compositional analysis and added in data for other destinations (e.g., sewer, home composting) from other methods. Examples include the Netherlands (van Dooren et al., 2019), the United Kingdom (WRAP, 2020b), the United States (U.S. Environmental

Protection Agency, 2020b) and Flanders (Belgium) (Flemish Food Supply Chain Platform for Food Loss, 2017).

Many studies also have been performed using methods that do not give accurate estimates of the amount of food waste from households: namely, diaries and questionnaires. As discussed in the methodology, these are not suited to tracking levels of food waste over time; however, they can be useful in understanding why food is thrown away in homes and finding out about related behaviours, practices, knowledge, skills, etc. They can also cover destinations – such as home composting – for which obtaining data from more accurate methods is difficult.

4 DISCUSSION AND RECOMMENDATIONS

The evidence presented in this Food Waste Index Report has demonstrated that food waste at the consumer level is everybody's problem. In all countries for which data was available, food waste, particularly at the household level, was substantial. Food waste is a waste of resources, time and money. Food waste means all of the environmental impacts of food production without any of the benefits of people being fed. With widespread food insecurity for many hundreds of millions around the globe, addressing food waste is a critical issue to creating low-impact, healthy and resilient food systems.

Earlier narratives of global food waste suggested that consumer food waste took place largely in developed countries, while production, storage and transportation losses were concentrated in developing countries. However, this report has found that household food waste per capita is similar across high-income, upper middle-income and lower-middle income countries, with insufficient data to make conclusions on low-income countries. The global estimates in the Food Waste Index suggest global consumer food waste could be approximately twice the size of previous estimates. This demonstrates that action on consumer food waste is needed worldwide.

Accurate, traceable and comparable measurement is a key starting point for national food waste strategies and policies to deliver the 50% reduction in consumer food waste targeted in SDG 12.3. At present, 17 countries have high-quality data compatible with SDG 12.3.1(b) reporting for at least one sector, with a further 42 countries with some measurement estimate which, with some small updates, could create an SDG 12.3- compatible estimation.

While this report improves our understanding of global food waste, there remain a number of data gaps. One significant gap is the proportion of inedible parts. Food waste as measured in the Food Waste Index includes both food destined for human consumption and its associated edible parts. Understanding how food waste in a particular sector is disaggregated between its edible and inedible parts will help stakeholders both in understanding the problem and in designing the solutions. At present, little is known about this disaggregation in middle- and low-income countries. The Food Waste Index Report provides strong evidence that makes the case for action globally. Measurement of food waste at retail, food service and household level using the framework and methods established in this report will strengthen estimates in most countries, informing the development of national food waste prevention strategies.

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