European Commission

## JRC Technical Report

# Literature review on drivers of consumer food waste and levers for behavioural change

The evolution of the literature on consumer food waste prevention

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2023

European Consumer Food Waste **Forum**

Joint Research Centre

# Contents

# Abstract

Consumer food waste at the household level results from a complex set of behaviours. These are influenced by psychological, sociocultural and economic factors such as awareness, attitudes, knowledge, emotions and context-related factors such as available technologies, referred to in this report as 'drivers'. Opportunities to reduce food waste systematically and practically, referred to in this report as 'levers', are distinct from drivers but have rarely been documented in previous studies. The identification of drivers and levers helps in designing effective interventions to tackle consumer food waste. The report aims to review drivers, levers and interventions relating to consumer food waste and to identify potential interventions to stimulate behavioural change. To achieve a systematic overview of food waste drivers and levers, this study builds upon (i) a systematic literature review conducted on scientific and grey literature published between 2010 and 2021, (ii) a revised version of the motivation–opportunity–ability framework distinguishing between micro, meso and macro situational factors and (iii) an iterative feedback mechanism enabling consultation with the experts of the European Consumer Food Waste Forum, which was established by the European Commission in 2021. Drivers and levers of consumer food waste are identified, categorised, analysed and discussed in relation to the revised motivation–opportunity–ability framework. This review suggests that further research is needed to understand household food waste better, to develop more evidence-based interventions and to devise standardised methods to measure their impacts

## Acknowledgements

# 1. Introduction

Food waste and losses have been recognised at the global level as among the most important manifestations of food system inefficiency. UN Sustainable Development Goal 12.3 calls for reduced food losses, including post-harvest losses, along production and supply chains and for per capita global food waste at the retail and consumer levels to be halved (UN, 2015) The UN Food System Summit 2021 [1], raising awareness of the importance of maximising the co-benefits of a food system approach as part of the 2030 agenda for sustainable development, emphasised the multiple impacts of food waste. Engaging a wide range of stakeholders from academic organisations, civil society and the policy domain, the summit aimed to identify potential mitigation actions that could create co-benefits for society and the environment. The call for action at the Food System Summit was further spotlighted at the UN Framework Convention on Climate Change 26th Conference of the Parties (COP 26) [2], where attention was drawn to the link between environmental justice and social equity, with an emphasis on the idea that responses to climate change require public interventions to be combined with individual actions.

Given this growing international awareness of the issue, the European Commission has taken up the challenge. In 2016, a Commission communication on the circular economy [3] announced the Commission's intention to establish the EU Platform on Food Losses and Food Waste, which brought together the EU institutions, experts from the EU Member States and relevant stakeholders selected through an open call. During its 2016–2021 mandate, the platform engaged its members in work on food waste measurement, date marking, food waste prevention and food donation. Under its 2022–2026 mandate, the platform has identified as its ambition the establishment of EU-level targets for food waste reduction, which are a key deliverable of the EU's farm to fork strategy.

The actions taken by national governments, the EU and international organisations have stimulated lively debate on the definitions of food losses and food waste (FAO, 2011; Östergren et al., 2014; Quested and Parry, 2017; Wasserman and Schneider, 2005) and on quantification of them (FAO, 2011; Parfitt et al., 2010; Silvennoinen et al., 2012; Stenmarck et al., 2016; van Herpen et al., 2019a). While there is no clear consensus on definitions, a large part of the literature allocates to consumers the responsibility for the majority of food waste in both industrialised countries (Stenmarck et al., 2016) and non-industrialised countries (UNEP, 2021). As a result, while the debate on definitions continues, growing attention has been dedicated to the consumption stage (in and outside the home) and the drivers of consumer food waste. Consumer food waste is complex, but – while it is influenced by the food supply chain and the food environment – it has been recognised as essentially a behavioural issue in which multiple interrelated and competing drivers play an influential role (Barone et al., 2019; Thyberg and Tonjes, 2016).

Food waste behavioural drivers include – at least – preferences such as personal taste and cultural issues (Sonesson et al., 2005; WRAP, 2011), habits such as frequency of shopping (Koivupuro et al., 2012; Quested et al., 2013; Stefan et al., 2013), attitudes related to thoughts and feelings (Parizeau et al., 2015; Quested and Luzecka, 2014; Quested and Parry, 2017; Stancu et al., 2016) and social norms (George et al., 2010; Johnson et al., 2008). Knowledge and skills are also considered crucial factors. Food can be wasted due to a poor understanding of date labels or of the best food storage practices to maximise shelf life (Abeliotis et al., 2014; Quested and Johnson, 2012; Quested and Parry, 2017; Quested et al., 2013; WRAP, 2011). Similarly, food waste can be related to the lack of ability in food preparation and portioning (Abeliotis et al., 2014; Quested and Johnson, 2012; Quested and Parry, 2017; Quested et al., 2013; WRAP, 2011).

Some attention has also been given to consumers' individual concerns about the implications of food waste and, therefore, to their understanding of food waste's environmental impacts (Neff et al., 2015; Qi and Roe, 2016; Richter and Bokelmann, 2017; Setti et al., 2016; Tucker and Farrelly, 2016) and economic and social impacts (Falasconi et al., 2019; Graham-Rowe et al., 2014; Neff et al., 2015; Parizeau et al., 2015; Philippidis et al., 2019; Quested et al., 2013; Richter and Bokelmann, 2017; Setti et al., 2016, 2018; Stancu et al., 2016). Some studies have investigated the relationships between consumers' concerns and behaviours, identifying groups of consumers with similar characteristics.

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[1]    https://www.un.org/en/food-systems-summit.
[2]    https://ukcop26.org/.
[3]    Commission communication – Closing the loop – An EU action plan for the circular economy, COM(2015) 614 final (https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF).

Several authors have suggested – in addition to looking at individual capacities and concerns – considering the question of opportunities, such as local shopping options (Silvennoinen et al., 2014; van Geffen et al., 2017) or the availability of high-tech kitchen appliances (Silvennoinen et al., 2012; WRAP and French-Brooks, 2012).

Demographics also play a role in the generation of food waste. The relevant factors include household size (Barr, 2007; Koivupuro et al., 2012; Parizeau et al., 2015; Quested and Luzecka, 2014), household composition in terms of age, presence of children and the relationship structure in the house (Glanz, 2008; Koivupuro et al., 2012; Parizeau et al., 2015; Quested and Luzecka, 2014; Wasserman and Schneider, 2005), employment status (Wasserman and Schneider, 2005), income (Wenlock and Buss, 1977) and education level (Silvennoinen et al., 2012; Wasserman and Schneider, 2005).

To better explain behaviours and systematically identify potential interventions to prevent and reduce consumer food waste, relevant behavioural drivers and levers have been investigated using various theories and models (Darnton, 2008). The first group of these are those that take a psychological approach, such as the theory of planned behaviour (TPB), which explains individual behaviours as a consequence of intentions based on the interaction among different beliefs, categorised as behavioural, normative and control (Ajzen, 1991, 2015). A second group consists of theories and models that take a sociological approach, extending the observations to situational factors. For instance, a major model of this type is the motivation–opportunity–ability (MOA) framework, which aims to understand the connections between consumers' behaviour and their desire, willingness and readiness to perform a specific behaviour (motivation), together with the available and accessible external resources to support the processing of that behaviour (opportunity) and the consumer's competence to conduct the behaviour (ability).

Although the literature focuses more on drivers than on levers and interventions, several tailored food waste prevention and reduction strategies were identified and are discussed in this report. Interventions are generally understood as tools that are primarily implemented to influence behaviour. There are two broad categories of studies on food waste interventions in the literature. Works in the first category recommend implementing interventions targeting specific drivers without providing any input on their impact (Ananda et al., 2021; Canali et al., 2016; Langen et al., 2015). The second category is made up of studies in which an intervention is tested in a certain setting, such as households (Romani et al., 2018; Schmidt, 2016), school or hospital canteens (Ellison et al., 2019; Favuzzi et al., 2020; Prescott et al., 2019) or restaurants or hotels (Kallbekken and Sælen, 2013; Wansink and van Ittersum, 2013).

The report aims to review drivers, levers and interventions relating to consumer food waste and to identify potential interventions to stimulate behavioural change. To achieve these objectives, the report is structured as follows: Chapter 2 defines the scope of the study; Chapter 3 sets out the methodology for the study, including how the bibliometric review was carried out; Chapter 4 reports the results, describing the evolution of food waste studies over time; Chapter 5 discusses the drivers and levers of consumer food waste and the related theoretical frameworks; Chapter 6 presents two sets of identified interventions to prevent food waste, namely proposed, untested interventions and implemented, tested interventions; Chapter 7 concludes and identifies a set of research needs.

## 2. Scope of the report

### 2.1. Definition of food waste

Several studies have focused on the definition of food waste, identifying the boundaries of what should be considered in the analysis and understanding the problem. In this debate on definition, there is a consensus on focusing on food intended for human consumption that has been removed from the food value chain or discarded for some reason (FAO, 2011; Katajajuuri et al., 2014; Koivupuro et al., 2012; Östergren et al., 2014; Stancu et al., 2016; Stefan et al., 2013). At the same time, there is limited agreement regarding the inclusion of inedible parts of food in the definition of food waste (Östergren et al., 2014; Wasserman and Schneider, 2005) and on the distinction between avoidable food waste (e.g. edible food gone bad) and unavoidable food waste (e.g. parts of food discarded during preparation) (Östergren et al., 2014; Quested and Parry, 2017).

A major step towards an agreed definition of food waste was made with the project 'Food use for social innovation by optimising waste prevention strategies' (Fusions), implemented under the European Commission's seventh framework programme, which proposed the following definition:

> *any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea).*

<div align="right">(Östergren et al., 2014)</div>

The Fusions definitional framework adopts a resource efficiency perspective, focusing on the uses and destinations of food throughout the food supply chain. The framework does not separate food waste into edible and inedible fractions. However, the framework encourages researchers to treat the two separately where possible.

In laying down a common methodology for quantifying food waste at each stage of the food supply chain, European Commission Delegated Decision (EU) 2019/1597 of 3 May 2019 states that:

> *Food waste does not include losses at stages of the food supply chain where certain products have not yet become food as defined in Article 2 of Regulation (EC) No 178/2002, such as edible plants which have not been harvested. In addition, it does not include by-products from the production of food that fulfil the criteria set out in Article 5(1) of Directive 2008/98/EC, since such by-products are not waste.*

<div align="right">(EU, 2019)</div>

The decision also states that:

> *Food also includes inedible parts, where those were not separated from the edible parts when the food was produced, such as bones attached to meat destined for human consumption. Hence, food waste can comprise items which include parts of food intended to be ingested and parts of food not intended to be ingested.*

<div align="right">(EU, 2019)</div>

In accordance with the Commission's definition and with other studies on consumer food waste (Setti et al., 2018; Stancu et al., 2016; van Geffen et al., 2017), this work considers food waste to be the edible fraction of food originally planned for human consumption that has not been consumed and has been discarded.

### 2.2. Measurement of food waste

In the food waste debate, significant importance has traditionally been placed on measurement. A wide array of methodologies have been applied in various studies, including direct measurement and waste composition analysis (Parizeau et al., 2015; Quested and Luzecka, 2014; Wenlock and Buss, 1977), food waste diaries (Abeliotis et al., 2014; Giordano et al., 2018; Koivupuro et al., 2012; Stefan et al., 2013; Van Garde and Woodburn, 1987) and other methods involving self-reporting, such as surveys, apps and interviews (Abeliotis et al., 2014; Falasconi et al., 2019; Gaiani et al., 2018; Koivupuro et al., 2012; Setti et al., 2018; Stefan et al., 2013; Van Garde and Woodburn, 1987). Especially when data are collected via self-reporting methodologies, the literature emphasises the possibility that food waste quantities generated

in the household may be underestimated due to cognitive biases such as social desirability and hypothetical biases (Grainger et al., 2018). Indeed, most people do not even realise how much food waste they generate.

However, while most of these methodologies are characterised by specific limitations that reduce their explanatory capacity (Gaiani et al., 2018; Møller et al., 2014; van Herpen et al., 2019a), they nonetheless contribute to a better understanding of consumer food waste in different settings. Several studies have been dedicated to comparing these methodologies and evaluating their positive and negative characteristics (see, for example Xue et al., 2017).

Commission Delegated Decision (EU) 2019/1597 (EU, 2019) states that consumer food waste should be measured adopting any of the following methods or a combination of those methods: direct measurement (weighing or volumetric assessment), scanning and counting, waste composition analysis and diaries. Additionally, mass balance should be employed when there is no direct (physical) access to food waste or when direct measurement is not feasible. Other methods may be used if they are equivalent in terms of relevance, representativeness and reliability.

In addition, if direct measurement is not feasible, estimates based on primary and/or secondary data, possibly combined with empirical economic models, can be employed, for instance to model household food consumption and waste using production functions (Yu and Jaenicke, 2020).

It is worth noting that this work will not focus on food waste measurement, and hence will not contribute to this debate. However, for the sake of consistency, it will consider any study or report adopting a methodology specified in Commission Delegated Decision (EU) 2019/1597 or any indirect measurement method considered reliable by the scientific community after a peer-review process.

## 3. Methodology

### 3.1. Background

This report takes as starting references the publication of the journal article 'Food waste within food supply chains: quantification and potential for change to 2050' (Parfitt et al., 2010) and the Food and Agriculture Organization of the United Nations report *Global Food Losses and Food Waste – Extent, causes and prevention* (FAO, 2011). Since their publication, the research on food waste has expanded rapidly.

From 2010 onwards, the increase in the number of articles was accompanied, and in part stimulated, by the interest of a growing number of journals. Initially, food waste attracted the attention of journals in the waste and resource conservation area (e.g. *Journal of Cleaner Production*, *Resource Conservation and Recycling*, *Waste Management*), but, over time, consumer, management and policy journals began to lend more attention to the issue.

To untangle the complexity of the literature and take into account the rapid growth of published documents and interested journals during 2010–2021, a more systematic approach to reviewing the state of the art is needed, aiming to:

— consider a large number of documents and heterogeneous journals;

— systematically map the evolution of the topic over time;

— reduce the risk of excluding contributions, approaches and journals that are not in the mainstream of the food waste discourse.

For this purpose, this study uses mixed methods, taking advantage of an iterative feedback mechanism enabling consultation with the experts of the European Consumer Food Waste Forum, established by the European Commission in 2021, and undertaking a bibliometric literature review using a large dataset of scientific papers and grey literature.

Bibliometric analysis was selected as the methodology best suited to integrating the results of an opinion poll of the experts. It entails combining quantitative analysis of all knowledge carriers with mathematical and statistical methods. It is a comprehensive knowledge system that integrates mathematics, statistics and philology and pays attention to quantification. Bibliometric analysis makes it possible to quantitatively assess the literature on a specific research field using statistical techniques that ensure a rigorous review process and support researchers in understanding the evolution of the field (Garfield, 1979; White and Griffith, 1981; Zupic and Čater, 2015). The most common techniques support descriptive analysis and network extraction: in particular, bibliometrics can focus on co-word, co-author and citation analysis, including co-citation analysis and bibliographic coupling (Aria and Cuccurullo, 2017; Cobo et al., 2011a, 2011b).

The adoption of a bibliometric approach made it possible, then, to identify a larger number of contributions and to select them in accordance with supervised criteria. In particular, the main references shown in Tables 4–6 were selected based on the following conditions: (i) papers published before 2015 had to have received at least 40 citations, (ii) papers published between 2016 and 2019 had to have received at least 20 citations and (iii) papers issued in 2020 and 2021 had to have been published in journals with an impact factor of at least 4. These criteria were not applied to grey literature.

### 3.2. The role of expert opinion

To lay the groundwork for the bibliometric analysis and better define the boundaries and the key elements of the work, a first opinion poll with experts was organised. Questions aimed to co-identify the boundaries of the search strategy for the bibliometric review and develop an initial understanding of food waste drivers and interventions. The short opinion poll consisted of the following questions.

— **Q1 Method 1.** The identification of specific exclusion criteria is a crucial step to identify what is out of scope and to refine the bibliometric literature review. A preliminary list of exclusion keywords includes "food waste definition", "food waste quantification", "food waste & retail", "food losses". Would you suggest any further exclusion keywords considering the scope of this work?

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- **Q2 Drivers 1.** Which scientific papers should be considered for the analysis of food waste drivers? (Please list up to 10 relevant papers.)

- **Q3 Drivers 2.** Which reports should be considered for the analysis of food waste drivers? (Please list up to 10 relevant papers.)

- **Q4 Drivers 3.** Which theoretical frameworks should be considered in the literature review (apart from the theory of planned behaviour and the motivation–opportunity–ability framework)? (Please list the most relevant frameworks in your opinion.)

- **Q5 Interventions 1.** Which papers and reports should be considered for the analysis of the interventions? (Please list up to 10 relevant papers.)

- **Q6 Interventions 2.** Which reports should be considered for the analysis of the interventions? (Please list up to 10 relevant papers.)

- **Q7 Interventions 3.** In your opinion how should levers be classified addressing behavioural change? Would you be able to suggest any structure? (For instance, information and awareness-raising campaigns, regulation, economic instruments, nudging / change to consumer's choice architecture, and voluntary agreements.)

## 3.3. Data collection: a bibliometric review

The results of the opinion poll of the experts represented the first step towards developing the search strategy for the bibliometric review aimed at mapping the evolution of food waste literature.

The main objects of bibliometric cover the amount of literature (journals, papers and citations), the number of authors (individual or group), and the number of vocabulary (various literature marks, among which the majority are descriptors). The essential feature of bibliometrics is that it combines qualitative inputs (the documents) with quantitative outputs, making it possible to classify and organise a large corpus of information using a systematic and reproducible methodology. For these reasons, it represents an opportunity to bring order to the numerous and diverse contributions produced on food waste in recent years.

The search for scientific literature on consumer food waste was conducted using the Web of Science (WoS) search engine. WoS allows users to download multiple items of information (metadata) related to scientific papers – such as names and affiliations of the authors, numbers of citations, keywords and abstracts – that can be used to perform systematic analysis on large quantities of documents. Regarding the inclusion of scientific papers in the dataset and their exclusion from it, bibliometrics' main criteria relate to (i) the use of a specific term or expression, or a set of them, to identify documents published on the topic under investigation, and (ii) the definition of a time period to be considered.

For the purposes of this work, the research focused on papers published from 2010 onwards that included the terms "food waste" and "consumer*" in the abstract, in the title or among the keywords. The term "consumer*" is a truncated expression that covers "consumer", "consumers" and "consumer's". These terms enabled the identification of a large number of studies, including some potentially outside the scope of this research. To exclude irrelevant a set of exclusion criteria based on papers' keywords was created; these criteria will be described in more detail below.

At the end of the search process, the dataset of scientific papers extracted from the WoS database consisted of 1 160 unique documents.

Grey literature was then identified following a two-step approach. The first step consisted of a search on Google Scholar for documents related to food waste at the consumer level published in English between January 2010 and November 2021. In the second step, the documents retrieved via Google Scholar were integrated with those suggested by the experts (and not already included in the results of the previous search). The result of the grey literature search was a dataset of 78 documents.

To make the grey literature documents suitable for bibliometric analysis, a set of specific keywords was extracted for each of them. Keyword extraction was performed using the YAKE! algorithm, which is an extension of the established keyword extraction algorithm RAKE (Campos et al., 2020). Since not all grey literature documents had preselected keywords or a proper abstract, keywords were identified by analysing forewords and introduction sections also. The results from the YAKE! algorithm were assessed by the authors of this study and a final set of keywords was decided on for each grey literature document.

The final step in the creation of the complete dataset consisted in the aggregation of scientific papers and grey literature. The final dataset was completed on 18 November 2021, having reached 1 238 documents (see Figure 1).

**Figure 1.** Dataset development
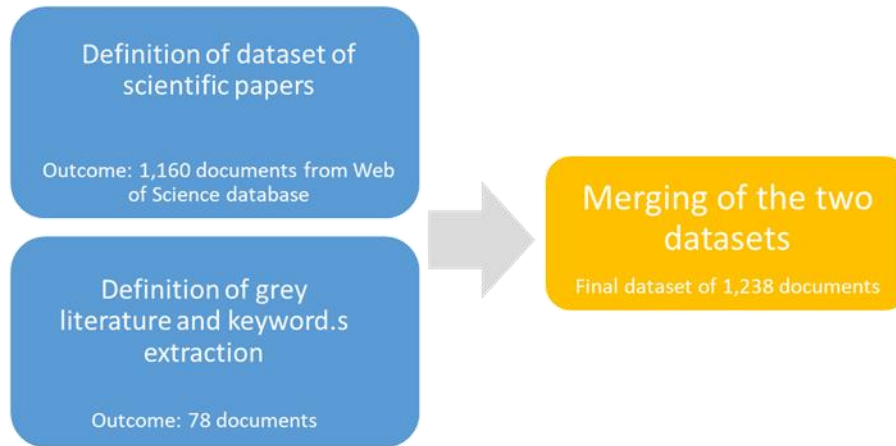
## 3.4. Analysis of the data

The bibliometric analysis consisted of three steps.

**Step 1.** Descriptive analysis of the number of publications, their impact on the literature and the journals with the highest numbers of publications on drivers of food waste at the consumer level.

**Step 2.** Country productivity and co-authorship analysis, describing cross-country collaboration networks: a collaboration between two countries (i.e. a link between two countries in a network) was considered to have occurred when authors affiliated to organisations located in those countries had co-authored a document.

**Step 3.** Content analysis of the documents based on KeyWords Plus (Garfield, 1990) for each scientific and grey literature article, making it possible to map the conceptual structure of the dataset, through the identification of clusters of documents that cover the same concepts.

According to the WoS website,

> *The data in KeyWords Plus are words or phrases that frequently appear in the titles of an article's references, but do not appear in the title of the article itself. Based upon a special algorithm that is unique to Clarivate databases, KeyWords Plus enhances the power of cited-reference searching by searching across disciplines for all the articles that have cited references in common* ([4]).

It was decided to base the bibliometric analysis on KeyWords Plus instead of keywords provided by authors because of the high explanatory power of KeyWords Plus and to maintain consistency with the technique used for the extraction of keywords from the grey literature documents, based on the use of a quasi-unsupervised process (conducted using the YAKE! algorithm, with the results assessed by the authors to arrive at the final sets of keywords).

An analysis of the dataset's conceptual structure was carried out by implementing a multiple correspondence analysis (MCA) and a cluster analysis of the KeyWords Plus to identify patterns in the

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([4]) 'KeyWords Plus generation, creation, and changes', WoS website (https://support.clarivate.com/ScientificandAcademicResearch/s/article/KeyWords-Plus-generation-creation-and-changes?language=en_US).

topics covered by the literature. MCA makes it possible to identify groups of documents with common KeyWords Plus and thus to map the conceptual structure of the dataset, through the identification of clusters of documents that cover the same concepts (Aria and Cuccurullo, 2017).

In the MCA, 909 documents out of 1 238 were automatically sorted into 3 groups, according to their KeyWords Plus: cluster 1 (2 items), cluster 2 (854 items) and cluster 3 (53 items). A further analysis of the papers not assigned automatically to the clusters resulted in 231 other papers being manually assigned to the clusters on the basis of their KeyWords Plus. The supervised analysis added 41 documents to cluster 1, 135 to cluster 2 and 55 to cluster 3. The remaining 98 items were considered unsorted and were excluded from further investigation. At the end of this process, there were 43 documents in cluster 1, 989 documents in cluster 2 and 108 documents in cluster 3. Figure 2 represents the process.

**Figure 2.** Sorting of documents
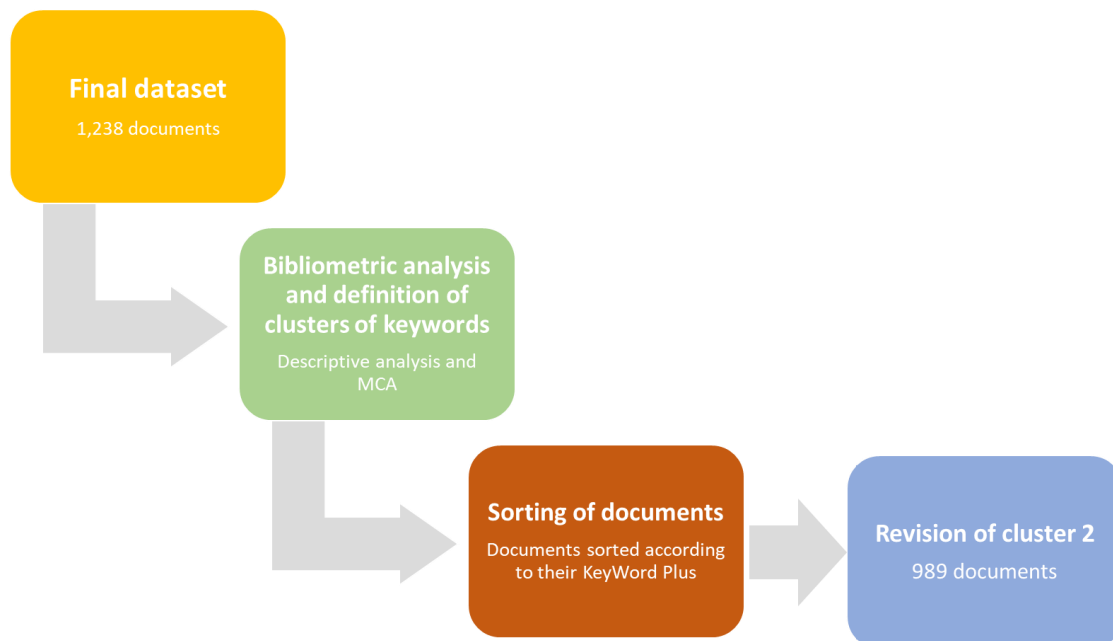


*Source:* Created by the authors.

According to the results of the MCA, the articles investigating topics relevant for this work are those included in cluster 2. This cluster includes all the documents investigating behavioural factors influencing household food waste. Therefore, articles included in cluster 1 (related to the environmental impact of food waste) or cluster 3 (related to quantification and food losses) or that were unsorted were not considered in the further analysis. A more detailed description of the clusters and topics is provided in Chapter 4.

The last step in the analysis of the data was the creation of the final dataset of documents to be considered in this study. Starting with the 989 documents in cluster 2, a subset of documents was identified that fell into at least one of three groups based on their KeyWords Plus:

— those related to the drivers of consumer food waste, namely those with the keywords "driver*", "determinant*" or "cause";

— those related to the frameworks adopted to investigate the dynamics of consumers food waste, namely those with the keywords "conceptual framework" or "theoretical framework";

— those related to interventions to tackle food waste, namely those with the keywords "intervention*", "strateg*" or "initiative*".

Particular attention was paid also to the term "lever", although it is not frequently used in consumer food waste literature.

After this final step, the dataset included 225 items. The strategy for the creation of the final dataset is represented in Figure 3.

**Figure 3.** Selection criteria for the final database, based on KeyWords Plus



*Source:* Created by the authors.
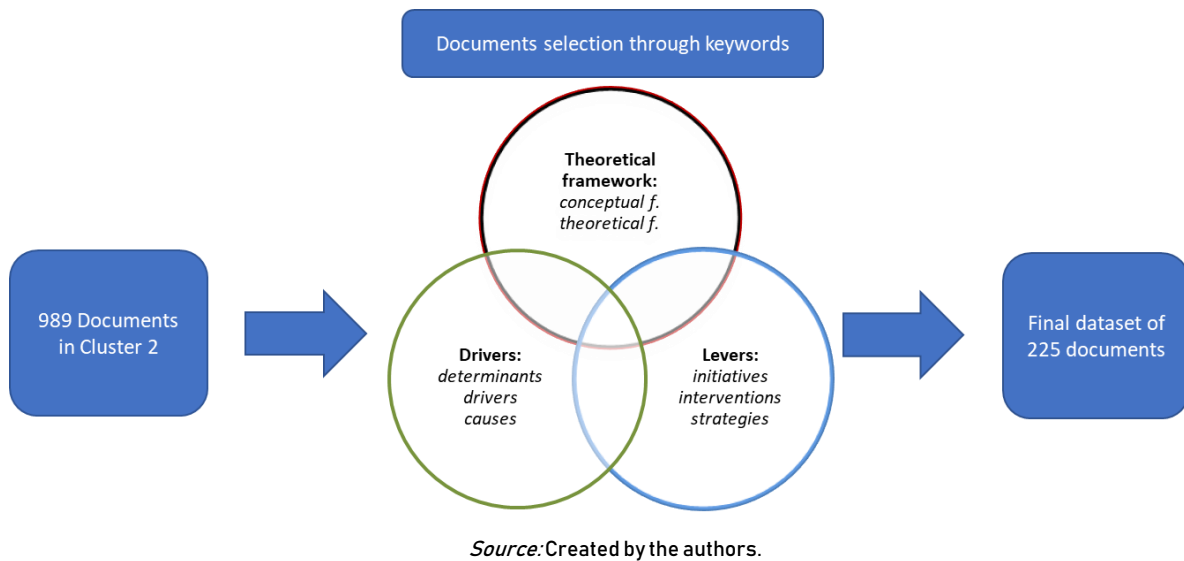
To identify a further subset of relevant documents that tested behaviour change interventions to reduce food waste, the following criteria were applied in reviewing the titles, keywords and abstracts of documents from the intervention group : studies will be selected only if (i) their main objective was reducing consumer food waste by changing consumer behaviour, (ii) they applied effective intervention impact evaluation methods and (iii) they presented sufficient information on the intervention testing results. The final poll contained a total of 20 studies, with 14 documents from the intervention group, 2 papers from the driver group that had been found to be relevant to intervention testing, and 4 additional studies that had been recommended by experts during the first round of manuscript review.

## 3.5. Limitations

Despite the added value it created, the methodology adopted for the construction and analysis of the dataset also had some limitations that should be considered for a better understanding of the results.

While the integration of the grey literature represents a novelty in a bibliometric review and adds value, the heterogeneous structure of the report required supervised selection of the keywords using algorithms that might generate some inaccuracies. To mitigate this, the grey literature results – their keywords and their classification – were revised in a supervised analysis conducted through manual checks of the consistency of the keywords generated for the grey literature documents by automated extraction algorithms.

Another possible shortcoming of automated bibliometric analysis relates to linguistic differences in documents.

## 4. Results: evolution over time of food waste studies

### 4.1. Production of documents

Since 2010, the production of documents on food waste has increased exponentially, reaching more than 250 articles published per year. The discussion kicked off with the publication of the scientific article 'Food waste within food supply chains: quantification and potential for change to 2050' in 2010 (Parfitt et al., 2010) and of the Food and Agriculture Organization of the United Nations report *Global Food Losses and Food Waste – Extent, causes and prevention* in 2011 (FAO, 2011). The most important turning points since that moment can be identified first in 2014 and then in 2017. The overall trend in annual document production over the past 11 years is shown in Figure 4.

**Figure 4.** Annual document production (2010–2021)
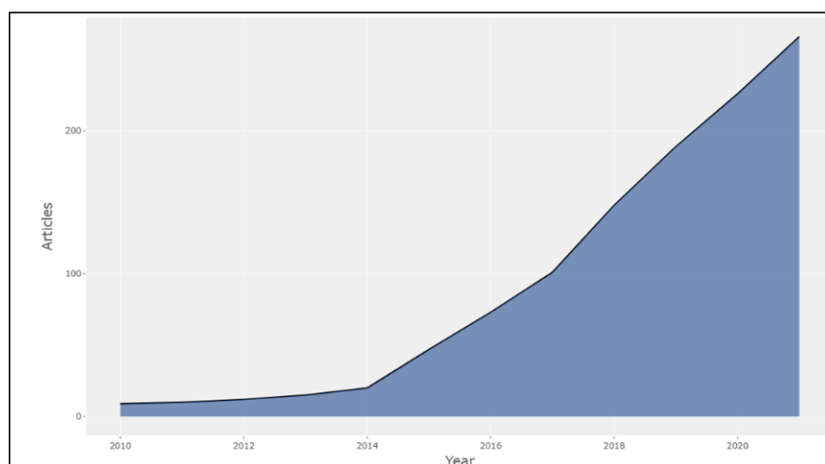


*Source:* Created by the authors.

Table 1 shows numbers of articles published by the 10 journals that produced the most food waste articles over 2010–2021. It is worth noting that, for 2021, a set of articles whose publication was planned for 2022 were included in the total, potentially over-representing the cumulated number of articles for that year.

Overall, *Sustainability* is by far the journal having published the largest number of articles on the topic, for a total of 122. The *Journal of Cleaner Production* follows, with 94 articles published. None of the remaining scientific journals has published more than 60 articles to date.

Not surprisingly, all the journals increased the number of articles they published from 2016, with the number increasing five-fold between 2016 and 2019, and with additional growth between 2019 and 2021. *Resources, Conservation and Recycling* was the first of these journals publishing on the topic, with one article already produced in 2010. The journals that started to accumulate articles later are also those with lower numbers of published articles.

**Table 1.** Top 10 journals for published articles (2010–2021)

| Journal | Cumulated number of articles published | | | | |
|---|---|---|---|---|---|
| | **2010** | **2013** | **2016** | **2019** | **2021 (*)** |
| *Sustainability* | 0 | 1 | 7 | 48 | 122 |
| *Journal of Cleaner Production* | 0 | 2 | 9 | 51 | 94 |
| *Resources, Conservation and Recycling* | 1 | 1 | 6 | 37 | 59 |
| *Waste Management* | 0 | 2 | 7 | 34 | 44 |
| *British Food Journal* | 0 | 1 | 8 | 27 | 42 |

| | | | | | |
|---|---|---|---|---|---|
| *Food Quality and Preference* | 0 | 1 | 2 | 14 | 26 |
| *Appetite* | 0 | 0 | 3 | 12 | 23 |
| *Foods* | 0 | 0 | 0 | 3 | 20 |
| *Journal of Retailing and Consumer Services* | 0 | 0 | 2 | 6 | 16 |
| *Trends in Food Science and Technology* | 0 | 0 | 1 | 10 | 15 |

(*)  Some articles for publication in 2022 were included, since some journals were already displaying them online.

*Source:* Created by the authors.

To better understand the impact of the top journals on the debate, we need to go beyond simple numbers of publications to analyse the citations collected by the articles published in each of the journals. This may achieve a more accurate estimate of their relevance.

Table 2 shows that, when we look at the number of citations per journal, rather than the number of articles published, the ranking changes, with some journals leaving the top 10. In this case, too, it is important to note that, for 2021, a set of articles whose publication was planned for 2022 were included when counting the citations.

The *Journal of Cleaner Production* collected the largest number of citations, followed by *Waste Management* and *Resources, Conservation and Recycling*. These two are quite close, with a difference of only 17 citations, and have around two thirds the citations of the *Journal of Cleaner Production*. Interestingly, *Sustainability* ranks fourth, showing that, although it has the largest number of published articles, these articles have not been widely cited compared with those of the journals in the top three positions. A set of journals not among the top 10 for total number of publications appears more important when looking at their citations. These journals are *Food Policy*, *Bioresource Technology* and *PLOS One*, which take the places of *Foods*, *Journal of Retailing and Consumer Services* and *Trends in Food Science and Technology*.

Like publications, cumulated citations had grown significantly in 2016, 2019 and 2021, while numbers were quite low in 2010 and 2013.

**Table 2.** Top 10 journals for citations (2010–2021)

| Journal | Cumulated citations | | | | |
|---|---|---|---|---|---|
| | **2010** | **2013** | **2016** | **2019** | **2021** (*) |
| *Journal of Cleaner Production* | 7 | 17 | 156 | 1 225 | 2 934 |
| *Waste Management* | 7 | 21 | 163 | 900 | 1 998 |
| *Resources, Conservation and Recycling* | 6 | 8 | 104 | 830 | 1 981 |
| *Sustainability* | 0 | 1 | 1 | 376 | 1 125 |
| *Appetite* | 0 | 8 | 91 | 534 | 1 079 |
| *Food Quality and Preferences* | 0 | 3 | 43 | 427 | 961 |
| *British Food Journal* | 0 | 3 | 35 | 349 | 807 |
| *Food Policy* | 2 | 7 | 80 | 428 | 776 |
| *Bioresource Technology* | 21 | 37 | 115 | 345 | 615 |
| *PLOS One* | 1 | 9 | 28 | 219 | 477 |

With regard to affiliated institutions, Aarhus University, in Denmark, produced the highest total number of documents, with more than 30 items published between 2010 and 2021, followed by the University of Illinois (the United States) and Wageningen University (the Netherlands) (see Figure 5).

**Figure 5.** Affiliated institutions that produced the most relevant documents
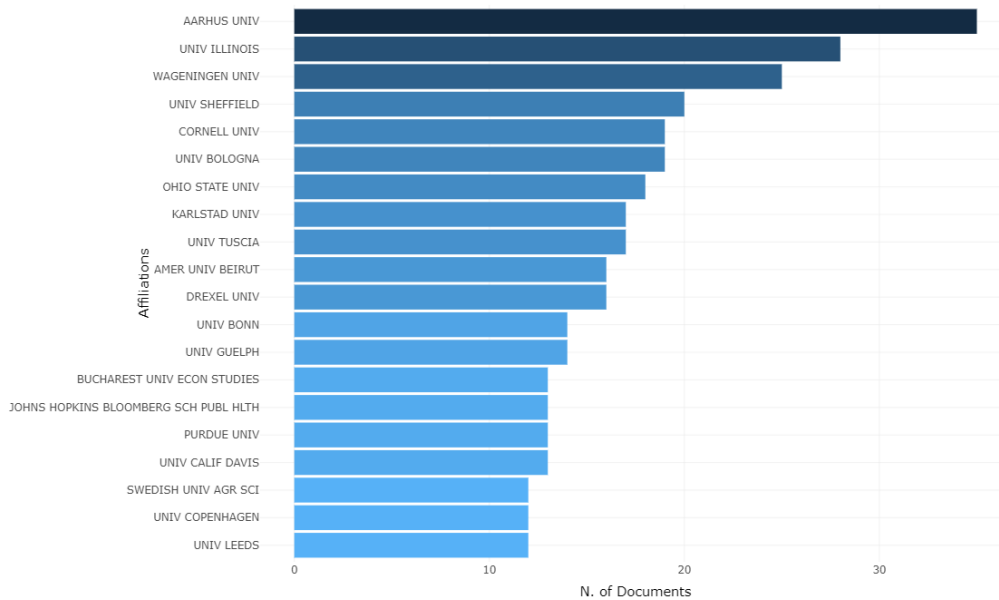


*Source:* Created by the authors.

## 4.2.  Content analysis

The analysis of the content was based on KeyWords Plus, generated by WoS on the basis of automated analysis of the documents in the dataset. The following figures (6–8) present relations and connections among the documents based on an analysis of their KeyWords Plus.

The topic of consumer food waste was initially observed through the lens of environmental impacts, with publications considering technical aspects such as carbon dioxide emissions and effects on climate change. Later, the topic of behavioural analysis rose to prominence, registering the most coverage in 2019, thanks to publications on the emerging topics of losses, consumption and behaviour, followed by a discussion of attitudes, barriers and waste generation. This transition led to a greater focus on the issues of management and intervention strategies, which emerged in 2020–2021 (see Figure 6).

However, it is worth noting that findings such as these may have been partially influenced by the search strategy, which focused on consumer food waste and behavioural issues rather than on other topics. This means that the dataset mostly included documents in which environmental impacts and other sustainability aspects are directly connected with consumers and behavioural issues. Hence Figure 6 may underestimate the presence of some topics in the debate, not necessarily fully reflecting overall trends in the development of documents on food waste.

**Figure 6.** Trends in topics addressed in food waste publications (2015–2021)
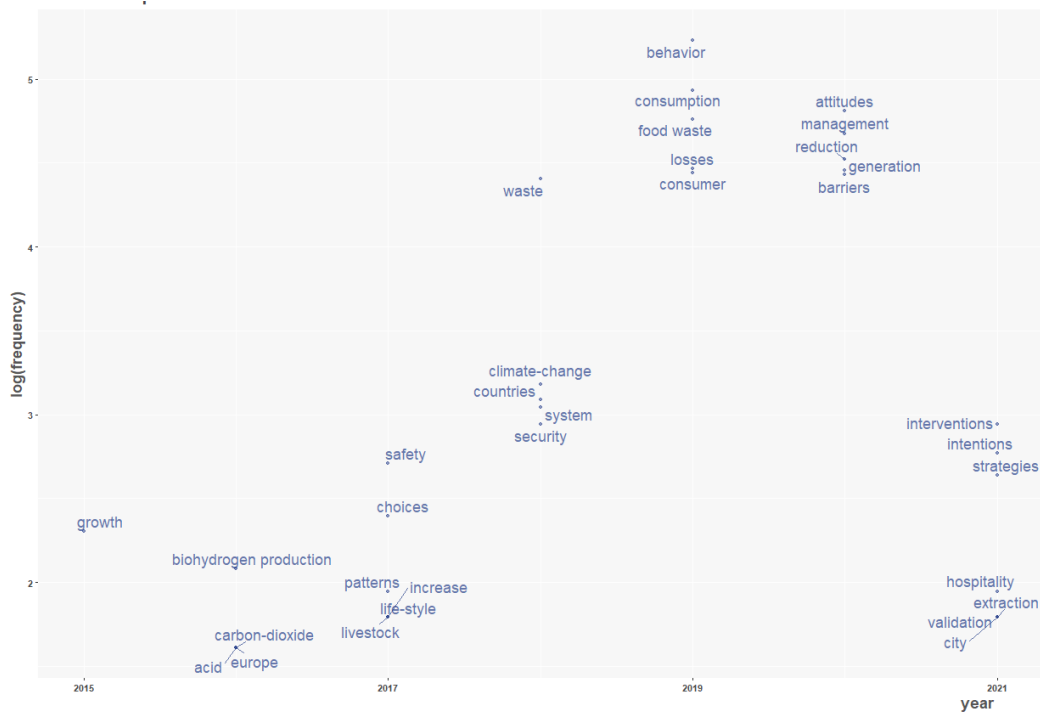


*Source:* Created by the authors.

Regardless of evolution over time, behavioural issues in consumer food waste are the most investigated in absolute terms. The tree map presented in Figure 7 depicts the KeyWords Plus most commonly used in the debate. The absolute number in each box indicates the frequency of occurrence of terms, with the relative percentage. According to the tree map, behaviour and food waste are the most frequent topics, followed by consumption, attitudes and management.

The topic of sustainability (as measured by the KeyWords Plus "sustainability" and "life cycle assessment") remains quite marginal in the overall debate. A possible explanation lies in the fact that a focus on the sustainability dimension of food waste arose slightly later in the debate.

**Figure 7.** Tree map of topics
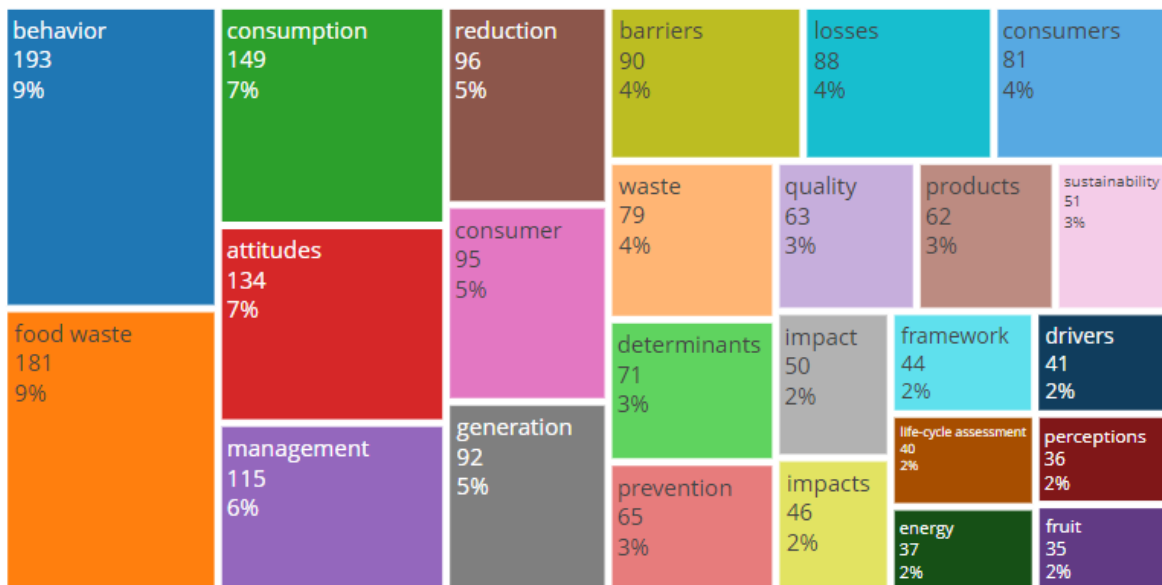


*Source:* Created by the authors.

## 4.3. Thematic evolution

Overall, there was over time a consolidation in the themes covered by the publications. In 2010–2013, food waste-related issues were analysed through a multifaceted lens, with hard science topics and impacts on the environment receiving particular attention. Later, the topics decreased in number, with themes of consumption, behaviour, management, waste and food waste dominating. More precisely, in the first time span the predominant themes were solid waste and municipal solid waste, as publications tended to relate to the valorisation of food waste rather than to its prevention. As Figure 8 shows, many themes converged later, in the second time period (2014–2015), on life cycle assessment. This means that many topics, such as consumption, solid waste and food waste, were addressed in 2014–2016 from a life cycle assessment perspective. Consumption and waste are present in all four time spans, suggesting that these themes are strongly connected to consumer food waste drivers.

**Figure 8.** Thematic evolution of food waste publications
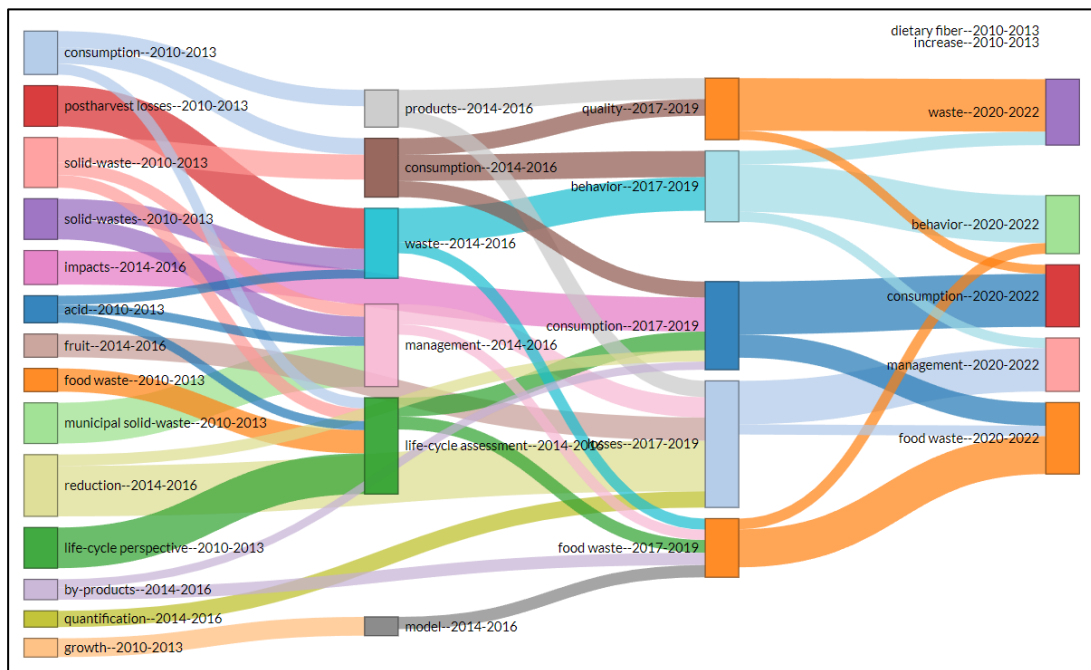


*Source:* Created by the authors.

Going deeper into the analysis of the thematic evolution of publications on consumer food waste, Figures 9–12 show the impact of the topics analysed by the documents under consideration in four time spans. To achieve this, the clusters of topics were scored on centrality, indicating the importance in the scientific debate, and density, indicating frequency of occurrence of the topics in the literature (Cahlik, 2000; Cobo et al., 2011a, 2011b). The combination of centrality and density scores makes it possible to determine the position of the thematic clusters in the debate: low scores for centrality and density characterise emerging or declining themes that are not yet or no longer central to the discussion. A low density score and a high centrality score indicate that the topic is one of the basic themes under discussion. A high density score and a low centrality score characterise niche themes discussed in a significant minority of documents with a limited impact on the global discussion. Topics with high scores for density and centrality are motor themes, driving the debate (see Table 3). Finally, in Figures 9–12, the diameter of the circles is directly proportional to the number of documents included in the cluster.

**Table 3.** Characteristics of the topics

| Density | High | Low |
|---|---|---|
|  |  |  |

| Centrality | | |
|---|---|---|
| High | Motor themes | Basic themes |
| Low | Niche themes | Emerging or declining themes |

### 4.3.1.   Time slice 1: 2010–2013

In the first period under analysis, the large majority of topics relate to hard science aspects of food waste, highlighting an approach to food waste more interested in valorisation than in an analysis of the behavioural and economic elements driving its generation. In particular, the right-hand side of Figure 9, representing the most central themes, includes Keywords Plus such as "acid", and "dietary fiber" that are clearly related to the composition of wasted food.

The Keyword Plus "consumption" (in the yellow circle) shows a high level of centrality and density, thus demonstrating the growing importance of the topic, which will become still more prominent in the following periods.

**Figure 9.** Time slice 1 (2010–2013)
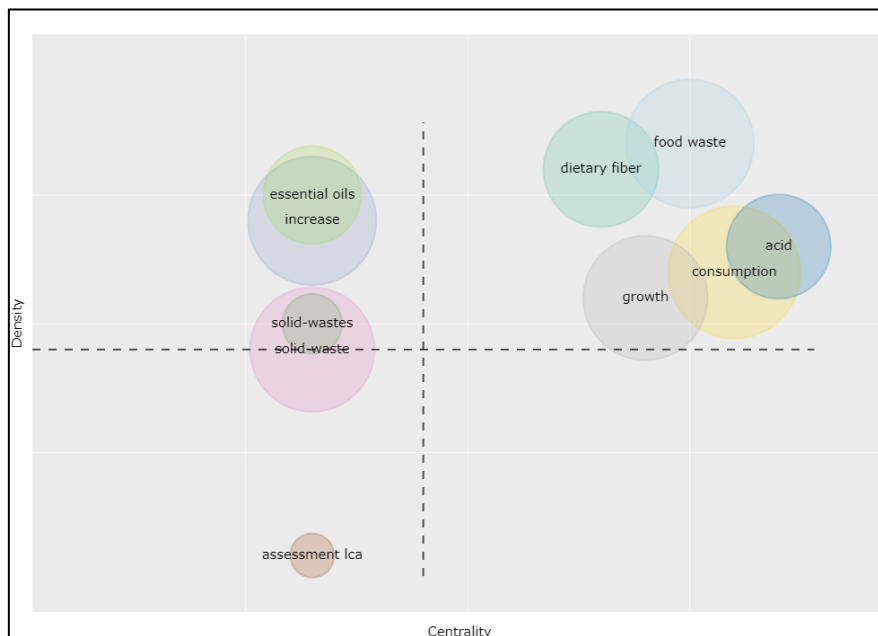
### 4.3.2.   Time slice 2: 2014–2016

Moving ahead in time, topics related to the behavioural approach to food waste emerge in the scientific debate. As shown in Figure 10, Keywords Plus such as "consumption behaviour" and "consumer", themes that previously arose only in the form of the KeyWord Plus "consumption", are now among the basic themes, having become central the scientific debate. Furthermore, in this time span hard science topics (e.g. "lycopene", "inductively-coupled plasma") are more marginal (see Figure 10).

**Figure 10.** Time slice 2 (2014–2016)
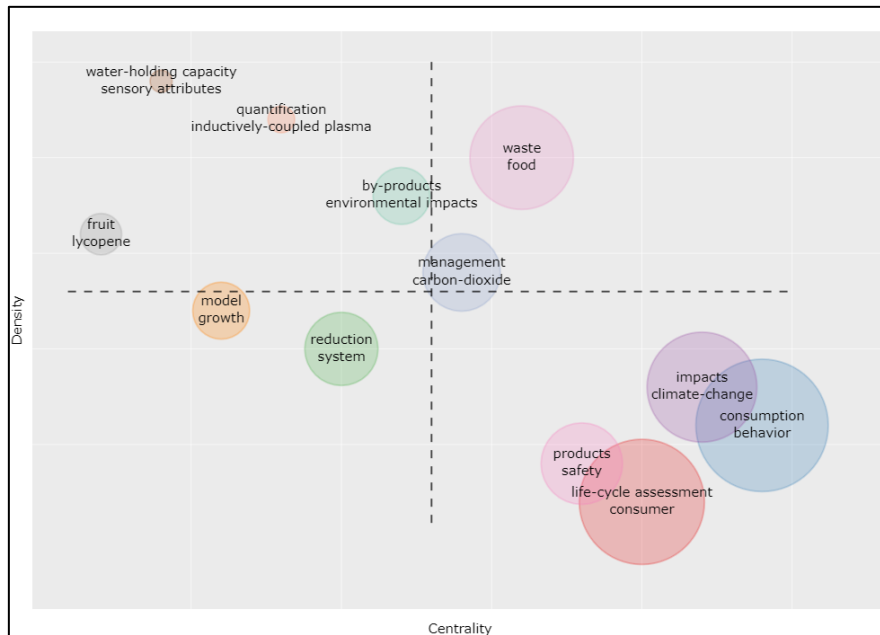


*Source:* Created by the authors.

### 4.3.3.   Time slice 3: 2017–2019

The trend towards a consumer-based approach in the food waste literature is even clearer for the 2016–2019 period, during which hard science topics disappear from the most central themes, while topics such as "behaviour" and "attitudes" become more important in the debate and can now be considered motor themes. The topics "losses" and "management" appear in the emerging or declining themes area: considering their evolution over time, it can be presumed that those are emerging topics, gaining space in the debate (see Figure 11).

**Figure 11.** Time slice 3 (2017–2019)
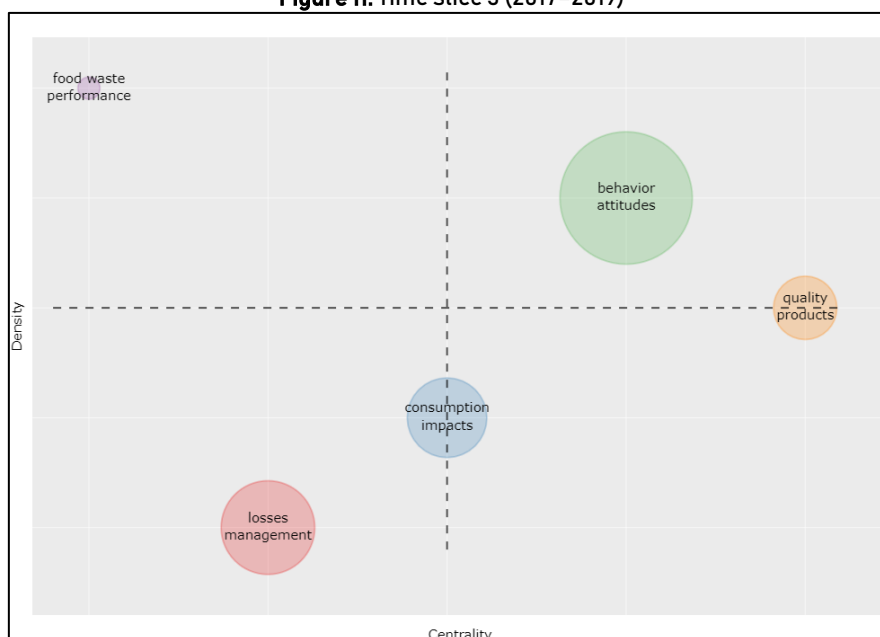


*Source:* Created by the authors.

### 4.3.4. Time slice 4: 2020–2021

The final time span, 2020–2021 (in which some documents planned for 2022 are included), sees the consolidation of the behavioural approach to consumer food waste in the literature. During this period, the largest share of documents related to three clusters of topics (represented by the red, blue and green circles in Figure 12). Moreover, the largest cluster includes the KeyWords Plus "behaviour" and "attitudes", which are now basic themes of the literature (see Figure 12). During this period, many documents focused on the implications of COVID-19-related restrictions for food waste generation, as discussed in Section 5.5.

**Figure 12.** Time slice 4 (2020–2021)
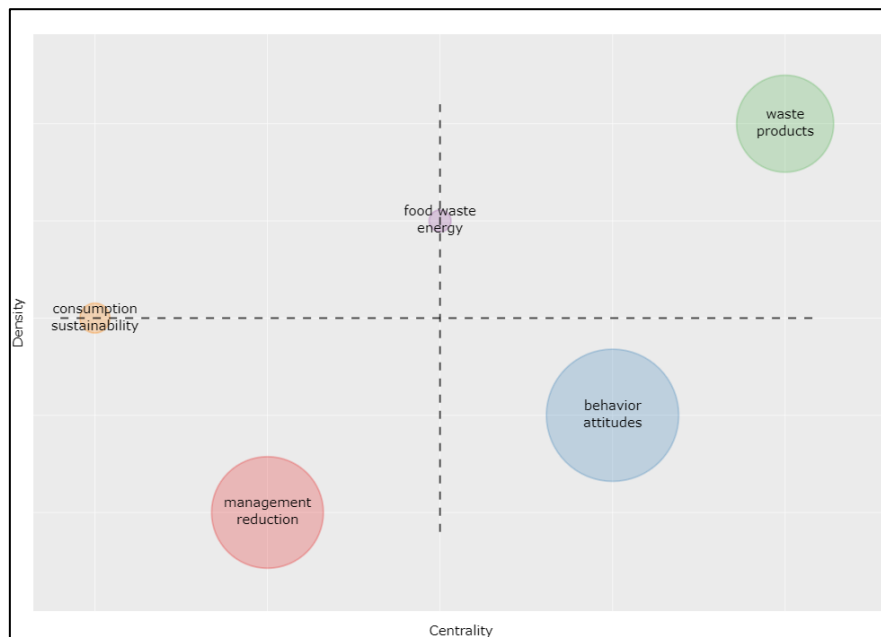


*Source:* Created by the authors.

## 4.4. Co-occurrence network

Co-occurrence is a concept that refers to the presence, similar frequency of occurrence and proximity of KeyWords Plus across several documents. The sizes of the rectangles in Figure 13 are proportional to the number of documents associated with each Keyword Plus, while the strength of the lines relates to the number of co-occurrences between KeyWords Plus. As could be anticipated from the preceding analysis, "behavior" is by far the most frequently occurring KeyWord Plus, at the very centre of the network.

There are clear interrelations across documents focusing on behaviour, consumption, management, attitudes and food waste, as also highlighted by Figures 6 and 7 and Figures 9–12.

Other KeyWords Plus are less common among the documents but still co-occur in the same documents. This is the case, for example, with "information", "fruit" and "vegetables", "planned behaviour" and "anaerobic digestion".

**Figure 13.** Co-occurrence network
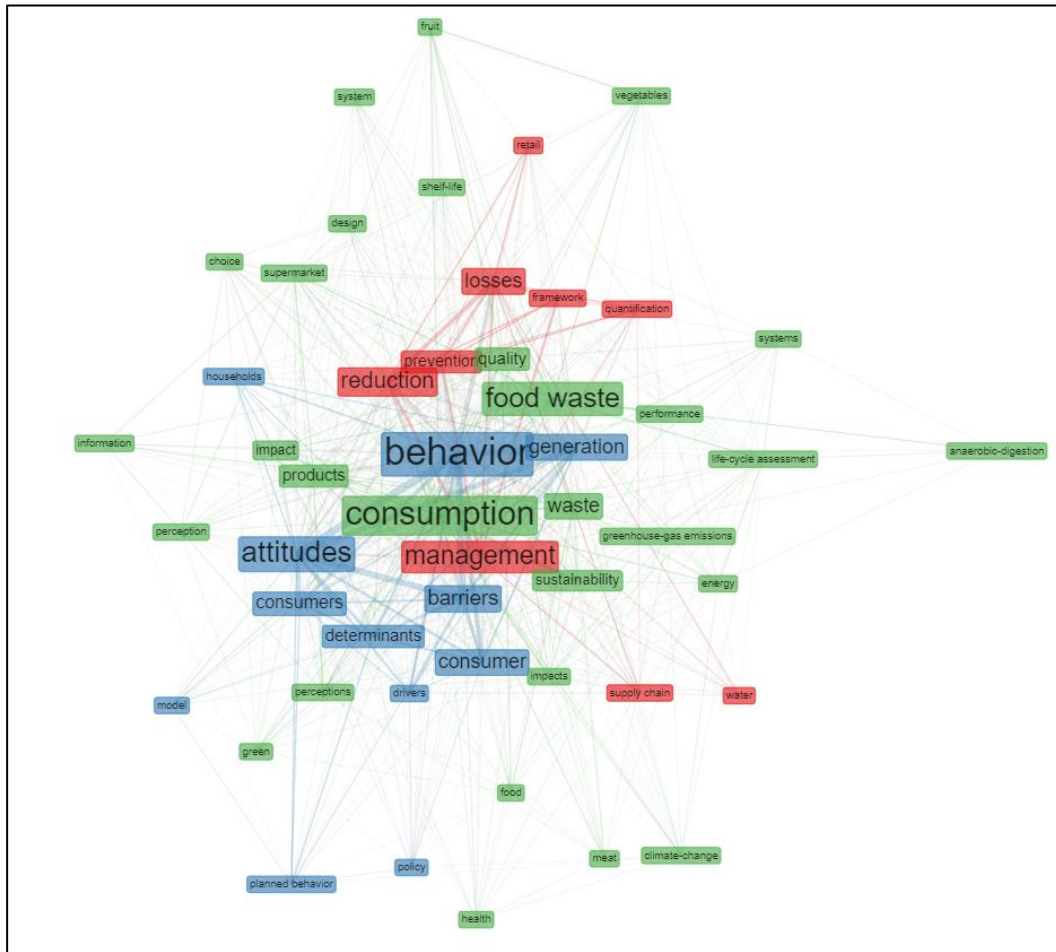
## 4.5. Factorial analysis and clustering of topics

Figure 14 shows a map of the clusters identified during the analysis of the literature, with the size of each cluster being proportional to the importance of the topics within it.

The variance explained by the first two dimensions of the MCA has a value greater than 60 %, so these dimensions explain majority of variance in the whole dataset. Three thematic clusters resulted from the MCA, with most of the keywords included in the blue one (cluster 2).

The large blue cluster includes KeyWords Plus referring to consumer behaviour interventions and drivers and contains a fairly wide range of keywords. KeyWords Plus such as "consumers", "health", "drivers", "barriers", "perceptions" and "determinants" are dominant in the debate. This means that a large share of publications have analysed these topics with reference to food waste. This conclusion confirms the findings illustrated in Figures 9 –13.

The green cluster includes KeyWords Plus related to the environmental aspects of food waste. The themes explored here are connected to keywords such as "water", "energy", "environmental impact", "performance" and "sustainability". Finally, the red cluster includes KeyWords Plus such as "quantification", "retail" and "losses".

**Figure 14.** Conceptual structure of the dataset, mapped using the results of the MCA
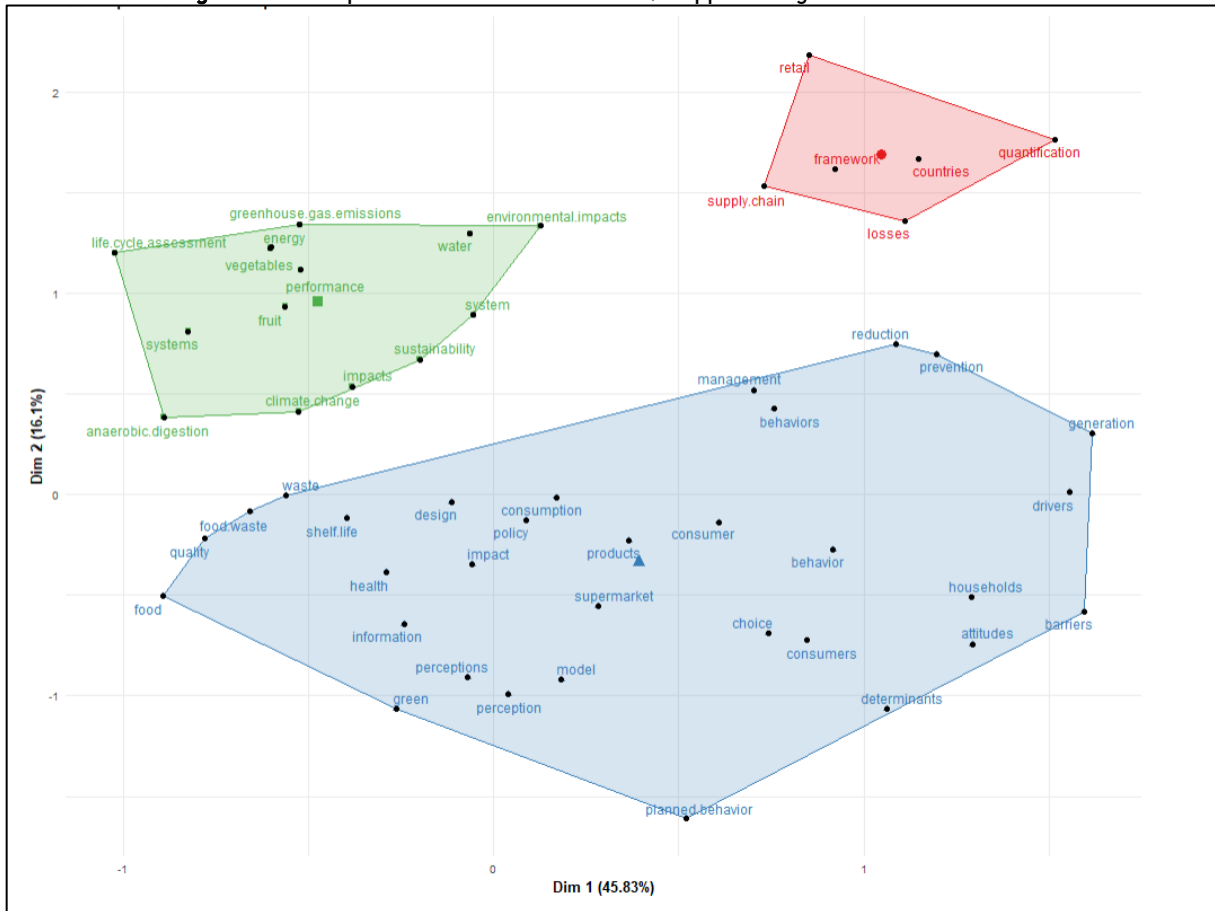


NB: Dim 1 = most important latent dimension and Dim 2 = second most important latent dimension in terms of proportion of variances retained by the dimensions represented on the two axes (61.93 % of variance retained, values in parentheses).

*Source:* Created by the authors.

In the 11 years from 2010 to 2021, the food waste literature increased exponentially, with two important turning points in 2014 and 2017.

In terms of document production, the United States, the United Kingdom and Italy are the three countries that produce the most documents, and also the documents that are cited the most. However, collaborations across countries take place, especially between the United States and EU countries.

The topic of consumer food waste was initially viewed from a hard science perspective, with researchers particularly interested in technical aspects of environmental impacts, such as carbon dioxide emissions and effects on climate change. Only later did the topic of behavioural analysis arise more consistently, through investigations of attitudes, barriers and waste generation.

Leaving aside the trends over time, behavioural issues in consumer food waste are today the most investigated topic in absolute terms.

Two major clusters of topics can be identified in consumer food waste publications today, one relating to consumer behaviour interventions and drivers and the other to the environmental aspects of food waste.

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## 5. Investigating drivers and levers of consumers food waste

As described in Chapter 4, the food waste literature has shifted to pay significant attention to consumer behaviour, prompted by the idea that stimulating behavioural change might make a significant contribution to reducing food waste. Food waste can be considered the product of individual behaviours that are driven by a wide range of factors. Individual factors such as attitudes, motivations and preferences are coupled with social and situational factors. Given the complexity of this, a better understanding is required of the drivers – meaning the factors that affect behaviour – but also of the levers – that is, opportunities for action that can be incorporated into interventions.

### 5.1. Understanding consumer food waste

Food waste is the result of multiple and interconnected behaviours taking place at different moments and stages in the food supply chain (Quested et al., 2013; Setti et al., 2018; van Geffen et al., 2016). A step towards better understanding this complex issue can be taken by developing or adapting theoretical and conceptual frameworks.

In the early years of consumer food waste studies, several authors suggested potential classifications of the drivers without providing a specific conceptual framework (Canali et al. 2016). A first attempt at developing a framework for the analysis of food waste generation and prevention was made by Papargyropoulou et al. (2016), focusing on the hospitality sector. This first framework identified and explained the patterns and drivers of food waste generation with the aim of discovering effective measure for food waste prevention.

The first consistent theoretical approach can be identified in the TPB, which explains individual behaviours as a consequence of cognitive processes that are mainly internal to individuals, such as attitudes, intentions and norms (Ajzen, 2015). The TPB has been extensively applied to the food waste domain (Aktas et al., 2018; Graham-Rowe et al., 2015; Russell et al., 2017; Setti et al., 2016, 2018) and has been further developed and discussed over the years.

Some authors have proposed adapting the theory by including additional determinants of behaviour influencing consumers' decisions and contributing to the generation of consumer food waste. Those additions have related to routinised behaviours (Stefan et al., 2013), knowledge (Visschers et al., 2016), habits and emotions (Russell et al., 2017) and situational factors such as food environments and access to food (Boulet et al., 2021; Evans et al., 2011, 2012). Situational factors were introduced by researchers working on sociological contributions revolving around social practice theory, which acknowledges individuals as embedded in wider social, economic and cultural facets of everyday life (Schanes et al., 2018). In particular, Evans (2011, 2012) associated food waste with sequences of daily routines around food practices, including time organisation and management, material access to infrastructures such as markets and supermarkets, and social relations.

However, limiting the analysis to cognitive aspects, such as attitudes and intentions, has proven to be inadequate in providing a framework for understanding consumer food waste. Indeed, one of the main limitations of the TPB relates to the fact that food waste is not a planned behaviour, as assumed by TPB, but rather an unintended consequence of food-related behaviours and choices (Quested et al., 2013; van Geffen et al., 2016).

In support of this criticism, some studies identify a weak relationship between the intention to reduce food waste and the action of doing so and explain this as the 'attitude–behaviour gap' (Stefan et al., 2013). Furthermore, the distance between food-related decisions and food waste generation can create a degree of uncertainty, leading individuals to rely on heuristics and adopt non-standard behavioural patterns that do not have the rationality assumed by the TPB (Setti et al., 2018).

An attempt to integrate psychologically oriented approaches, such as the TPB, with sociological approaches is represented by the MOA framework (van Geffen et al., 2016, 2017), which was inspired by the work of Rothschild (1999). The MOA framework considers food waste not as an intended outcome but as an unintended consequence of iterative decisions and behaviours related to food management practices in and outside the home that are driven both by internal (individual) and external (social and societal) factors. While 'motivation' relates to the attitudes, intentions and norms on which the TPB focuses, 'opportunity' and 'ability' expand the framework beyond cognitive boundaries, bringing added value to the approach. 'Opportunity' refers to the availability and accessibility of materials and resources

needed to change behaviour (MacInnis et al., 1991; Rothschild, 1999). Time and schedule, materials, technologies and infrastructure further shape food waste drivers such as portion or package size and discount promotions in shops (Kallbekken and Sælen, 2013; Katajajuuri et al., 2014; Stancu et al., 2016; van Geffen et al., 2020a).

'Ability' refers to the knowledge, skills and individual capacities required to solve the problems encountered when changing behaviour, including breaking well-formed habits and routines or countering the arguments of peers (Rothschild, 1999).

Another attempt to integrate psychological and sociological approaches is represented by installation theory, which explains behaviour as resulting from individual, social and situational factors (Lahlou, 2016). Installation theory refers to the specific settings where individuals behave predictably as 'installations'. Installations are composed of three layers that interact together: embodied competences (in the individual), material infrastructures (in the local context) and social regulations (within society) (Castro et al., 2019). In the adaptation of installation theory to food waste, a simplified version of the consumer food management routine is adopted in which the stages are limited to acquisition (including planning), consumption (including preparation) and disposal. Furthermore, storage is considered as a transversal element. Each stage is associated with an installation (supermarkets for acquisition, the kitchen for consumption and disposal), potentially facilitating the identification of practical solutions in real-life settings (Castro et al., 2019; Lahlou, 2016).

A further interpretation is proposed by Boulet et al. (2021), who suggest approaching consumer food waste from a three-level perspective. The micro level has the individual as the focal entity, the meso level relates to the social unit within the physical setting of the household and the macro level is the material and social setting outside the home. Like the MOA framework, this multi-level framework of household food waste and consumer behaviour moves beyond cognitive aspects to integrate a wide range of external elements and daily routines around food practices.

Most theoretical frameworks – the TPB and the MOA framework being exceptions – represent only theoretical contributions, since their application is still limited. The TPB and the MOA framework, however, have been applied to analyse consumer food waste in several contexts and countries. The TPB has been applied to predicting motivation and behaviour (Graham-Rowe et al., 2015), to understanding the role of emotions and habits in food waste generation (Russell et al., 2017) and to analysing the clash between food choices and intentions to reduce waste generation in home (Setti et al., 2018). The MOA framework was originally applied to consumers' behaviours in processing information found in advertising (MacInnis et al., 1991), and was then extended to the field of food waste in order to investigate consumers' perceptions around food waste and identify potential mitigating factors (van Geffen et al., 2017; van Geffen et al., 2020a; Vittuari et al., 2020), to evaluate the impacts of food waste reduction campaigns (Soma et al., 2021) and to assess the impacts of social restrictions on food waste in the context of the COVID-19 pandemic (Vittuari et al., 2021).

Based on the various applications, the TPB seems more suitable for analysing food waste behaviour at home, while the MOA framework appears to be more flexible and more easily adjusted to analysing out-of-home consumption.

Having considered the features of the frameworks in terms of goal, scope, adaptability and maturity, this work will build on a revised version of the MOA framework that integrates the three-level perspective described by Boulet et al. (2021). Drivers, levers and interventions will then be identified, analysed and discussed, taking inspiration from the different constructs represented in the model (Figure 15).

**Figure 15.** The MOA framework

*Source:* Created by the authors.

## 5.2. Unpacking behavioural constructs in relation to consumer food waste

Each driver analysed in this section belongs to one of the macro-categories of the MOA framework and has its own peculiarities in shaping food waste production at the individual and household levels. As well as the drivers, potential levers are also discussed. Table 4 provides a synthetic overview of drivers and levers.

### 5.2.1. Individual motivations and psychological factors

Motivations relate to the intentions of one or more individuals to carry out an action or a set of actions. Their role in preventing or reducing food waste lies in their positive/negative effects on attitudes towards the goal (e.g. how people think and feel about wasting food) (Russell et al., 2017; van Geffen et al., 2020b). Attitudes, and consequently behaviours, towards food waste are influenced by the levels of awareness of the problem and of consciousness of the global impact of food waste (Abeliotis et al., 2014; Russell et al., 2017). Motivations also relate to perceptions of degree of control, of capability of establishing or changing a behaviour and of the effectiveness that consumers can have in minimising food waste (Ertz et al., 2021). Emotion and engagement – in the form, for example, of concerns around health and environmental issues and preference for a healthy diet – are also crucial in driving motivation to minimise food waste (Russell et al., 2017; van Geffen et al., 2020a).

Potential levers related to individual motivations and psychological factors might include providing information on climate and environmental concerns in interventions in order to emphasise the consequences of food waste. Building on emotions and engagement might motivate consumers to take a more active role in food waste reduction.

### 5.2.2. Social norms

Social norms relate to the belief that behaviour is influenced by what other individuals do and what individuals believe is expected of them. The former (what others do) involves descriptive social norms, which relate to people's personal perceptions about other consumers' efforts to prevent food waste (Elhoushy, 2020). The latter (what people believe is expected of them) involves injunctive norms, which relate to consumers' perception of wasting food as a socially disapproved behaviour (Schanes et al., 2018). Results on the extent to which social norms can predict intention to reduce food waste are mixed, either because wasting food is a private behaviour with little social interference or because studies have looked at how social norms affect the behaviour of groups rather than individuals.

Additionally, personal norms such as the concept of a 'good provider' (making sure that a wide variety of healthy and tasty foods are available to household members and guests) can also cause food waste at the domestic level (Evans, 2011; Graham-Rowe et al., 2014; Hebrok and Boks, 2017).

Potential levers related to social norms might involve creating a positive social environment in which food-related good practices (including food waste prevention) and values are promoted and which could build a sense of community in individuals.

### 5.2.3. Ability

Following the definition of MacInnis et al. (1991) and Rothschild (1999), ability is the capacity of each individual to deal with the creation, management and reduction of food waste, relying on personal knowledge and skills. Taking the food chain as a whole, ability relates to a set of different aspects (e.g. skills and knowledge) related to food management and food literacy, spanning planning and organisational skills, purchasing ability, and food preparation and storage skills (Bravi et al., 2020; Neff et al., 2019; van Geffen et al., 2020b; Vittuari et al., 2021).

Possible levers might be based on promoting and building technical skills and food literacy.

### 5.2.4. Micro-level situational factors and opportunities

The concept of opportunity is defined as the ability of one or more individuals to access external material and non-material resources such as time, technology and infrastructures (MacInnis et al., 1991; Rothschild, 1999). When dealing with food systems, opportunity refers to access to a set of material resources such as physical access to food production, distribution and consumption settings and access to food-related services (e.g. the availability of storage and cooking tools and technologies). Non-material resources include time available for food-related activities, the cultural knowledge needed to undertake them and the development of good habits in managing cooking or storage activities (Silvennoinen et al., 2012; Stancu et al., 2016; van Geffen et al., 2020b; Vittuari et al., 2021). Indeed, lifestyles and routines are decisive in driving households' food waste trends (Hebrok and Boks, 2017) as are cultural influences, in terms of both cookery and other traditions.

Potential levers related to micro-level situational factors to trigger behavioural change include measures to encourage better working time organisation (thus increasing time available for food management) and to support the provision of affordable technology and tools (e.g. smart kitchen tools) to enable better food management. Outside the home, the design of food environments can also nudge consumers towards food waste reduction practices.

### 5.2.5. Macro-level situational factors and opportunities

Boulet et al. (2021) suggest not only considering opportunities at the individual and household levels but integrating them into the material and social settings outside the household. One example of this might be looking at legal and regulatory frameworks that impose requirements, such as food safety standards, influencing the way food is disposed of. In addition, Canali et al. (2016) suggest considering the institutional context, identifying three groups of legislation and policy-related drivers: those related to agricultural policy and food quality and marketing standards; those related to food safety, consumer health and information, and animal welfare; and those related to waste and taxation. Finally, van Herpen et al. (2019b) highlight the role of the food infrastructures surrounding individuals and households, such as the availability and the accessibility of shops, their density in a specific area and the types of products sold.

Potential levers involving macro-level situational factors and opportunities include promoting regulatory frameworks and/or public policies that remove barriers to and foster incentives encouraging practices aimed at food waste reduction, such as food donation.

### 5.2.6. Demographics

Socio-demographics are considered to exert an indirect influence on consumer food waste behaviour (van Geffen et al., 2020a), even though the empirical evidence is far from generating consensus (Schanes et al., 2018). However, unlike previous drivers, socio-demographic factors cannot be directly changed by interventions, although motivation, opportunities and abilities relating to them could be changed by tailored interventions, (van Geffen et al., 2016).

Age, gender, education level, household size and composition, employment status and income appear to be the most frequently discussed and influential factors (van Geffen et al., 2016). According to van Geffen et al. (2016), age has been found to correlate with the quantity of food waste produced and the attitude of

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consumers towards waste: elderly consumers are found to waste less, which is explained by different attitudes towards food as well as a greater knowledge among older people of the impacts of food waste (Qi and Roe, 2016; Schanes et al., 2018). However, other studies have found that differences between older and younger individuals have not been found consistently (Koivupuro et al., 2012; Parizeau et al., 2015). Regarding the gender difference, too, the evidence is not straightforward: some studies, such as that by Secondi et al. (2015), have found that men waste more than women and that women tend to have more positive attitudes to reducing fruit and vegetable waste (Graham-Rowe et al., 2015), while others suggest no significant gender effect (Principato et al., 2015) or even that women tend to waste more (Visschers et al., 2016).

Furthermore, despite a lack of consensus on the evidence, some authors suggest that a higher level of education may be correlated with a higher self-reported amount of food waste (Cecere et al., 2014; Neff et al., 2015). Household size and composition have also been linked to food waste levels. Larger households waste more than smaller households in absolute terms (Quested et al., 2013), but they waste less food per capita (Koivupuro et al., 2012; Parizeau et al., 2015; Silvennoinen et al., 2014). This, however, does not apply to households with children, in which food waste is higher than in all-adult households of equal size (Parizeau et al., 2015; Visschers et al., 2016). While employed people tend to produce more food waste (Cecere et al., 2014) than individuals not in the labour force (Secondi et al., 2015), results on the effect of income on food waste levels are less clear. Some studies indicate that a lower income is related to higher food waste amounts (Stancu et al., 2016), but the opposite has also been reported (Stefan et al., 2013; Szabó-Bódi et al., 2018). Additionally, there are studies that have found no relation between food waste and income (Koivupuro et al., 2012; Qi and Roe, 2016). Furthermore, some preliminary findings suggest that lower wages or higher food prices (Setti et al., 2016) are related to reduced food waste (Britton et al., 2014). However, price variability and income constraints not only induce consumers to reduce household food waste (Graham-Rowe et al., 2014; Quested et al., 2013; Stancu et al., 2016) but also stimulate over-purchasing of discounted and lower quality foods, which potentially leads to more household waste (Setti et al., 2016).

## 5.3. The role of consumer food management stages

Food waste drivers are diverse, interrelated and vary (both in nature and in terms of their importance) across food management stages, from food production (farm) to consumption (fork), including all stages of the food supply chain such as transportation, processing and retail. For this reason, several authors suggest paying attention to routinised behaviours and food management practices (Stancu et al., 2016; Stefan et al., 2013). According to Boyd and McConocha's model, also described by van Geffen et al. (2016), food moves through a set of interconnected stages (also called routines) encompassing planning, purchasing, storing, preparing, consuming and disposing. These are the relevant stages for in-home food routines; van Geffen et al. (2016) emphasise that in the case of out-of-home consumption ordering and serving and consuming are the relevant stages.

### 5.3.1. In-home consumer food management stages

#### 5.3.1.1. Planning

Food purchasing and meal planning are crucial activities within the household and can significantly contribute to minimising food waste (Stancu et al., 2016). When talking about planning habits, consumers can be divided into planners and improvisers, depending on their degree of organisation and flexibility (Hebrok and Boks, 2017). Additionally, planning skills may be tested by a number of factors, such as a large amount of stocked food to be monitored for spoilage and to prevent over-accumulation (Karunasena et al., 2021). Furthermore, unexpected schedule changes are not easily foreseeable and cannot be included in household planning strategies. Psychological and social factors, such as a fear of running out of supplies (Amuakwa-Mensah et al., 2021) or the desire to organise a dinner with friends, can further limit planning capacity.

#### 5.3.1.2. Purchasing

Purchasing food for a household can be done in different ways, such as visiting brick-and-mortar shops (e.g. farmers' markets, supermarkets, grocery stores) or ordering online for home delivery. Shopping habits can have a significant impact on the amount of food wasted by households (Nabi et al., 2021; Stefan et al., 2013). Diverse factors may have an impact on the provisioning process, including psychological

dynamics such as impulse or panic buying (Amuakwa-Mensah et al., 2021). Furthermore, marketing strategies are determinant. Examples include the package size of food products, often containing a larger quantity of food than the consumer needs (Hebrok and Boks, 2017; Petit et al., 2020), and discounts and promotions such as 'buy one, get one free' offers (Aschemann-Witzel et al., 2017). These factors may contribute to increasing food waste at the household level.

### 5.3.1.3. Storing

Effective storage aims to maintain or even prolong food products' shelf life. Households can usually take advantage of various storage techniques, such as refrigeration, freezing or storing in a dry place (e.g. a cupboard). Even before food products reach the home, consumer behaviours (e.g. the storage method used in transporting food from the shop/market to home) can influence the shelf life of food. Often, barriers such as poor food routines, lack of knowledge or lack of awareness prevent people from using optimal storage methods (Le Borgne et al., 2021). Moreover, the organisation of the storage facilities (e.g. the fridge or cupboards) may also affect household food management. Negative impacts can arise from messy kitchen cupboards, which can cause people to forget about stored food products and increase the risk of household food waste (Karunasena et al., 2021). Finally, the diversity of attitudes and habits that people have with regard to determining if food is edible (Samotyja and Sielicka-Różyńska, 2021), including with respect to cosmetic deterioration (Dusoruth and Peterson, 2020), can be reflected in different food waste levels.

### 5.3.1.4. Preparing

Preparation methods include not only means of making food edible, such as peeling, cooking and baking, but also food preservation techniques, such as pickling, glazing and vacuum packing. A few drivers have been identified as affecting food waste generation at this stage. The implications of lifestyles and food routines need to be considered when investigating how food preparation correlates to food waste (Hebrok and Boks, 2017). Recipes or preparations that require food products to be used only partially, together with the preparation of excessive quantities of food for a meal (Eičaitė et al., 2021), are among the main causes of household food waste.

### 5.3.1.5. Consuming

Waste issues occurring at the consuming stage mainly relate to leftovers from meals (Eičaitė et al., 2021). Various factors act as barriers to the later consumption of leftovers, such as forgetfulness and uncertainty about food safety (Karunasena et al., 2021). Drivers fall into psychological, individual, demographic and situational categories creating or affecting needs and desires, and hence food management habits.

### 5.3.1.6. Disposing

At this stage, consumers can no longer prevent food waste, but they can make a difference by choosing the best way of disposing of it. A food product may be reused as pet food or used as a resource for other purposes, such as compost, following the food waste hierarchy. The wide range of disposal possibilities cannot always reduce food waste, but it can mitigate the impacts by offering more sustainable food waste management scenarios (Jereme et al., 2018).

## 5.3.2. Consumer food management stages outside the home

Out-of-home settings can assume very different forms, from public food services such as school and hospital canteens to private food services including restaurants and food markets. In out-of-home settings, the management of consumer food waste assumes a slightly different meaning. A large set of food management activities are performed by the employees of the business in question, rather than by individuals consuming food. The staff purchase the ingredients, store them and prepare the dishes.

Hence, according to van Geffen et al. (2016), there are two food management steps in which consumers have a direct influence on food waste streams outside the home, namely ordering and serving, and consumption.

### 5.3.2.1.    Ordering and serving

The acts of ordering food and receiving it in accordance with the specific type of service offered (e.g. self-service, buffet service, table service) influence consumer food waste streams.

Portion size is among the most important elements to be considered (Betz et al., 2015). Where larger amounts of food end up on the consumer's plate, they tend to waste more food. Although it has not yet been established if certain ordering and serving models consistently increase or decrease the amount of food going in the bin, some evidence exists. For example, buffet meals encourage consumer food waste. In a buffet-style setting, plates tend to be larger than necessary, and by reducing their size food waste savings can be achieved (Ravandi and Jovanovic, 2019).

Furthermore, in schools, letting students select the composition of their meal, rather than serving a standard option, can avoid excessive food waste.

Other elements influencing food waste relate to information, education and direct involvements of users in the design of the service (Antón-Peset et al., 2021).

### 5.3.2.2.    Consuming

Depending on the out-of-home setting under consideration, the amount of food waste produced at the consumption stage can be addressed from several angles.

The reasons why people gather to eat together have been shown to represent a relevant food waste indicator. On average, dining with friends leads to increased food waste streams compared with meals with colleagues or family gatherings (Wang et al., 2017).

It has also been found that the seated time dedicated to lunch can influence food waste; a longer time sitting down to eat, with people interacting and socialising, decreases the proportion of food wasted (Burg et al., 2021). However, overall, consumers eating out are not excessively concerned about the food waste they produce.

Where there are leftovers from a meal, providing takeaway containers in which diners can take food home has been suggested as a winning strategy (Hamerman et al., 2018). However, the effectiveness of this remedy has often been limited, since taking leftovers home is not a social norm (Talwar et al., 2021).

## 5.4.  Targeting groups of consumers

In the domain of food waste, consumers can be segmented into groups or clusters the members of which have in common characteristics related to food waste drivers and to the amount of food waste that they produce. For instance, consumers can be divided into those with positive attitudes towards food waste reduction and those with negative attitudes. They can also be divided according to their sensitivity to social norms, access to advanced kitchen tools and technologies, or skills in food management and disposal.

Cluster members are, then, similar to other members of their cluster and quite different from members of other clusters. Thus, segmentation can form the methodological basis for designing tailored food waste reduction interventions targeting specific groups of consumers. Those kinds of interventions, targeting specific characteristics of homogeneous groups of consumers, have been proven to be more effective than 'one size fits all' ones (Teeny et al., 2021).

For instance, a persuasion message can use different styles and ways of framing the message depending on the target audience or interventions targeting social norms can relate to different norms relevant to different social groups. These techniques have been used in persuasion psychology (Dixon et al., 2017; Joyal-Desmarais et al., 2020; Luong et al., 2019) and communications related to health risks (Noar et al., 2007; Pink et al., 2021; Schmid et al., 2008). More recently, tailored interventions have been adopted in the domains of nudging (Mills, 2022; Peer et al., 2020), debunking of misinformation (Lunz Trujillo et al., 2021) and appropriate household food waste recording (Roe et al., 2022).

Targeted interventions can be particularly effective for various reasons. Specifically, they can appear more relevant, fitting, familiar, empowering and authentic to recipients. In addition, they may be easier to process and attract more attention. However, targeted interventions can be less effective, particularly when consumers become aware they are being targeted. In this case, the interventions can be perceived

as invasive of the consumer's privacy, manipulative, repetitive or based on unfair or stereotypical judgements about the person targeted (Teeny et al., 2021).

Generally, all segmentation studies are based on a survey, such as an online questionnaire, to gather data on consumers' attitudes and food-related behaviours to inform the segmentation process. Such studies can also be informed by waste compositional analysis, which helps to relate what citizens say they do with what they actually do. It provides a more objective assessment of the consequences of a given segment's behaviour than self-assessment of food waste alone. Alternatively, there may be a focus on technological solutions that can more accurately assess waste by individuals, for example cameras linked to artificial intelligence systems (Zhai et al., 2020).

While there are some insights from the available evidence on the potential reasons why targeting can be effective (Boerman et al., 2017; van Reijmersdal et al., 2022), there appears to be no underlying theory. There is a variety of approaches. For example, an intervention can be designed in a way that is expected to be more appealing to or convincing for consumers with negative or positive attitudes towards food waste. Groups identified as non-responsive to food waste interventions may not be targeted at all. Or one segment might be targeted with an information campaign and another with a nudging intervention. In any case, how a targeted intervention should be designed to be effective for a specific segment or whether one segment will profit more or less from a specific intervention, or no intervention at all, will generally needs to be considered and tested in advance.

## 5.5. The implications of COVID-19 restrictions for food waste drivers

The sudden and unforeseen COVID-19 outbreak forced national governments all over the world to implement restrictive measures that proved to be effective in containing the diffusion of the virus. At the same time, these measures imposed dramatic changes on the collective management of workplaces, schools and transport systems and on private households' behaviours. On the supply side, social restrictions generated serious inefficiencies and distortions, affecting distribution and logistics, potentially leading to limits on access to food and to the generation of food losses. On the demand side, the lockdowns generated peaks of food consumption at home, influencing consumers' preferences and purchasing decisions. Lifestyle modifications, reduced incomes and job insecurity contributed to generating psychological stress and a growing sense of uncertainty, including around threats to food security (Ben Hassen et al., 2021; Galanakis, 2020; Lahath et al., 2021), which, together with drastic changes in available time, induced individuals to cope through changes in behaviours and eating habits (Ibn-Mohammed et al., 2021; OECD, 2020). Consumers made changes to how they purchased, preserved and disposed of food in pursuit of access to food (addressing the fear of limited food availability) and food security (addressing the fear of potential contamination). The restrictions forced the entire population to adopt a similar lifestyle while the fear of being exposed to COVID-19 increased. Fear, uncertainty and restrictions influenced grocery shopping approaches. The perception of possible lack of food in shops, the number of meals consumed at home and the limited occurrence of unforeseen events (e.g. a plan for a meal with a certain number of people being changed by a decision to eat elsewhere or with fewer or more people) (Roberts and Downing, 2020; Vittuari et al., 2021) affected food-related decisions and meal management.

While the concept of risk in economics is associated with a measurable probability of future events, the concept of uncertainty refers to a situation of incomplete information or knowledge, where the possible alternatives, the probability of their occurrence and their outcomes are not known by the subjects (Scholz, 1983). The COVID-19 outbreak and its consequences provided a unique opportunity to analyse the impact of crisis-induced changes on household food management and food waste-related behaviours. Despite some initial concerns about a potential increase in food waste levels, multiple studies have shown decreased food waste during the pandemic (Pappalardo et al., 2020; Roe et al., 2021). Available time has proven to be a relevant driver of household food waste, since lack of time is correlated with the occurrence of wasteful behaviours (Smith and Landry, 2020). Indeed, several studies have connected reduced food waste during the pandemic with increased time spent at home (e.g. less travel to work and fewer social activities) which enabled more time and effort to be dedicated to food-related issues and the development of a wide range of positive food management strategies (Vittuari et al., 2021). According to Roe et al. (2021), individuals stated that their housekeeping skills had improved during the pandemic. One exception is a study by Aldaco et al. (2020), which suggested that at the beginning of the pandemic household food waste increased. On the other hand, when waste arising from out-of-home consumption – which drastically fell due to the restrictions – is included, the overall increase in food

waste does not appear significant in comparison with the levels generated before the outbreak. It is worth noting that other authors have pointed out that the COVID-19 pandemic increased other types of waste related to food, such as plastic packaging used for food delivery (Sharma et al., 2020; Vanapalli et al., 2021; Zhang et al., 2022).

**Table 4.** Behavioural drivers of food waste

| Behavioural constructs | Behavioural factors | Drivers (examples) | Levers (examples) | Main references (*) |
|---|---|---|---|---|
| Psychological factors / individual motivations | Attitudes | Media-induced environmental attitudes; personal attitudes towards food waste | Emphasise through different communication strategies the environmental consequences of food waste to generate better attitudes | Abeliotis et al., 2014; Russell et al., 2017; Graham-Rowe et al., 2014 |
| | Awareness | Awareness/perception of consequences of food waste | Emphasise food waste-related issues to raise awareness | van Geffen et al., 2020a; Parizeau et al., 2015 |
| | Perceived control | Perceived consumer effectiveness | Improve consumers' perceptions of their role in food waste reduction | Setti et al., 2018; Graham-Rowe et al., 2015; Ertz et al., 2021 |
| | Emotions and engagement | Risk preferences; healthy diet; enjoyment of food | Emphasise food waste-related issues to trigger guilt, concern and other personal emotions (positive or negative) | Russell et al., 2017; van Geffen et al., 2020a |
| Norms | Social norms | Environmental concern; injunctive norms; descriptive norms | Promote in-person and online community activities to disseminate good practices for reduction of household food waste and food management advice and run awareness-raising campaigns on the environmental consequences of food waste | Schanes et al., 2018a; Elhoushy, 2020 |
| | Personal norms | Subjective views on food waste; non-readily changeable behaviours; being 'a good provider'; saving money | Promote monetary and non-monetary incentives for citizens to reduce food waste | Evans 2011; Graham-Rowe et al.2014; Hebrok and Boks, 2017 |
| Ability | Skills | Planning, food-related capabilities | Introduce and promote meal planning and food storage methods, cooking skills and food waste reduction tips | van Geffen et al., 2020a; Bravi et al. 2020 |
| | Knowledge | Knowledge of techniques for purchasing, managing and discarding food efficiently; | Promote self-learning methods to increase knowledge about food waste generated. | Vittuari et al., 2021; Neff et al., 2019 |

| Behavioural constructs | Behavioural factors | Drivers (examples) | Levers (examples) | Main references (*) |
|---|---|---|---|---|
| | | knowledge of the real quantity of food waste produced | | |
| Micro-level situational factors and opportunities | Time, schedule and lifestyle | Available time; time pressure; purchase planning | Promote efficient meal planning and food storage methods; promote better working time organisation, leaving more free time to be dedicated to preparation of food (e.g. working from home) | Silvennoinen et al., 2012; Stancu et al., 2016; Vittuari et al., 2021; Hebrok and Boks, 2017 |
| | Availability of tools and/or technologies | Availability of tools and technologies | Provide affordable technology and tools (e.g. smart kitchen tools) to enable optimisation of food management | van Geffen et al., 2020b |
| | Food environment | Mismanagement; convenient environment | Design environments that nudge consumers towards food waste reduction practices | van Geffen et al., 2020b |
| Macro-level situational factors and opportunities | Legal and regulatory frameworks | Inefficient legislation; food waste dedicated policies | Promote regulatory frameworks that remove barriers to food waste and encourage practices such as food donation; design public policies fostering incentives for the reduction of household food waste | Boulet et al., 2021; Canali et al., 2017; van Herpen et al. 2019b |
| Demographics | Age | | Promote discussions targeting different generations, considering that different age groups react better to some issues in climate and other awareness-raising campaigns than others | van Geffen et al., 2016; Qi and Roe, 2016; Schanes et al., 2018b; Koivupuro et al., 2012; Parizeau et al., 2015 |
| | Gender | | *No shared consensus on the role of gender* | Secondi et al., 2015; Visschers et al., 2016; Graham-Rowe et al., 2015; Principato et al. 2015 |
| | Household size | | *No shared consensus on the role of household size* | Koivupuro et al., 2012; Parizeau et al., 2015; Silvennoinen et al., 2014 Quested et al., 2013 |

| Behavioural constructs | Behavioural factors | Drivers (examples) | Levers (examples) | Main references (*) |
|---|---|---|---|---|
| | Household composition | | The attitudes of others (partners, friends and family members) may play a key role in supporting individual behaviours, highlighting the importance of social norms | van Geffen et al., 2016; Parizeau et al., 2015; Visschers et al., 2016 |
| | Income | | *No shared consensus on the role of income* | Stancu, et al. 2016; Stefan et al., 2013; Szabó–Bódi et al., 2018; Koivupuro et al., 2012; Qi and Roe, 2016; Graham–Rowe et al., 2014; Quested et al., 2013 |
| | Employment status | | Employed people tend to produce more food waste; therefore, actions targeting workplaces might represent a focus area | Cecere et al., 2014; Secondi et al., 2015; Setti et al., 2016 |
| | Education level | | *No shared consensus on the role of education level* | Schanes et al., 2018; Cecere et al., 2014; Neff et al., 2015 |

(*) Documents included here consider positive, negative or null findings for each behavioural construct.

*Source:* Created by the authors.

## 6. Interventions addressing consumer behavioural change

The complexity underlying consumer food waste means that tailored and diversified actions are required to stimulate behavioural change. The literature addresses this need for action by proposing two different groups of interventions. The first group comprises interventions proposed by authors but not tested (e.g. Canali et al., 2016; Hebrok and Boks, 2017; Karunasena et al., 2021). The second group is based on interventions that are designed for and tested in specific environments (e.g. van Dooren et al., 2020; Visschers et al., 2016; Young et al., 2018).

Building on the results of the expert consultation and on the literature, with inspiration from the behaviour change wheel (Michie et al., 2011), in this chapter designed and tested interventions are organised into specific categories:

— awareness raising;

— economic and material incentives/disincentives;

— nudging strategies and changes to the consumer choice architecture;

— training and knowledge enhancement;

— social influence – showing what others have done.

This classification supports a better understanding of the intervention mechanisms that can be used to reduce food waste through consumer behavioural change. Implementing effective interventions requires the identification not only of behavioural aspects that need to be changed but also of the most suitable intervention design. Some interventions are more suited to moving people towards goal setting, such as awareness-raising campaigns and social influence interventions, while others are more suited to facilitating goal implementation (van Herpen et al., 2019a), such as economic and material incentives, nudging strategies, and training and knowledge enhancement.

### 6.1. Proposed interventions (untested)

This group is made up of studies that, generally, analysed food waste drivers as their primary goal and then built on their specific findings to speculate about effective interventions. These proposed interventions are therefore untested and lack evidence-based results to prove their effectiveness. Not all the intervention types specified above are covered by this group of studies. Table 5 provides a short summary of potential interventions that have been suggested but not implemented or tested.

#### 6.1.1. Awareness raising

Awareness-raising interventions could be carried out through education initiatives to highlight food waste problems among young consumers (Marek-Andrzejewska and Wielicka-Regulska, 2021a), by using virtual platforms and apps to emphasise the value and consequences of avoiding food waste to female consumers (Fami et al., 2019a) or by running campaigns and holding events to sensitise consumers in the home and outside it to the impacts of food waste (Goodman-Smith et al., 2020; Stöckli and Dorn, 2021).

#### 6.1.2. Nudging strategies and changes to the consumer choice architecture

Hebrok and Boks (2017) and Wansink (2018) suggested smaller package sizes and improved packaging or product naming to increase expectations about taste. Measuring cups and portion calculators might be useful to reduce food waste among young consumers (Hebrok and Boks, 2017; Karunasena et al., 2021), and technology-based solutions, such as smart fridges or smart kitchens, could contribute to food waste prevention by enabling optimisation of food management (Hebrok and Boks, 2017; Vittuari et al., 2021). This type of intervention might involve the private sector and/or legislation.

#### 6.1.3. Training or knowledge enhancement

Of the intervention types, training and knowledge enhancement is the most commonly proposed in this group of studies. Food management skills, cooking skills, storage skills and training in methods of dealing with leftovers are mentioned across the relevant studies (i.e. Canali et al., 2016; Karunasena et al., 2021). All these skills could be transferred to consumers in a variety of ways: school curricula, videos and

competitive gamification (Nabi et al., 2021), mobile applications, social media and digital networks (Fami et al., 2019b; Marek-Andrzejewska and Wielicka-Regulska, 2021b).

### 6.1.4. Social influence – showing what others have done

Showing what others have done to reduce food waste (Nabi et al., 2021) might be effective in mitigating food waste through social influence; in addition, online food-sharing platforms used to sell and donate leftovers are emerging as potentially effective interventions (Hebrok and Boks, 2017) using social influence.

## 6.2. Implemented behavioural interventions (tested)

In the set of documents extracted from the bibliometric analysis, 20 papers aiming to test interventions addressing food waste behavioural change were identified. The results show that food waste reduction interventions have been carried out mostly in industrialised countries (e.g. Canada, Italy, the United Kingdom and the United States), both in households and in out-of-home settings. In the latter context, the school canteen is the most important hotspot for intervention studies, followed by restaurants and hotels. Weighing and visual estimation have been widely applied to evaluate interventions' impact. Several studies collected food waste data through consumer self-reporting. Table 6 provides a summary of all these food waste intervention studies, which intervened in various consumption stages. To guarantee more specific evidence-based results in future, it lists the related settings – the environment in which the intervention was tested – and the food waste data collection methods used to evaluate intervention impacts.

Considering the complex settings in which these studies were carried out and the variety of methods and measurement approaches they applied to evaluating the impact of the interventions, it is worth noting that comparing the behavioural change impacts directly would lead to inconsistent results. For instance, impacts are measured in terms of weight, share and per capita savings. However, the present report considers the food waste amounts presented in these studies as a proxy to assess the performance of all the interventions. Table 6 reports the impact of the selected interventions classifying them as (i) high, when the intervention created a positive and significant reduction in the food waste amount; (ii) low, when the intervention created a positive and non-significant reduction in the food waste amount; and (iii) negative, when the intervention created a negative and significant increase in food waste amount.

As illustrated in Table 6, awareness-raising interventions led to a reduction in food waste levels in the majority of the interventions of this type. In most cases, economic and material incentives were effective in food waste reduction (Eckert Matzembacher et al., 2020). Nudging strategies and changes to the consumer choice architecture were demonstrated to have a high impact on food waste reduction. Training and knowledge enhancement interventions produced a low impact in one study out of five. Other interventions, such as food-sharing practices, led to a positive impact in 60 % of the households in question. The results show that most strategies demonstrated a rather good performance in reducing food waste.

### 6.2.1. Awareness raising

Interventions aiming to raise awareness of the environmental consequences of food waste can be classified as awareness-raising campaigns. These are usually carried out by displaying information-based posters, cards or pamphlets to highlight food waste problems and the related variety of impacts and thus trigger consumers' intentions to reduce food waste. Due to their relatively low cost and easy operation, awareness-raising campaigns are one of the major food waste reduction strategies at the consumption stage, despite the fact that several studies have observed low-impact cases (Jagau and Vyrastekova, 2017; Soma et al., 2021; Visschers et al., 2016); on the other hand, a high impact has been found in other tests (Ahmed et al., 2018; Alattar and Morse, 2021; Dolnicar, 2020; Manomaivibool et al., 2016; Stöckli et al., 2018; Werf et al., 2019). To avoid poor performance in food waste mitigation, the information provided should be tailored to take account of consumers' behaviours in different contexts (Schmidt, 2016). Awareness raising conducted through self-reported kitchen diaries enabled individuals to become aware of their own waste-related behaviour and resulted in food waste reduction (Pelt et al., 2020)

### 6.2.2. Economic and material incentives/disincentives

Targeting consumers' personal and consumption norms, economic and material incentives or disincentives can be implemented by changing pricing models from fixed price to variable price based on consumer demand (Eckert Matzembacher et al., 2020). Otherwise, regardless of the price, several studies directly rewarded no-waste consumers (e.g. Dolnicar, 2020), leading to a 14–17 g reduction in food waste per capita. Similarly, establishing fines for leaving too much food unconsumed halved food waste levels from 94.3 g to 43.8 g (Kuo and Shih, 2016). These incentives and disincentives were all applied in out-of-home contexts, and they were generally accompanied by tailored restaurant sales regulations. Overall, all interventions of this type led to food waste reductions.

### 6.2.3. Nudging strategies and changes to the consumer choice architecture

Even though consumers may have strong intentions to avoid food waste, lack of suitable opportunities may nonetheless result in food waste. Nudging strategies could potentially promote food waste reduction from this perspective. For example, serving smaller portions (Ahmed et al., 2018; Kallbekken and Sælen, 2013; Visschers et al., 2016) resulted in a 17–20.5 % reduction in food waste. Similarly, simple tools to measure food during preparation (van Dooren et al., 2020) led to a 6 % reduction in wasted pasta, a 21 % reduction in wasted rice and a 12.5 % reduction in mixed food waste. Improving situational factors, for example by changing plate shape and size (Richardson et al., 2021) or providing canteen decorations and using creative names for school meals (Hamdi et al., 2020), significantly reduced average food waste.

### 6.2.4. Training and knowledge enhancement

Although psychosocial factors typical of the TPB, can explain and influence food waste behaviours, recent findings agree on the importance of households' food-related practices (Stancu et al., 2016; Stefan et al., 2013). The adoption of food waste-reducing routines related to planning, shopping, storing and cooking can significantly affect levels of food waste (Romani et al., 2018; Young et al., 2018). As an example, increasing consumers' meal-planning skills positively impacts the minimisation of food waste (Romani et al., 2018). Similarly social marketing programmes have resulted in reduced self-reported household food waste and increased self-efficacy in cooking (Kim et al., 2020). Experiential learning projects have succeeded in training highly educated students to address food waste reduction and build their own abilities to transform food systems (Ahmed et al., 2018). Providing tips for food storage, meal planning, shopping and recipes through fridge magnets and newsletters produced no significant results (Soma et al., 2020), while providing information on the quantity and monetary impact of food waste was found to be a successful intervention (van der Werf et al., 2021).

### 6.2.5. Social influences – showing what others have done

Perceived social norms related to the behaviour of others can steer individuals towards pro-environmental behaviour (Osbaldiston and Schott, 2012). Social influence can promote food waste reduction behaviours, leveraging on the impulse of people to compare themselves with others (Young et al., 2018), with consumers seeking to reduce waste levels to conform with their social groups (van Geffen et al., 2017). Interventions testing messaging about subjective norms have proven to be successful in reducing food waste. For example, the use of on-pack stickers in supermarkets increased the percentage of shoppers avoiding food waste, leading to an annual per capita saving of almost EUR 100 (Young et al., 2018). By contrast, community workshops attracted a low level of participation and had no significant effects on food waste reduction (Soma et al., 2020).

Food-sharing practices have become increasingly widespread, in terms of both a growth in initiatives and the emergence of start-ups; however, their correlation with waste reduction has rarely been tested. One of the few examples is Morone et al. (2018); the study focused on the food-sharing practices of students purchasing, cooking and consuming food collectively. The study found a positive impact leading to food waste reduction in 60 % of the households in question (Morone et al., 2018).

**Table 5.** Levers – areas of opportunity and potential intervention types (untested)

| Levers – areas of opportunity for action | Intervention type | Potential interventions | Setting | Main references |
|---|---|---|---|---|
| Emphasise through different communication strategies the environmental consequences of food waste to generate better attitudes | Awareness raising | Educational initiatives in rural areas that highlight food waste problems | Household young consumers | Marek-Andrzejewska and Wielicka-Regulska, 2021a |
| Emphasise food waste-related issues to raise awareness | | Raise awareness about the value and consequences of avoiding food waste through virtual platforms and apps | Household female consumers | Fami et al., 2019a |
| Improve consumers' perceptions of their role in food waste reduction | | Emphasise the cost-saving potential of food waste reduction in a campaign, referring to economic, environmental and social motivators | Restaurant/café consumers | Goodman-Smith et al., 2020 |
| Emphasise food waste-related issues to trigger guilt, concern and other personal emotions (positive or negative) | | Campaigns or events that sensitise people to the environmental consequences of consuming only fruit and vegetables that comply with conventional norms | Household consumers | Stöckli and Dorn, 2021 |
| Design environments that nudge consumers towards food waste reduction practices. Examples are cafeterias decorated with food waste awareness messages, increased quality of food available in food services, reduced portions, providing plates of a shape and size that discourage the self-serving of large quantities of food | Nudging strategies and changes to the consumer choice architecture | Provide free tools such as measuring cups and portion calculators | Household young consumers | Hebrok and Boks, 2017; Karunasena et al., 2021; |
| | | Smaller package sizes | Household consumers | Wansink, 2018; Hebrok and Boks, 2017 |
| | | Improve expectations about taste through packaging or product naming changes | | |
| Provide affordable technologies and tools (e.g. smart kitchen tools) to enable optimisation of food management | | Smart kitchens, smart fridges | Household consumers | Hebrok and Boks, 2017; Vittuari et al., 2021 |

| Levers – areas of opportunity for action | Intervention type | Potential interventions | Setting | Main references |
|---|---|---|---|---|
| Introduce and promote meal planning and food storage methods, cooking skills and food waste reduction tips in educational and community-based initiatives | Training and knowledge enhancement | Incorporate food management skills into school curricula | Household young consumers | Karunasena et al., 2021 |
| | | Promote short videos on cooking with leftovers | | |
| | | Create exciting competitions using gamification of these desired food management skills | | |
| | | Increase household inventory turnover and encourage more frequent purchases | Household consumers | Wansink, 2018 |
| | | Promote storage solutions that facilitate consumption, such as storing on the central refrigerator shelf | | Hebrok and Boks, 2017; Wansink, 2018 |
| | | Provide easy tips for cooking, storage, food handling and using leftovers through a mobile application to facilitate shopping and meal planning | Household young consumers | Marek-Andrzejewska and Wielicka-Regulska, 2021 |
| | | Improve knowledge and skills on planning, preparation and storage using social media, digital networks and apps | Household female consumers | Fami et al., 2019 |
| Promote in-person and online community activities to disseminate good practices for reduction of household food waste and food management advice and run awareness-raising campaigns on the environmental consequences of food waste | Social influences – showing what other have done | Intergenerational cooking shows/events | Household young consumers | Karunasena et al., 2021 |
| | | Social sharing platforms | Household consumers | Hebrok and Boks, 2017 |

*Source:* Created by the authors.

**Table 6.** Levers – areas of opportunity and suggested intervention types (tested)

| Levers – areas of opportunity for action | Intervention type | Intervention description (examples) | Setting | Impact | Data collection method | Countries | Main references |
|---|---|---|---|---|---|---|---|
| Emphasise through different communication strategies the environmental consequences of food waste to generate better attitudes | Awareness raising | Emphasise food waste problems, such as social, economic and environmental impacts, by displaying posters, table cards, messages, booklets, signage and pamphlets and providing self-reported kitchen diaries to trigger personal emotions such as guilt to raise awareness | Students, restaurant consumers, household consumers | High (7 studies)  Low (3 studies) | Visual estimation, weighing | Canada, Netherlands, Switzerland, Thailand, United States | Ahmed et al., 2018; Alattar and Morse, 2021; Dolnicar, 2020; Jagau and Vyrastekova, 2017; Manomaivibool et al., 2016; Pelt et al., 2020; Soma et al., 2021; Stöckli et al., 2018; Visschers et al., 2016 van der Werf et al., 2021 |
| Emphasise food waste-related issues to raise awareness | | | | | | | |
| Improve consumers' perceptions of their role in food waste reduction | | | | | | | |
| Emphasise food waste-related issues to trigger guilt, concern and other personal emotions (positive or negative) | | | | | | | |
| Promote monetary and non-monetary incentives for citizens to reduce food waste. Examples are material rewards for reducing food waste in food service settings; designing different pricing models for services such as buffets and canteens; financial penalties for leaving too much food unconsumed | Economic and material incentives/disincentives | Different pricing models: variable-price buffet service, fixed-price buffet/canteen service, fixed-price table service | Restaurant consumers | High (depending on levels of incentives) | Weighed by a digital scale | Brazil | Eckert Matzembacher et al., 2020 |
| | | Material reward for never wasting food during a hotel stay | Hotel consumers | High | Weighing | Slovenia | Dolnicar, 2020 |
| | | Fine for leaving too much food unconsumed | University students | High | Weighing | Taiwan | Kuo and Shih, 2016 |

| Levers – areas of opportunity for action | Intervention type | Intervention description (examples) | Setting | Impact | Data collection method | Countries | Main references |
|---|---|---|---|---|---|---|---|
| Design environments that nudge consumers towards food waste reduction practices. Examples are cafeterias decorated with food waste awareness messages, increased quality of food available in food services, reduced portions, providing plates of a shape and size that discourage the self-serving of large quantities of food | Nudging strategies and changes to the consumer choice architecture | Reduced portion sizes | Students, hotel consumers | High | Weighing | Norway, Switzerland, United States | Ahmed et al., 2018; Kallbekken and Sælen, 2013; Visschers et al., 2016 |
| | | Providing measuring cups | Household consumers | High | N/A | Netherlands | van Dooren et al., 2020 |
| | | Changing plate shape and size | Students | High | Visual estimation and weighing | United States | Richardson et al., 2021 |
| | | Multi-level approaches: **cafeteria decorations** (e.g. fruit and vegetable rainbow mural); **creative names** (e.g. 'Brain-Boosting Broccoli'); '**social norming tease test**' (displaying the student vote results when offering a choice of different meals); setting up a '**flavour station**' (offering spices and seasonings) | Students | High | Visual estimation and weighing | United States | Hamdi et al., 2020 |
| Introduce and promote meal planning and food storage methods, cooking skills and food waste reduction tips in educational and community-based initiatives | Training and knowledge enhancement | Introduce meal planning and food storage methods, cooking skills and food waste reduction tips | Household consumers, students | High (4 studies) Low (1 study) | Self-reported, weighing | UK, USA, Canada, Australia, Italy | Ahmed et al., 2018; Kim et al., 2020; Romani et al., 2018; Soma et al., 2020; van der Werf et al., 2021; Young et al., 2018 |
| Promote in-person and online community activities to disseminate good practices for reduction of household food waste and food | Social influence – showing what others have done | On-pack sticker campaign, detailing cooking and storage methods and how the other shoppers avoid food waste, together with | Shoppers | High | Self-reported | United Kingdom | Young et al., 2018 |

| Levers – areas of opportunity for action | Intervention type | Intervention description (examples) | Setting | Impact | Data collection method | Countries | Main references |
|---|---|---|---|---|---|---|---|
| management advice and run awareness–raising campaigns on the environmental consequences of food waste | | an online platform for sharing food waste reduction tips | | | | | |
| | | Community workshops (sharing cooking and storage methods, general food waste issues wrap–up) | Household consumers | Low | Waste audits, household surveys | Canada | Soma et al., 2020 |
| | | In the **food–sharing** treatment group, consumers were instructed to purchase food, cook it and consume it collectively | Household consumers | High (60 % households), Negative (40 % households) | Weighing | Italy | Morone et al., 2018 |

*Source:* Created by the authors.

# 7. Conclusions

This report aimed to review the context characterising food waste generation at the consumer level (in and outside the home) and to identify the mechanisms of behavioural change – drivers and levers – that could represent a basis for interventions in food waste prevention and reduction.

Since 2010, the food waste literature has increased exponentially, with more than 250 articles published per year. The topic of consumer food waste was initially observed through the lens of environmental impacts, with publications considering technical aspects such as carbon dioxide emissions and effects on climate change. Later, the topic of behavioural analysis rose to prominence, registered the most coverage in 2019. Two major clusters of topics can be identified in consumer food waste publications today, one relating to consumer behaviour interventions and drivers and the other to the environmental aspects of food waste. However, leaving aside the trends over time, behavioural issues in consumer food waste are today the most investigated topic in absolute terms.

Food waste can be understood as the product of individual behaviours that are driven by a wide range of factors. Individual factors such as attitudes, motivations and preferences are coupled with social and situational factors. Consumer food waste is complex, but – while it is influenced by the food supply chain and the food environment – it has been recognised as essentially a behavioural issue in which multiple interrelated and competing drivers play an influential role (Barone et al., 2019; Thyberg and Tonjes, 2016). Therefore, the literature has shifted to pay significant attention to consumer behaviour, prompted by the idea that stimulating behavioural change might make a significant contribution to reducing food waste.

Food waste is the result of multiple and interconnected behaviours taking place at different moments and stages in the food supply chain. Developing or adapting theoretical and conceptual frameworks to investigate food waste represents a further step towards understanding this complex issue. Most of the frameworks that have been developed represent theoretical contributions, since their application is still limited. However, the TPB and the MOA framework have been applied to analysing consumer food waste in several contexts and countries.

Consumer food waste's complexity means that tailored and diversified actions are required to stimulate behavioural change. The literature addresses this need for action by proposing two different groups of interventions. The first group comprises interventions proposed by authors but yet to be tested (e.g. Canali et al., 2016; Hebrok and Boks, 2017; Karunasena et al., 2021). In contrast, the second group is based on interventions that are designed for and tested in specific environments (e.g. van Dooren et al., 2020; Visschers et al., 2016; Young et al., 2018).

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## List of abbreviations

| DG | Directorate-General |
|---|---|
| EU | European Union |
| Fusions | Food use for social innovation by optimising waste prevention strategies |
| MCA | multiple correspondence analysis |
| MOA | motivation–opportunity–ability |
| TPB | theory of planned behaviour |
| UN | United Nations |
| WoS | Web of Science |
| WRAP | Waste and Resources Action Programme |

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## Annex – KeyWords Plus by cluster

| KeyWord Plus | Cluster | KeyWord Plus | Cluster |
| --- | --- | --- | --- |
| supply.chain | 1 (red) | households | 2 (blue) |
| quantification | 1 (red) | policy | 2 (blue) |
| losses | 1 (red) | design | 2 (blue) |
| framework | 1 (red) | green | 2 (blue) |
| countries | 1 (red) | information | 2 (blue) |
| retail | 1 (red) | shelf.life | 2 (blue) |
| management | 2 (blue) | model | 2 (blue) |
| prevention | 2 (blue) | quality | 2 (blue) |
| reduction | 2 (blue) | choice | 2 (blue) |
| behaviors | 2 (blue) | health | 2 (blue) |
| barriers | 2 (blue) | food.waste | 2 (blue) |
| food | 2 (blue) | waste | 2 (blue) |
| behavior | 2 (blue) | system | 3 (green) |
| generation | 2 (blue) | life.cycle.assessment | 3 (green) |
| impact | 2 (blue) | anaerobic.digestion | 3 (green) |
| planned.behavior | 2 (blue) | greenhouse.gas.emissions | 3 (green) |
| determinants | 2 (blue) | environmental.impacts | 3 (green) |
| supermarket | 2 (blue) | systems | 3 (green) |
| products | 2 (blue) | climate.change | 3 (green) |
| perception | 2 (blue) | impacts | 3 (green) |
| consumer | 2 (blue) | sustainability | 3 (green) |
| attitudes | 2 (blue) | energy | 3 (green) |
| drivers | 2 (blue) | water | 3 (green) |
| consumption | 2 (blue) | fruit | 3 (green) |
| perceptions | 2 (blue) | vegetables | 3 (green) |
| consumers | 2 (blue) | performance | 3 (green) |

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