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How to reduce consumer food waste at household level: A literature review on drivers and levers for behavioural change

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How to reduce consumer food waste at household level: a literature review on drivers and levers for behavioural change

Abstract

Consumer food waste at the household level results from a complex set of different behaviours. They are influenced by psychological, socio-cultural, and economic factors such as awareness, attitudes, cognitions, emotions, and context-related factors such as available technologies, referred to as drivers. Furthermore, opportunities to reduce food waste systematically and practically, referred to as levers are distinct from drivers but have rarely been documented in previous studies. Identification of drivers and levers helps to design accurate interventions to tackle consumer food waste. To provide a systematic overview of these 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 (MOA) framework distinguishing micro, meso and macro situation factors, and iii) an iterative feedback mechanism with experts of the European Consumer Food Waste Forum established by the European Commission in 2021. Drivers and levers of consumer food waste are identified, categorised, analysed, and discussed in line with the revised MOA framework. Thirteen drivers and their connected levers were identified in the literature in response to the MOA framework, while others fell under individual characteristics such as demographics. Considering different consumer segments into account when considering drivers and levers has been identified as a powerful instrument that could help design more impactful interventions. Similarly, targeting particular consumer segments with interventions may also maximise the food waste prevention effect (e.g., those consumers wasting the most or those most likely to change their behaviour). Hence, the reviewed studies provide several indications of potential consumer food waste reduction interventions with their limitations and advantages under specific environmental settings. This review leads to a research agenda to understand household food waste better and develop more evidence-based interventions and standardised methods to measure their impacts.

Keywords: food waste prevention; consumer behaviour; food systems sustainability; consumption patterns; food waste reduction;

1. Introduction

Food waste and losses have been globally recognized among the most important manifestations of food system inefficiencies. In Europe in 2020, household and food service sectors accounted for about 65% of food losses and waste (Eurostat, 2022).The United Nations (UN) Sustainable Development Goal (SDG) 12.3 calls for reducing food losses along production and supply chains, including post-harvest losses, and halving per capita global food waste at the retail and consumer levels (UN General Assembly, 2015). The UN Food System Summit 2021 also asked for food waste mitigation actions ensuring co-benefits for the society and environment. Overall this call was for a wide engagement of stakeholders, ranging from academic organizations to civil society to the policy domain. Further emphasis was put on the fact that responses to climate change require coupling public interventions with individual actions during the UN Framework Convention on Climate Change's 26th Conference of the Parties (COP26). At the EU level, the ambition of targeting food waste has been operationalized with the EU Platform on Food Losses and Food Waste established in 2015, which brings together institutions, experts, relevant stakeholders and EU Member States (MSs). A key action against food waste in the Farm to Fork Strategy – a core strategy within the European Green Deal aiming to make food systems fair, healthy and environmentally friendly – is, aside from the commitment to achieve target 12.3, the definition of binding targets for food waste amounts in MSs.

To define its targets, the European Commission follows its definition of food waste based on the definition of food in Article 2 of Regulation (EC) No 178/2002 (European Parliament and Council, 2002). Acknowledging that defining food waste is notoriously difficult as it depends on various factors (Sanchez et al., 2020), the authors of this work follow the FUSIONS framework, which defines food waste as “food and inedible parts of food [*including drinks*] removed from the food supply chain” that is to be disposed of (e.g., crops ploughed back into the soil, left unharvested or incinerated, food disposed of in sewers or landfill sites, or fish discarded at sea) or used for nutrient recovery or energy generation (e.g., through composting, or anaerobic digestion and other bioenergy pathways) (Östergren et al., 2014). Inedible parts of food are those parts that are not intended for human consumption, such as bones.

Looking at the contributors of food waste both in industrialized (Stenmarck et al., 2016) and non-industrialized countries (UNEP, 2021), a large part of the literature allocates the responsibility to consumers, particularly at the household level (Stenmarck et al., 2016). As a result, along with the definitional debate, growing attention has been dedicated to the consumption stage and the drivers of consumer food waste (Harvey et al., 2022). We follow this trend by mapping the drivers and levers of consumer food waste at the household level. Under drivers, we understand the factors that impact behaviour, such as awareness, attitudes, cognitions, emotions, and external, context-related factors, such as available technologies or the behaviour of others. As levers, we consider those aspects of drivers that can be leveraged to influence food waste behaviour by implementing specific interventions systematically.

Before 2010, research on food waste was limited. However, it expanded rapidly after two leading publications in this area (FAO, 2011; Parfitt et al., 2010). The way food waste has been addressed in this period time encompasses several challenges and perspectives both in terms of scope (measurement and quantification, identification of food waste drivers, assessment of the impacts, management practices, identification of successful interventions) and in terms of disciplines (at least economics, management science, political science, psychology, sociology, food technology). Therefore, identifying and understanding food waste drivers and levers are often mixed with other goals. To unveil such complexity and consider

the rapid growth of attention to the food waste topic expressed by the increasing number of documents in recent years and the diversity of publishing journals, a more systematic approach to reviewing the state of the art is needed.
This work reviews and critically appraises the literature identifying consumer food waste drivers and levers. These insights aim to lay the foundation to identify different profiles of consumers and their likelihood to reduce their food waste levels and then can inform targeted interventions. The review also provides recommendations for further research in consumer food waste prevention, focusing on drivers and levers of individual behaviour.

2. Methodology

Scientific literature was collected considering a high number of documents from journals covering a wide range of sectors. An automated bibliometric approach was adopted for the preliminary selection and screening of scientific and grey literature covering food waste topics (section 2.1). Then academic and grey literature was analysed to categorise documents according to the topics investigated systematically and to select relevant works for mapping drivers and levers of consumer food waste at the household level (section 2.2). Finally, the most relevant works were selected for discussion according to number of citations and journal impact factor.

2.1 Document collection

This work is based on a bibliometric literature review integrated with the feedback from the 16 members of the European Consumer Food Waste Forum (ECFWF), an experts group including researchers and practitioners with a recognised knowledge of food waste related issues.[1]
The bibliometric literature review statistically analyses the bibliography information of published manuscripts and documents, allowing to handle of large numbers of contributions. This approach ensures a more objective selection of documents and provides insights into the evolution of a topic over time. It combines qualitative inputs (the documents) with quantitative outputs (e.g., quantitative analysis of co-citations and citation networks or the distribution of published articles over time). The Bibliometrix R package (Aria and Cuccurullo, 2017) was adopted for data analysis and visualization.
To set the ground for the bibliometric analysis and better define the boundaries and the key elements of the work, a first opinion poll with experts from the ECFWF was organised to develop the search queries described below, adopted to identify the relevant literature. On top of the identified search queries, ECFWF experts highlighted the scientific papers and grey literature they considered fundamental for analysing the drivers of consumer food waste and the most relevant food waste reduction interventions. Finally, experts were asked to identify the most relevant theoretical framework to investigate the drivers of consumer food waste and identify the most efficient classification of behavioural change levers.
The search for scientific literature on consumer food waste was conducted through the Web of Science (WoS) portal to identify papers published from 2010 to November 2021, including

[1] In 2016 the Communication on Circular Economy called on the Commission to establish the European Union (EU) Platform on Food Losses and Food Waste, bringing together EU institutions, experts from the EU countries Member States and relevant stakeholders selected through an open call. During the 2016-2021 mandate, the Platform engaged its members to work on food waste measurement, date marking, food waste prevention, and food donation. For the 2022-2026 mandate the Platform has identified as the ambition to establishment of EU-level targets for food waste reduction which represents a key deliverable of the Farm to Fork Strategy.

the terms “food waste” and “consumer*” in the abstract, the title, or among their KeyWord Plus. KeyWord Plus are standardized keywords generated by an WoS algorithm developed by WoS that selects words or phrases that frequently appear in the titles of article's references, but do not appear in the title of the article itself (Garfield and Sher, 1993). Also, the term “consumer*” is a truncated expression that covers “consumer”, “consumers”, and “consumer’s”, amongst others. The search resulted in a first dataset of 1,160 scientific articles.

This dataset was then integrated with grey literature identified through a search on Google Scholar for documents related to consumer food waste published in English from January 1st 2010 to November 1st 2021. Those documents were then integrated with those suggested by the experts, and duplicates were removed. This process added 78 documents to the first dataset and generated a final dataset of 1,238 documents, completed on November 18th, 2021 (Figure 1).

To make grey literature documents suitable for the bibliometric analysis, a set of specific keywords has been extracted for each of them. Keyword extraction was performed using the YAKE! Algorithm, an extension of the established keywords extraction algorithm RAKE (Campos et al., 2020). Since not all grey literature documents had preselected keywords or a proper abstract, keywords were identified and also analysed in the foreword and introduction sections when present. Results generated from the YAKE! Algorithm were interpreted by the authors, and a final set of keywords for each grey literature document was identified.

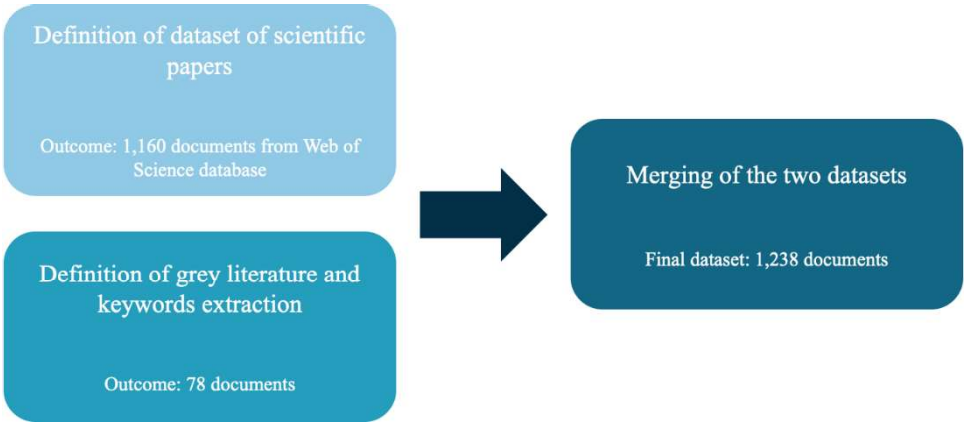

Figure. 1 Dataset Development

2.2 The systematic review: classification of consumer food waste studies

The bibliometric analysis presented in this work was developed in two phases. The first consisted of a descriptive analysis of the number of publications, their impact on the scientific discourse, and the identification of journals with the highest numbers of publications on drivers of food waste at the consumer level.

The second step consisted of the analysis of the documents’ conceptual structure of documents to identify the homogeneous groups, or clusters, of those expressing common concepts. This analysis was conducted by implementing a Multiple Correspondence Analysis (MCA), a data analysis technique for identifying underlying structures in datasets (Greenacre and Blasius, 2006). MCA output was the starting point for analysing keywords of selected documents, allowing the authors to identify the patterns of topics present in the literature (Aria and Cuccurullo, 2017).

The final output of the bibliometric analysis consisted of the automatic categorisation of 909 documents out of 1,238 in 3 homogeneous groups: cluster 1, including 854 documents, cluster 2, including 2 documents; and cluster 3, with 53 documents. A further analysis, supervised by

the authors, of the papers not assigned automatically to the clusters allowed to manual assign 231 other papers to the 3 groups of documents, namely 135 to cluster 1, 41 to cluster 2, and 55 to cluster 3. The remaining 98 documents were considered unsorted and excluded from further investigations.

After the categorisation of documents, the final dimensions of the clusters are 989 documents in cluster 1, 43 documents in cluster 2, and 108 documents in cluster 3.

Figure 2 illustrates the map of the three clusters obtained by analysing of the dataset. The x axis represents the most important dimension regarding the amount of variance accounted for (in parenthesis), while the y axis is represents the second most important. Cluster 1 (in blue), the largest, includes documents whose keywords refer to consumer behaviour interventions and drivers. Hence consumers, health, drivers, barriers, perceptions, and determinants are dominant in the documents included in this group. Cluster 2 (in green) includes documents whose keywords are related to the environmental dimension connected to food waste. Here the explored themes are connected to keywords such as water, energy, environmental impact, performance, and sustainability. Finally, Cluster 3 (in red) includes papers investigating topics on food waste quantification, retail sector and food losses.

Hence, the documents investigating topics relevant to this work are those included in cluster 1, as it considered all the documents investigating the behavioural factors of consumer food waste. So, articles included in cluster 2 (related to the environmental impact of food waste), in cluster 3 (related to quantification and food losses topics), and unsorted were not considered in further analysis.

Starting from the 989 documents identified in cluster 1, a subset of documents was considered for an in-depth review of the text according to three groups of keywords: (i) those including “lever”, “driver*”, “determinant*” and “cause” keywords; (ii) those including “conceptual framework” and “theoretical framework”; (iii) those including “intervention*”, “strateg*”, and “initiative*”. After this additional step, 225 documents were considered.

The same procedure was adopted to identify the relevant articles investigating behavioural change interventions to reduce food waste. Among those, only studies that i) had reducing consumer food waste from the perspective of changing consumer behaviour as their main objective, ii) applied effective intervention impacts evaluation methods, and iii) presented sufficient information on the intervention testing results were retained for further discussion. The final group of documents on behavioural change included 20 studies, with 14 documents from the intervention group, 2 papers from the driver group found relevant for the intervention testing, and another 4 extra studies recommended by experts during the first round of manuscript review.

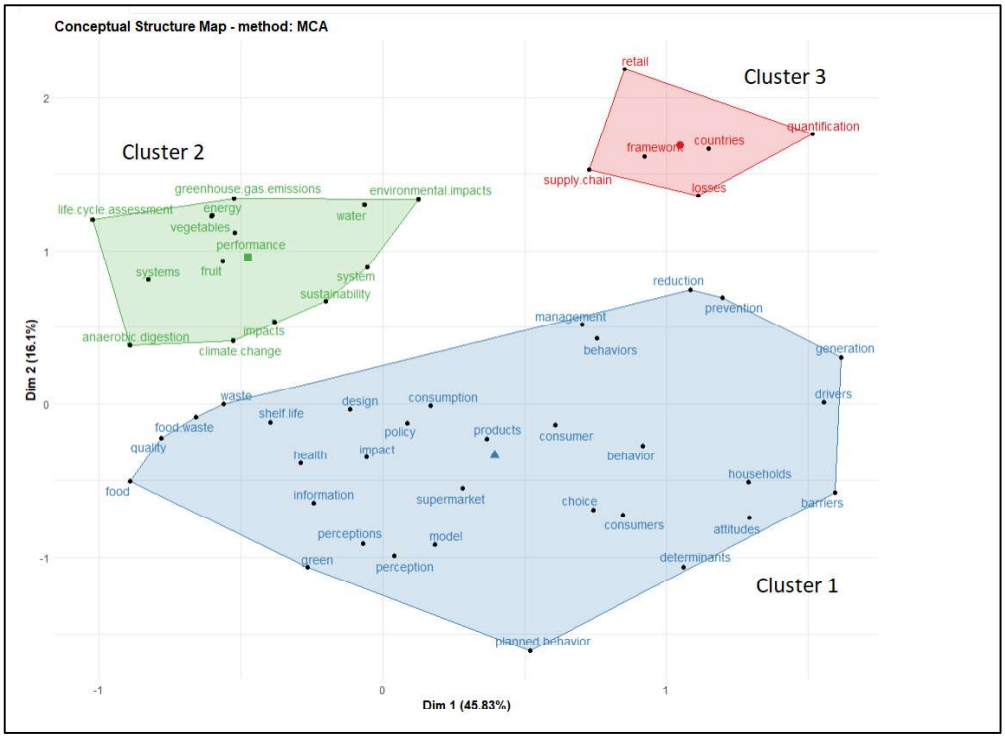

Figure 2. Conceptual structure of the dataset from Multiple Correspondence Analysis (MCA) – "*Dim 1"=most important latent dimension and "Dim 2"=second most important latent dimension in terms of proportion of variances retained by the dimensions represented in the two axes (value in parenthesis).*

The discussion was then conducted on the documents included in cluster 1 and complying with the following criteria: i) papers published before 2015 should have received at least 40 citations, ii) papers published between 2016 and 2019 should have received at least 20 citations, iii) papers issued in 2020 and 2021 should have been published in journals with an impact factor at least equal to 4. These criteria were not applied to grey literature, which was included in the discussion based on keywords.

3. Results and Discussion

This review presents a systematic assessment of the scientific and grey literature published from January 1st, 2010, to November 1st, 2021 based on an adjusted version of the Motivation-Opportunity-Ability (MOA) framework. This approach allowed to draw an overview of the current knowledge on food waste at a consumer level and to describe food waste drivers and potential levers or opportunities to reduce food waste resulting from behaviour systematically.

3.1 Motivation Opportunity Ability (MOA) framework

Several authors suggested potential theoretical frameworks to analyse food waste behavioural drivers, among which one of the first and most often applied is the Theory of Planned Behaviour (TPB). However, this framework limits the analysis only to cognitive drivers related to food waste, which is assumed as intended behaviour. (Quested et al., 2013; van Geffen et al., 2016). An attempt to overcome TPB's limitation is represented by the Motivation-Opportunities-Abilities (MOA) framework, adopted in this work to classify drivers, levers, and interventions related to consumer food waste. Inspired by the work of Rothschild (1999) and Ölander and Thøgersen (1995), the MOA framework models behaviour as the outcome of three theoretical constructs (van Geffen et al., 2017, 2016). While Motivation encompasses

attitudes, intentions and norms identified by the TPB, Opportunities and Abilities expand the framework out of cognitive boundaries, bringing added value to the framework. Opportunity refers to the availability and accessibility of materials and resources needed to change behaviour (MacInnis et al., 1991; Rothschild, 1999). For example, time and schedule, materials, technologies and infrastructure influence opportunity by shaping food waste drivers such as a 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). Abilities refer to the knowledge, skills and individual capacities to solve the problems encountered when changing behaviour, including breaking well-formed habits and routines or countering the peers' arguments (Rothschild, 1999).

Therefore, unlike the TPB, the MOA framework considers food waste not as a purely intended outcome but as an unintended consequence of iterative decisions and behaviours related to in - and outside home food management practices, driven both by internal (individual) and external (social and societal) factors.

A further attempt to provide a framework for consumer food waste drivers, which is also exploited in this work, is proposed by Boulet et al. (2021), who suggest a three-level perspective. The *micro* level considers the individual as a focal entity, the *meso* level is related to the social unit within the physical setting of the household, and the *macro* level represents the material and social setting out-of-home. As in the MOA, this Multi-level Framework for household food waste and consumer behaviour moves beyond cognitive aspects, integrating a large variety of external elements and daily routines around food practices into the analysis. Given the potential of MOA for analysing consumer food waste in several contexts and countries, this work builds on a revised version of this framework that integrates the three-level perspective of Boulet et al. (2021).

3.2 Framing drivers and levers of consumers food waste

As described in the previous section, food waste literature shifted attention from measurement to consumer behaviour on the base of the concept that stimulating behavioural change might ensure a significant contribution in terms of food waste reduction. Individual food waste behaviour is driven by a wide range of factors, including multiple and interconnected behaviours taking place at different stages of the food supply chain (Bretter et al., 2022; Quested et al., 2013; Setti et al., 2018; van Geffen et al., 2016). Individual factors such as attitudes, goals, motivations, and preferences influence food waste, together with social and situational factors.

Moreover, the role of specific food waste drivers varies across food management stages due to different consumer behaviours (Block et al., 2016). These stages encompass planning, purchasing, storing, preparing, consuming and disposing (Boyd and McConocha, 1996; Stancu et al., 2016; Stefan et al., 2013). Some drivers are more relevant than others in affecting behaviours related to food waste in each stage, where individuals adopt repetitive, multiple and hidden choices (Setti et al., 2018). Such complexity requires a better understanding of the drivers and levers, especially to design effective interventions to reduce consumer food waste. To face this complexity, this work adopts the MOA framework to classify and structure drivers and levers of food waste. This structure also helps to identify which interventions, generally understood as actions implemented to change behaviours and outcomes systematically, can be the most efficient for reducing consumer food waste.

In the next paragraphs, drivers, levers and interventions for consumer food waste reduction are identified, analysed and discussed in the light of the constructs defined in the MOA framework. Also, levers are classified on the base of the findings of literature to identify which

drivers have to be targeted by policy interventions to achieve a decrease in consumer food waste.

3.2.1 Motivations

Table 1 includes an overview of behavioural factors, drivers and levers related to Motivation, considered as the intention of consumers to adopt actions to reduce food waste (Vittuari et al., 2020). The impact of motivations in avoiding or reducing food waste relies on their positive or negative effects on the individual propensity to achieve such reduction (e.g., how people think and feel about wasting food) (Abeliotis et al., 2014; Russell et al., 2017; van der Werf et al., 2021). Motivations, and consequently behaviours, towards food waste are influenced by the awareness of the problem and of its personal and global impacts (Abeliotis et al., 2014; Russell et al., 2017). Motivations are also determined by an individual's perception of the personal capability of reducing food waste (Ertz et al., 2021). Emotions, personal concerns around health and environmental issues, and preferences towards healthy diets are also crucial in driving motivations towards food waste minimisation (Russell et al., 2017; van Geffen et al., 2020a).

Table 1. Examples of behavioural drivers and levers of food waste related to Motivation

Behavioural factors	Drivers	Levers
Psychological factors/ individual motivations		
Attitude (Abeliotis et al., 2014; Russell et al., 2017; Graham-Rowe et al., 2014)	Media-induced environmental attitude; personal attitudes towards food waste.	Emphasize the environmental impact of food waste through communication strategies to trigger better attitudes.
Awareness (van Geffen et al., 2020a; Parizeau et al., 2015)	Awareness/perception of consequences of food waste.	Emphasize food waste-related issues for instance raise awareness.
Perceived control (Setti et al., 2018; Graham-Rowe et al., 2015; Ertz et al., 2021)	Perceived consumer effectiveness.	Improve consumer perception on their role on food waste reduction.
Emotions and engagement (Russell et al., 2017; van Geffen et al., 2020a; Birau and Faure, 2018)	Risk preferences; healthy diet; enjoyment of food.	Emphasize food waste-related issues to trigger concern and other personal emotions.
Norms		
Social norms (Schanes et al., 2018a; Elhoushy, 2020)	Environmental concern; injunctive social norms; descriptive social norms.	Host community events to promote good practices in reducing food waste and conduct awareness campaigns.

Personal norms (Evans 2011; Graham-Rowe et al.2014; Hebrok and Boks, 2017)	Subjective views on food waste; non-readily changeable behaviours; being a good provider; saving money.	Promote monetary and non-monetary incentives to reduce food waste.

Potential levers related to individual motivations to reduce food waste might emphasize food waste-related issues to trigger concern and other personal emotions (positive or negative). An example is the design of communication strategies highlighting the environmental consequences of food waste to generate better attitudes to raise awareness and improve consumer perception of their role in food waste reduction.
A particular set of motivations are represented by the social norms since individual behaviour is influenced by what other individuals do (descriptive social norms) and what individuals think others expects from them (injunctive social norms). Descriptive social norms include beliefs regarding what is "normal" or usually done, as personal perceptions of other consumers' efforts to prevent food waste (Elhoushy, 2020). Injunctive social norms include beliefs about what is socially approved behaviour, for example, what an individual thinks others approve of regarding food waste (Schanes et al., 2018a). A relevant category of injunctive social norms is represented by the concept of a "good provider", intended as the desire to provide a wide variety of healthy and tasty foods for household members and guests (Evans, 2011; Graham-Rowe et al., 2014; Hebrok and Boks, 2017).
Potential levers related to social norms might regard the promotion of live and on-line community activities to promote results from good practices for reduction of household food waste, food management advice, and awareness campaigns on status and environmental consequences of food waste. In addition, potential levers related to personal norms could promote monetary and non-monetary incentives for citizens to reduce food waste.

3.2.2 Opportunity
Table 2 includes behavioural factors, drivers, and levers related to Opportunity, defined as the possibility for one or more individuals to access external material and non-material resources such as time, technology and infrastructures (MacInnis et al., 1991; Rothschild, 1999).

Table 2. Behavioural factors, drivers and levers of food waste related to Opportunity

Behavioural factors	Drivers	Levers
Micro level situational factors		
Availability of tools and/or technologies (van Geffen et al., 2020b)	Availability of tools and technologies, resources.	Provide affordable technology and tools (e.g., smart kitchen tools) to improve food management.
Time, schedule, and lifestyle (Silvennoinen et al., 2012; Stancu et al.,2016; Vittuari et al., 2021; Hebrok and Boks, 2017)	Availability of time; time pressure; purchase planning.	Promote efficient food planning or storage methods, especially with busy schedules.
Meso level situational factors		
Food environment (van Geffen et al., 2020b)	Mismanagement; convenient environment; packaging size.	Design environments that can nudge food waste reduction practices.
Macro level situational factors		
Provision - adequate provision for consumers to buy appropriate food at appropriate intervals conveniently (Quested and Luzecka, 2014; Wilson et al., 2017)	Inadequate food provision; unbalanced food provision.	Improve food delivery and allocation system.
Legal and regulatory frameworks (Boulet et al., 2021; Canali et al., 2017; van Herpen et al. 2019; Kasza et al., 2019)	Inefficient legislation; food waste dedicated policies.	Improve regulatory framework by promoting food waste reduction/donation activities; integrate food waste mitigation into public policy design.

In the food system domain, Opportunity at the micro level is defined as access to a set of material resources such as technologies and kitchen tools, time availability for food activities, the habits in managing cooking or storing activities (Silvennoinen et al., 2012; Stancu et al., 2016; Vittuari et al., 2021). Proper tools and/or technologies to store raw food and leftovers increase the possibility for consumers to management effectively (van Geffen et al., 2020b), especially during holidays when a sequence of special events and gatherings disrupts food routines. Indeed, lifestyles and routines are decisive in driving households' food waste trends (Hebrok and Boks, 2017) as well as cultural influences, in cookery and traditions. Potential levers related to micro level situational factors could trigger behavioural change by encouraging efficient food planning or storage methods; providing affordable technology and tools, such as smart kitchen tools; promoting working time organizations leaving more free time to be dedicated to the preparation of food (e.g., working from home).
At meso level, Opportunity is influenced by the food environment, defined as the physical, economic, and socio-cultural context in which consumers perform their food-related behaviours. Levers, to take advantage of opportunity for food waste reduction at the meso level could be related to the improvement of food environments, for example by proposing packages of different sizes in supermarkets as a nudge for food waste reduction practices.

Concerning the macro level, Boulet et al. (2021) describe Opportunities as related to the individual or household level. The former level includes the availability of time to plan food purchases better to minimize the risk of wasting food, while the latter refers to the material and social settings and regulations defined beyond the consumer or household level. Examples of

regulation are food provision and waste regulation, food safety standards and recommendations such as different types of expiration dates, recommendations on the re-usability of leftovers, regulations for food donation, and food waste taxes. Those elements generate trade-offs for consumers, who are asked to choose between food waste reduction and stronger mitigation of risks related to food safety. (Kasza et al., 2019).
Also, Canali et al. (2016) identify three categories of drivers related to food legislation and policies influencing consumers' opportunities to reduce food waste: drivers related to agricultural policy and to food quality and marketing standards, drivers related to food safety, consumer health and information, and animal welfare policies, and drivers related to waste and taxation policies. Those policy factors might directly or indirectly influence consumer food storage, preparation, and cooking behaviour, leading to food waste generation.
Finally, van Herpen et al. (2019) highlight the role of food infrastructures. These include the availability and accessibility of stores, their density in a specific area and the typology of food products available.
Potential levers targeting macro level opportunities could include the promotion of regulatory frameworks that remove barriers to food waste reducing practices without significantly compromising food safety, such as revised legislations for food donations; the adoption of public policies fostering incentives for the reduction of household food waste; the differentiation between 'best before' and 'consumed by' products in official risk communication, and an extension of package date labels (Yu and Jaenicke, 2021).

3.2.3 Ability

Following the definition of MacInnis et al. (1991) and Rothschild (1999), Ability represents the capacity of each individual to deal with a specific situation, relying on personal knowledge and skills. Table 3 includes examples of behavioural factors, drivers and levers related to ability.

Table 3. Behavioural factors, drivers and levers of food waste related to Ability

Behavioural factors	Drivers	Levers
Capabilities and skills (van Geffen et al., 2020a; Bravi et al. 2020).	Food management skills; food literacy.	Promote and introduce food planning or storage methods, cooking skills, and food reduction tips.
Knowledge of techniques for purchase, manage food efficiently; knowledge of the amount of food waste produced (Vittuari et al., 2021; Neff et al., 2019).	Promote self-learning methods to increase the food waste related knowledge.	

Within the food domain, ability relates to a set of aspects, in particular concerning skills and knowledge related to food management and food literacy. Those factors span from planning and organisational skills to purchasing ability and food preparation and storing skills (Bravi et al., 2020; Neff et al., 2019; Romani et al., 2018; van Geffen et al., 2020b; Vittuari et al., 2021). Possible levers might be based upon the promotion of food planning or storage methods, cooking skills, food reduction tips, and self-learning methods to increase the knowledge about food waste generated.

3.2.4 Other individual characteristics

Table 4 provides examples of drivers and levers referring to the role of demographic characteristics of consumers in food waste reduction.

Table 4. Behavioural factors, drivers and levers of food waste related to demographics

Behavioural factors	Drivers	Levers
Demographic characteristics	Age (van Geffen et al., 2016; Qi and Roe, 2016; Schanes et al., 2018b; Koivupuro et al., 2012; Parizeau et al., 2015; Szabó-Bódi et al., 2018).	Promote messages targeted to different generations (different age groups are more reactive towards different messages).
	Gender (Secondi et al., 2015; Visschers et al., 2016; Graham-Rowe et al., 2015; Principato et al. 2015; Szabó-Bódi et al., 2018).	*No shared consensus on the role of gender.*
	HH size (Koivupuro et al., 2012; Parizeau et al., 2015; Silvennoinen et al., 2014 Quested et al., 2013).	*No shared consensus on the role of household size.*
	HH composition (van Geffen et al., 2016; Parizeau et al., 2015; Visschers et al., 2016).	The attitudes of other family members (partners, friends and family circles) might play a key role in supporting individual behaviours, highlighting the importance of social norms.
	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).	*No shared consensus on the role of income.*
	Employment status (Cecere et al., 2014; Secondi et al., 2015; Setti et al., 2016).	Employed people tend to produce more food waste. Also, actions targeting the workplace might represent a focus area.
	Education level (Schanes et al., 2018b; Cecere et al., 2014; Neff et al., 2015).	*No shared consensus on the role of education level.*

Socio-demographics are considered to exert an indirect influence on consumer food waste behaviour (van Geffen et al., 2020a), even though the empirical evidence seems far from generating consensus (Schanes et al., 2018a). However, while tailored interventions might change Motivation, Opportunities and Ability, most socio-demographic factors cannot be directly changed (van Geffen et al., 2016).

Age, gender, education level, household size and composition, employment status and income appear to be the most common and relevant factors (van Geffen et al., 2016). According to van Geffen et al. (2016), age seems to be correlated with the quantity of food waste produced and the consumers' attitude towards waste. Indeed, elderly consumers are found to waste less food compared to young consumers. This is due to different attitudes

towards food and higher levels of awareness about the impacts of food waste compared to youngsters (Qi and Roe, 2016; Schanes et al., 2018b). Another factor leading to lower levels of food waste generated by elderlies is the personal experience with food scarcity during and after World War II, especially in Europe (Szabó-Bódi et al., 2018). However, other studies found that differences between older and younger individuals are often inconsistent (Koivupuro et al., 2012; Parizeau et al., 2015).

Evidence on the role of gender differences in food waste generation is not straightforward. Some studies, like Secondi et al. (2015), found that males waste more than females and that females tend to have more positive attitudes towards reducing fruit and vegetable waste (Graham-Rowe et al., 2015). However, other studies found no significant gender effect (Principato et al., 2015) or even that women tend to waste more food than men (Visschers et al., 2016).

On the educational level, despite a lack of shared consensus on this evidence, some authors suggest that higher levels of education might 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 related to food waste levels. In particular, 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). However, this does not apply to households with children, where food waste is higher than in all-adults households of equal size (Parizeau et al., 2015; Visschers et al., 2016; Szabó-Bódi et al. 2018).

While employed people tend to produce more food waste (Cecere et al., 2014) compared to individuals not in the labour force (Secondi et al., 2015), results on the effect of income on food waste levels still need to be determined. 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 which found no relationship between food waste and income (Koivupuro et al., 2012; Qi and Roe, 2016). Additionally, some studies suggest that lower wages or higher food prices (Landry and Smith, 2019) are related to reduced food waste (Britton et al., 2014). 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 that potentially lead to increased frequency of household waste due to burden shifting from retailers to consumers (Setti et al., 2016).

Possible levers targeting demographic factors could include the promotion of discourses targeted to different age groups, considering that some of them are more reactive towards different issues. Also, the attitudes of other family members (partners, friends, and family circles) might play a key role in supporting individual behaviours, highlighting the importance of social norms. Since employed people tend to produce more food waste, actions targeting workplace might represent relevant typology of levers.

3.3 Segmentation and targeting consumers

In the domain of food waste, consumers can be segmented into groups (or clusters) where members are relatively similar with respect to their drivers of food waste and to the amount of food waste 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 multiple characteristics, such as their sensitivity to social norms, access to advanced kitchen tools and technologies, and skills related to food management and disposal.

Segmentation can be the methodological ground 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 frames, or interventions targeting social norms can relate to social norms proper of 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 communication 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).

How the drivers of the target group translate to the most proper selection, design, source, or setting for administrating an intervention is a largely empirical question. While there are some insights from available evidence on the potential reasons why matching can be effective (Boerman et al., 2017; van Reijmersdal et al., 2022), there appears to be no underlying theory. 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, respectively. Also, groups identified as non-responsive to food waste interventions might not be targeted at all. In contrast, one segment might be targeted with an information campaign and another with a nudging intervention. Still, how a targeted intervention would need to be designed to be effective for a specific segment or whether one segment profits more or less from a specific or no intervention at all, mostly needs to be considered or tested in advance.

Targeted interventions can be effective for different reasons. Specifically, they can appear more relevant, fitting, familiar, empowering, and authentic to recipients. In addition, they can be more fluently processed and attract more attention. However, targeted interventions can be less effective, particularly when consumers become aware they are targeted. In this case, the interventions can be perceived as invasive of privacy, manipulative, repetitive, or based on unfair or stereotypic judgments about the person (Teeny et al., 2021).

Table 5 outlines some studies identified in the scientific literature that used segmentation in the context of food waste. Generally, all segmentation studies are based on a survey, like an online questionnaire, to uncover consumers’ attitudes and food-related behaviours then inform the consumer segmentation accordingly. They can also be informed by waste compositional analysis, which helps relate what citizens say they do with what they do. It is a more objective assessment of the consequences of any segment’s behaviour rather than accepting a self-assessment of food waste alone. Alternatively, there should be a focus on technological solutions that can more accurately assess wastage by individuals, for example, cameras linked to Artificial Intelligence (Zhai et al., 2020).

Table 5. Summary of relevant literature findings on consumer segmentation

Segments identified	**Connection with interventions**	**Potential limitations**
UK (Mallinson et al., 2016). Online questionnaire.		
Five consumer groups differed in their food-related behaviours: Epicures; Traditional consumers; Casual consumers; Food detached consumers; Kitchen evaders.	Interventions could target the principal groups identified, except for a new type of consumer identified (called "casual consumers").	Methodological limits due to self-reported information; Possible over-representation of some segments.

Switzerland (Delley and Brunner, 2017). Survey by mail.		
This study identified 6 types of consumers with distinct attitudes towards food waste: Conservative; Self-indulgent; Short-termism; Indifferent; Consumerist; Eco-responsible.	The work provides a multilateral action plan to reduce household food waste according to the different identified segments.	Methodological limits due to self-reported information.
Denmark, Germany, Norway, Sweden, and the Netherlands (Aschemann-Witzel et al., 2021). Online survey.		
This study investigates the relation between price orientation and food involvement in each segment. Well-planning cook and frugal food avoider; Young foodie; Established; Convenience and price-oriented low income; Uninvolved young male waster.	The outcome of this study indicates the typology of consumers that should be involved (or not) in food waste marketing actions and food waste reduction activities by including not often considered dimensions (such as cooking interest).	Methodological limits due to self-reported information; Weak assumptions when defining the segments.
Poland (Marek-Andrzejewska and Wielicka-Regulska, 2021). Online questionnaire survey.		
Three typologies of consumers are identified according to their demographic characteristics: Control-Conscious Young men from urban areas; Positive-Attitude Young women from urban areas; Planning– Seeking Young women from rural areas.	The work provides policy recommendations to address each segment identified.	Methodological limits due to self-reported information; Over-representation of women; A narrow focus on young people.
Australia (Borg et al., 2022). National surveys, in-depth interviews, and food waste audits.		
Three groups of consumers are distinguished in light of food planning behaviours: Under planners; Over providers; Considerate planners.	Over providers warrant a priority focus for interventions from policymakers and practitioners; under planners' changing behaviour will require a shift in choice architecture in food shopping environments.	Survey was limited to food providers; Methodological limits when using self-reported information.
Italy (Vittuari et al. 2020). Consumer in person survey.		
Three groups of consumers were identified according to their ability and motivations to reduce food waste: Pragmatic consumers; Thrifty altruists; Aware wasters.	The work identifies different food waste mitigating factors perceived as effective by consumers: improve quality-to-price ratio, economic incentives to reduce domestic garbage, improve the information available on food products.	Self-reported data may include biases in answers; Non-probabilistic samples can misrepresent some categories of consumers.
Australia (Liu, H., & McCarthy, B. (2022). Consumer in person survey.		

A total of six lifestyle segments are identified: the freshness lovers, the vegetarian and organic food lovers, the recycle/reuse advocates, the waste-conscious consumers, the label-conscious/sensory consumers and the food waste defenders.	The work is based on sustainable lifestyles and attitudes towards food waste and evaluates these drivers' effect on different levels of food waste.	Self-reported data may include biases in answers.

3.4 Limitations

Despite its added value, the methodology adopted for the development and analysis of the dataset also shows some limitations that should be considered for a better understanding of the results.

While the integration of the grey literature represents a novelty and an added value for a bibliometric review, the heterogeneous structure of the work required a supervised selection of the keywords using algorithms that might generate some inaccuracies. To mitigate any limitation, results related to grey literature documents, the definition of their keywords, and their classification were revised through a supervised analysis conducted through manual control of the consistency of the keywords generated for the grey literature documents by automated extraction algorithms.

Another possible shortcoming of the automated bibliometric analysis is related to the linguistic differences between the documents. For instance, inconsistencies might be related to the differences between British and American English. Because of these differences, some keywords are duplicated in the outcomes of the bibliometric analysis (e.g., "behaviour" and "behaviour"). To mitigate this potential shortcoming, outcomes from the bibliometric analysis were interpreted by the author considering synonymous (e.g., drivers and causes) and spelling differences. Furthermore, direct interventions in the dataset, such as changing all the keywords "behaviour" into "behaviour", were kept at a minimum also to avoid discretionarily and ensure the replicability of the method.

The last potential shortcoming is related to consistencies regarding the outcomes of the bibliometric analysis. For instance, the group of keywords related to interventions (e.g., "intervention*", "strateg*", and "initiative*") appears both in studies discussing but not testing interventions and in the studies identifying and testing interventions. To limit this shortcoming, identified documents were analysed through an in-depth text review.

4. Conclusions: a new research agenda for consumer food waste

This paper aimed to review consumer food waste generation at the household level and to disclose the mechanisms of behavioural change - drivers and levers - that could represent the base for interventions aiming at food waste prevention and reduction.

From 2010 until today, food waste literature increased dramatically, disentangling the faceted dimensions of consumer food waste - whilst influenced by food supply chains and food environments - that has been recognized essentially as a behavioural issue where multiple, interrelated and competing drivers and goals play an influential role. Within this evolving body of literature, three major clusters have been identified: one including papers focusing on consumer behaviour interventions and drivers, a second on the environmental dimension of food waste and a third broadly addressing quantification, retail food waste and food losses. This work analysed the first cluster of papers where food waste is defined as the product of

individual behaviours influenced by a wide and interrelated range of drivers as attitudes, motivations and preferences coupled with social norms and situational factors.
To isolate the elements of this puzzle, this paper adopted the lens of the Motivation-Opportunities-Abilities framework that also allowed the identification of levers to design reduction interventions based on specific drivers and targeting selected groups of consumers willing to change their behaviour towards reducing their food waste.
Consumer segmentation studies could support identifying high food waster groups and allow detection of their specific characteristics. Current works were based on surveys to classify and profile consumers according to their roles in food management activities and related habits, demographics, and orientation to food promotions. Despite limitations that might exist due to weaknesses in data collection methods, consumer segmentation leads future studies toward a rather paved way to curb FW and point out directions to design intervention studies.
This review helps identify several knowledge gaps aiming to contribute to creating a new data-driven research agenda stimulating researchers, governments and donors while including important messages to engage all the stakeholders. The final result is the 6-point research agenda proposed here below.
First, results from a systematic literature review show that current studies often fail to disentangle the impact of specific food waste drivers. More empirical studies are required to unveil the role of each specific driver and lever and their relationships. Such an approach could increase the understanding of those drivers that were not considered as particularly influential as demographics.
Second, this work introduces the concept of “lever” as a specific action to tackle specific food waste drivers. Future research should rely on this concept to design more effective food waste reduction interventions and to better estimate their impacts.
Third, current empirical studies often do not focus on consumer segmentation while analysing food waste drivers. Future research should consider tailoring data collection targeting different consumer profiles to identify the groups that are more likely to waste food. Results might leverage information to design policy interventions addressing clusters of consumers with specific characteristics.
Fourth, although some consensus emerges for behavioural models such as the Theory of Planned Behaviour (TPB) and Motivation-Opportunity-Ability (MOA) framework, most current work is not based on a consolidated theoretical framework. For example, the MOA showed the flexibility to be tailored to different contexts. However, it still does not provide information on how the different elements within each construct influence each other. To collect more robust and comparable results, a theoretical framework dedicated to understanding food waste drivers should be developed, addressing the heterogeneous role of drivers according to different consumer typologies. This framework could then be expanded through works exploring each of its constructs and components in detail.
Fifth, most empirical studies are not fully comparable due to the adoption of different measurement approaches. Therefore, a more comprehensive intervention framework and harmonized measurement approaches should be developed to facilitate comparisons to estimate the impacts of specific interventions.
Sixth, self-reporting has been proven to be one of the most common measurement strategies in food waste empirical studies due to its applicability and cost-efficiency. However, it also represents a major limitation due to self-reporting bias. Thus, alternative methodologies relying on new technologies should be developed to improve measurement and intervention evaluations.

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