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UNDERSTANDING FOOD WASTE THROUGH BEHAVIOURAL THEORIES IN DIFFERENT SETTINGS

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Abstract

Sustainable Development Goals 12.3 aims to promote sustainable consumption and production patterns by addressing the global food loss and waste problem. One of its specific goals to reduce food waste at retail and consumer levels by half requires collaborative efforts across all actors to identify better practices and overall achieve environmental integrity, economic viability, and social justice. Given the multiple interrelated impacts, food waste is recognized as one of the major food system challenges. The scope of this work is to contribute to the understanding on food waste generation and potential approaches to tackle it. This work was specifically designed to achieve the following goals: 1) *Understand specific factors that affect individual behaviours to generate FW at household*, 2) *Analyse the effective ways to reduce FW through behaviour change perspective given the catering and hospitality sector*, and 3) *Provide an evidence synthesis on intervention study that incorporate stakeholder insights focus on school meals*. To accomplish these goals, a mixed methodology was employed. The first goal of identifying food waste drivers was achieved by the systematically reviewing on peer-reviewed and grey literature. The Motivation-Opportunity-Ability (MOA) framework was applied to frame consumer behavioural drivers and identify levers that could be potentially utilized to reduce food waste. Consumer segmentation was further discussed to provide insights for developing tailored food waste reduction interventions. The second goal required the identification on practical interventions, which has been accomplished by systematic literature review basing on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses. The efficiency and working mechanism of interventions were evaluated basing on the combination of MOA and behavioural change wheel. Building on the evidence of effective interventions, a roadmap was developed for policymakers and practitioners to lead their own pathway on intervention study and upscaling. The third aim has been achieved with a school meal interventions mapping and the conduct of stakeholder mutual learning workshop. The method is built on the literature review and then enriched by intervention co-design dialogue among academia, municipality, and school management. The outcome improved understanding of the role of school meals in achieving sustainability and the extent to which it can be explored to further promote sustainable development. The overall conclusion addressed the major consumption challenges of food waste determents identification, tailored reduction interventions developing, effective intervention and underlying mechanism understanding, sustainable consumption promotion with school meals.

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OVERALL INTRODUCTION

Consumption stage food waste

The global issue of food waste (FW) is widely recognized as one of the major inefficiencies in the food system (Corrado and Sala, 2018), given its interrelated economic, environmental, and social impacts. The Food and Agriculture Organization (FAO) estimated that 1.3 billion tons of food are wasted annually (FAO, 2011). This waste results in significant economic loss (Ahamed et al., 2016), contributes to greenhouse gas emissions and resource depletion (Scherhaufer et al., 2018). Despite this, global food shortage, malnutrition and other food-related issues continue to be prevalent, particularly in underdeveloped regions (FAO, 2021). The ongoing COVID-19 pandemic has further exacerbated food insecurity (Vittuari et al., 2021) with a rise in the number of people facing food challenges. To address this issue, the United Nations' Sustainable Development Goal 12.3 aims to reduce food losses and waste throughout the production and supply chain process, including post-harvest losses, and aims to reduce the amount of global food waste per person in both retail and consumer levels by half (UN, 2015). In general, the consumption stage is where the most food waste occurs, particularly in developed countries (Beretta et al., 2013; Kummu et al., 2012; Priefer et al., 2016). Data from the European Union shows the household is responsible for 55% of food waste in Europe, which averages out to 70 kg per resident (EU, 2023). Hence, in line with SDGs (UN, 2015), identifying and promoting effective FW management initiatives are also integrated into the EU Green Deal (COMMISSION, 2019) and Farm to Fork Strategy (COMMISSION, 2020) as a crucial component. Additionally, the catering and hospitality sector generates 12% of the total food waste in the EU, coming in as the third highest generator after households and food processing industries (Stenmarck et al., 2016). In China, 13% of wasted food is associated with out-of-home consumption activities (Xue et al., 2021). The situation is even more severe in the USA, where the catering and hospitality sector alone generates 16 million tons of food waste, accounting for 26.67% of the total waste (ReFED, 2018).

Addressing consumer FW behaviours through MOA

As the consumption stage FW is widely recognized as a decisional consequence driven by multiple behaviour-related factors, a deep understanding of consumer behaviours, particularly the process that consumer performs the FW behaviour is of great importance to address FW issues. Several behavioural theories have been applied to better explain why consumers have been engaged in specific behaviours, with the theory of planned behaviour (TPB) being one of the most commonly used. TPB aims to explain how an individual's behaviour is determined by

considering the interactions between their beliefs, attitudes, and subjective norms. Thereby, TPB limits the understanding as it assumes that consumer behaviour is an intentional result of cognitive drivers alone (Quested et al., 2013; van Geffen et al., 2016). However, it does not fully address consumer FW behaviours and leaves several questions unsolved: how consumer reactions to the external environment and what the influence of external materials, individual knowledge, and competence on their behaviours are all not clarified.

The Motivation-Opportunity-Ability (MOA) framework may address this problem. MOA suggests that individuals' engagement in a particular behaviour is a result of the interactions between relevant factors of motivation, opportunity, and ability. The MOA framework (MacInnis et al., 1991) was initially designed to understand consumers' brand information processing when given promotional information and was further enriched with the work of Rothschild (1999) and Ölander and Thøgersen (1995). A growing number of FW studies (van Geffen et al., 2020; Vittuari et al., 2021, 2020) apply MOA thanks to the broad overview it could provide for understanding consumer behaviour. By systematically combining consumers' psychological and norm-related drivers, individual knowledge and skills, and the availability of external materials, MOA sheds light on the FW determinants identification and guides the potential FW reduction strategies development.

Motivation refers to the individual intention to perform a specific behaviour, reflecting the extent of an individual's desire to conduct a certain behaviour. Motivation is recognized as the psychological consequence interacted by individual attitudes, norms, personal values and goals. Opportunity is defined as the access and availability of external resources when an individual intends to perform a specific behaviour. Accessibility to technologies and tools, external environment, legal and regulatory frameworks, all these factors could enable or facilitate a certain behaviour. Ability refers to individual capacity and competence to conduct behaviours, by utilizing their personal knowledge and skills. Personal educational background, living or working experience, and mental as well as physical capacity all have an impact on ability. Based on these three components, the MOA framework suggests that individual behaviour could occur only when they are all presented. Hence, in the case of food waste, consumers may discard food when appropriate storage tools are not available, despite their high motivation to reduce food waste.

Food waste drivers and reduction interventions

The focus of food waste research has shifted from measurement to consumer behaviour understanding (Harvey et al., 2022), with the belief that changing consumer behaviour can significantly reduce food waste (Stöckli et al., 2018).

Consumer FW behavioural drivers refers to specific factors that influence an individual's behaviour related to FW. This can include attitudes, beliefs, norms, and other psychological factors, that are coupled with social and situational ones. Relevant drivers influence how people make decisions. Some examples of food waste behavioural drivers include but not limited to personal attitude towards FW, food literacy, availability of tools and/or technologies, individual skills to process and storge food, personal daily schedule and lifestyle, external food environment, and relevant legislation framework. Understanding these drivers is of great important to effective FW reduction strategy development and sustainable consumption promotion.

FW prevention and reduction strategies are recognized as the priorities in the FW hierarchy (Papargyropoulou et al., 2014), with practical activities to reduce consumer FW being proposed across studies. For instance, awareness campaigns to trigger consumer personal emotions (Filimonau et al., 2019; Jagau and Vyrastekova, 2017), the promotion of doggy bags (Giaccherini et al., 2021; Pancino et al., 2021), the donation of unconsumed food (Pancino et al., 2021), the personal engagement of the restaurant managers in FW mitigation strategies (Filimonau et al., 2020), as well as the provision of agricultural courses (Izumi et al., 2020). Potential interventions are recommended to be tailored to different individual-level and family-level characteristics (Qian et al., 2021), for example, portion size reduction (Visschers et al., 2020) and menu updating aiming to meet varied dietary preferences (Boschini et al., 2020). However, the effectiveness of such prevention and reduction strategies remains poorly understood (Stöckli et al., 2018).

Objectives of this research

Basing on behavioural change theories, the objective of this research is to improve the understanding of consumer FW in different settings, and to identify effective practices that could promote consumption stage sustainability. The first two chapters aimed to explore the behavioural FW drivers and related reduction interventions, across household, catering and hospitality sectors. Considering that in a specific school canteen context, FW waste issues were

often integrated into school meals sustainability along with nutrition, consumption and other issues (Byker et al., 2014; Byker Shanks et al., 2017; Cohen et al., 2014), informed by interventions and consumer behaviour knowledge in the previous two chapters, the third chapter further expanded the scope of discussion to the sustainable development of school meals to engage stakeholders. Specific goals were established as below:

1) understand specific factors that affect individual behaviours to generate FW at household by reviewing and critically appraising the literature that identifies the household FW drivers and levers, identifying different profiles of consumers and the likelihood to reduce their FW levels and then inform the exploration of relevant interventions, providing recommendations for further research in the field of consumer FW prevention, focusing on drivers and levers of individual behaviour.

2) analyse the effective ways to reduce FW through behaviour change perspective given the catering and hospitality sector by identifying interventions that have been tested in this sector to prevent and reduce FW, understating the mechanism of these interventions work on to stimulate behavioural change, evaluating the efficiency of these interventions contribute to FW prevention and reduction.

3) provide an evidence synthesis on intervention study that incorporate stakeholder insights focus on school meals by exploring the potential in promoting and boosting sustainability development, inventorying and codesigning tailored interventions based on stakeholder's knowledge and experience.

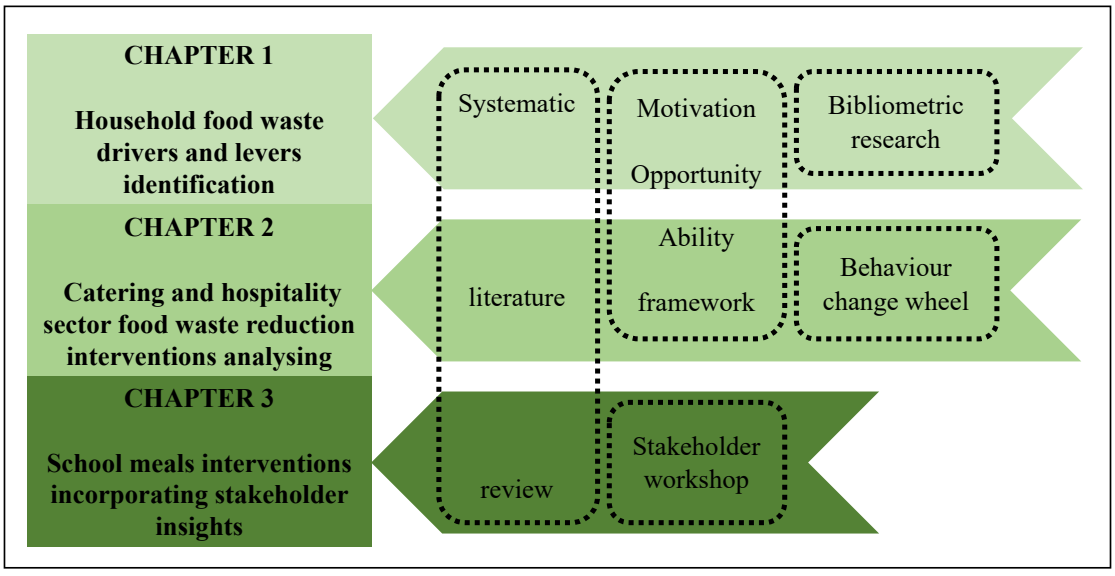

Figure I. Thesis methodology framework.

Thesis structure

The work is consisted of three independent studies covering both household and catering and hospitality sectors in consumption stage. Three studies were designed to achieve the above mentioned three research goals.

Chapter 1 conducted a systematic literature to review and critically appraise the literature that identify the drivers and levers of household consumer food waste. A mix of methodologies was applied: a systematic literature review based on a large dataset of scientific and grey literature; a revised version of the Motivation Opportunity Ability (MOA) framework distinguishing micro, meso, and macro situation factors; an iterative feedback mechanism with experts of the European Consumer Food Waste Forum established by the European Commission in 2021. Further attention has been given on consumer segmentation studies to provide insights on tailored intervention develop. Consumer behavioural factors were framed using the MOA framework, with opportunity factors being subdivided into three levels: individual or household, community, and region or nation. Consumer segmentation review identify the consumer groups with higher potential to reduce food waste.

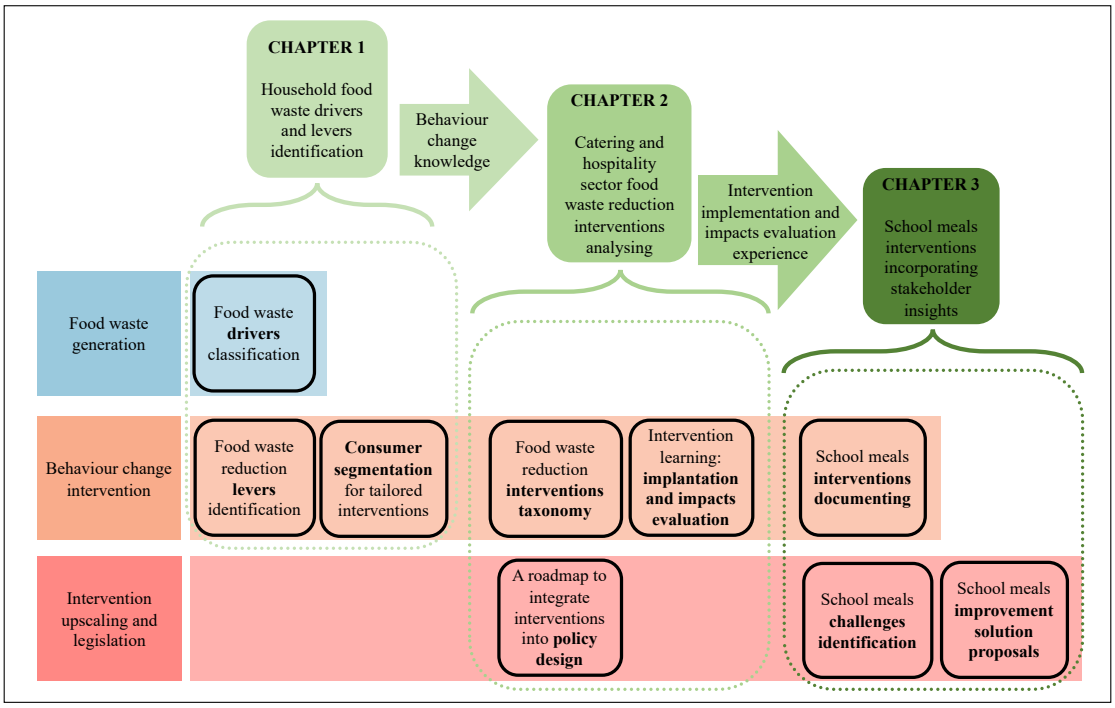

Figure II. Thesis structure and main outputs.

Chapter 2 addressed the second research goal with specific attention to the practical FW reduction interventions when residents are dining out. This study applied the Preferred

Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to identify the compatible peer-reviewed articles concerning FW prevention and reduction interventions in the catering and hospitality sector. The behaviour change wheel was further integrated with the MOA framework to unveil the complexity of intervention underlying mechanisms. Effective interventions were presented with descriptions and case profile disclosing. Intervention design approaches, data collection methods were compared across studies. How interventions influenced certain consumer behaviours was revealed with the underlying mechanism identification.

Chapter 3 aims to explore the role of school meals on sustainability development, basing on both academic evidence and stakeholder insights. This study applied PRISMA to select studies that carry out intervention study to reduce school meal impacts and/or increase benefits. Then reported a stakeholder workshop which connected school catering actors by empowering them to co-develop and co-design innovative ideas in school meal interventions. Three-stage stakeholder dialogue was held to promote knowledge sharing and mutual learning among stakeholders. Six benefit pillars related to school meals were identified from current literature. And aiming to achieve one or more pillars among these, nine interventions were identified. Stakeholders express their perspective and opinion on school meal challenges and potential intervention proposal. Research gaps were identified basing on the comparison study between literature review results and stakeholder workshop outcomes.

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CHAPTER 1 - How to reduce consumer food waste at household level: a literature review on drivers and levers for behavioural change

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Key words: food waste prevention, consumer behaviour, food systems sustainability

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Abstract

Consumer food waste at household level results from a complex set of different behaviours. They are influenced by psychological, socio-cultural, economic, and context-related factors such as awareness, attitudes, cognitions, emotions, or external circumstances, here referred to as drivers. Furthermore, opportunities to reduce food waste systematically and practically, here referred to as levers, are distinct from the drivers but have rarely been documented in previous studies. Identification of drivers and levers helps to design the 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 a large dataset of scientific and grey literature published between 2010 and 2021, ii) a revised version of the Motivation Opportunity Ability (MOA) framework distinguishing macro and micro 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 based the revised MOA framework. Thirteen drivers and their connected levers were identified in the literature in response to the MOA framework, while others fell in individual characteristics under demographics. Integrating the understanding of the drivers and levers with well-characterised consumer segments has been identified as a powerful instrument that could help design more impactful interventions. Such consumer segmentation helps to target proper interventions audience then 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 outcome leads to a research agenda to develop more evidence-based interventions as well as standardised methods to measure their impacts.

1.1 Introduction

Food waste and losses have been globally recognized among the most important manifestations of food system inefficiencies. In Europe, household and food service sectors together generated 65% of food waste, accounting for 82 kg per inhabitant (EU, 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, by the wide engagement of stakeholders, ranging from academic organizations, the civil society, to the policy domain. Further emphasis was put on the fact that responses to climate change require to couple public interventions with individual actions during the UN Framework Convention on Climate Change's 26th Conference of the Parties (COP26). At 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 and relevant stakeholders and EU Member States (MSs). A key action against food waste in the Farm to Fork Strategy is, aside 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 follow its own 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 external factors (Sanchez et al., 2020), we 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. The FUSIONS' definition of food waste is in line with the EU official definition, additionally including crops ploughed back into the soil or left unharvested.

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, especially at household level (Stenmarck et al., 2016). As a result,

along with the definitional debate, growing attention has been dedicated to the consumption stage (in- and outside home) and to 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 household level. Under drivers, we understand the factors that impact behaviour, such as awareness, attitudes, cognitions, emotions, or external circumstances, such as the behaviour of others, or available technologies. As levers, we understand those aspects of drivers that can be leveraged to systematically influence food waste behaviour using interventions.

Before 2010 research on food waste have been quite limited but from that year onwards it expanded rapidly, following two leading publications in this area (FAO, 2011; Parfitt et al., 2010). The way food waste has been addressed over this period of 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), with these two elements often combined. Therefore, the identification and understanding of 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 the recent years and the diversity of journals, a more systematic approach to review the state of the art is needed.

This work reviews and critically appraises the literature that identifies the drivers and levers of consumer food waste. These insights should lay the foundation to identify different profiles of consumers and their likelihood to reduce their food waste levels and then can inform the explore and use of targeted interventions. The review also provides recommendations for further research in the field of consumer food waste prevention, focusing on drivers and levers of individual behaviour.

The article is structured as follows. In Section 2, we outline the methodology used for the systematic review of the literature. Section 3 presents the results of drivers and levers identification, while Section 4 focuses on the discussion of main findings with the potential of targeted interventions in reducing consumer food waste and spotlights the work on segmentation of consumers. Section 5 concludes the work.

1.2 Methodology

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

Document collection: bibliometric research

Relevant literature was collected from a bibliometric literature review from a large dataset of both scientific papers and grey literature. Experts' opinions and feedbacks from the European Consumer Food Waste Forum (ECFWF) were integrated following the growing international commitment[1]. A bibliometric literature review statistically analyses bibliography information of published manuscripts and documents allowing to handle large quantities of documents, ensure a more objective selection of documents, and provide insights on 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 used 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 was organised to develop the search queries used to identify the relevant literature. Then, ECFWF experts highlighted the scientific papers and grey literature they considered fundamental for the analysis of the drivers of consumer food waste and of the most relevant food waste reduction interventions. Finally, experts were asked about the most relevant theoretical framework that should be adopted to

[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.

investigate the drivers of consumers food waste and about the most efficient classification of the levers of behavioural change.

The search for scientific literature on consumer food waste was conducted using the Web of Science (WoS) search engine. We included papers published from 2010 onwards if they included the terms "food waste" and "consumer*" in the abstract, the title, or among the keywords. The term "consumer*" is a truncated expression that covers "consumer", "consumers", and "consumer's", amongst others. The search resulted in a dataset of 1,160 scientific articles.

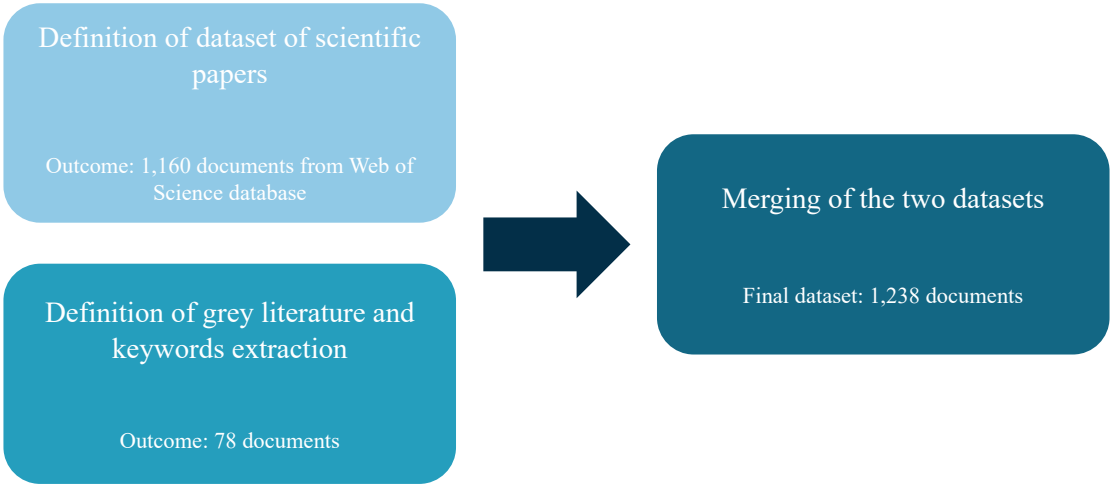

Figure 1. 1. Literature dataset development.

The systematic review: classification of consumer food waste studies

This dataset has been integrated with grey literature in a two-step approach. The first step consisted in a search on Google Scholar for documents related to food waste at the consumer level published in English language from 2010 onwards. In a second step, the documents retrieved via Google Scholar were integrated with those suggested by the experts. Duplicates were removed. This process added 78 documents to the dataset. To make the 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 which is 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 have been identified also analysing foreword and introduction sections. The results from the YAKE! Algorithm were interpreted by the authors and a final set of keywords for each grey literature document was identified.

The final dataset was completed on November 18, 2021 and consisted of 1,238 documents (**Fig.1.1**).

The bibliometric analysis conducted in this work consisted first on a descriptive analysis of the number of publications, their impact in the scientific discourse, and the identification of journals with the highest numbers of publications on drivers of food waste at the consumer level. The content analysis is based on KeyWords Plus, standardized keywords generated by a WoS algorithm that selects 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 (Garfield and Sher, 1993). Then an analysis of the documents' conceptual structure, that allows the identification of clusters of documents which express common concepts, was carried out by implementing a Multiple Correspondence Analysis (MCA) and a cluster analysis of key words of selected documents to define the patterns of topics in the literature (Aria and Cuccurullo, 2017).

The MCA is a data analysis technique used to detect and represent underlying structures in a data set through the identification of latent dimensions.

The MCA resulted in the automatic categorisation of 909 documents out of 1238 in 3 groups: cluster 1 (854 items), cluster 2 (2 items), and cluster 3 (53 items). A further analysis of the papers not assigned automatically to the clusters allowed to assign manually 231 other papers to the clusters. The supervised analysis allowed to assign 135 to cluster 1, 41 documents to cluster 2, and 55 to cluster 3. The remaining 98 items were considered as unsorted and excluded from further investigations. The final dimension of the cluster is: 989 documents in cluster 1, 43 documents in cluster 2, 108 documents in cluster 3.

Figure 1.2 depicts the map of the three clusters obtained by the analysis of the dataset with the x axes representing the most important dimension in terms of the amount of variance accounted for (in parenthesis) while on the y axis the second most important.

Cluster 1: The largest cluster (in blue) contains 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: The green cluster includes KeyWord Plus 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.

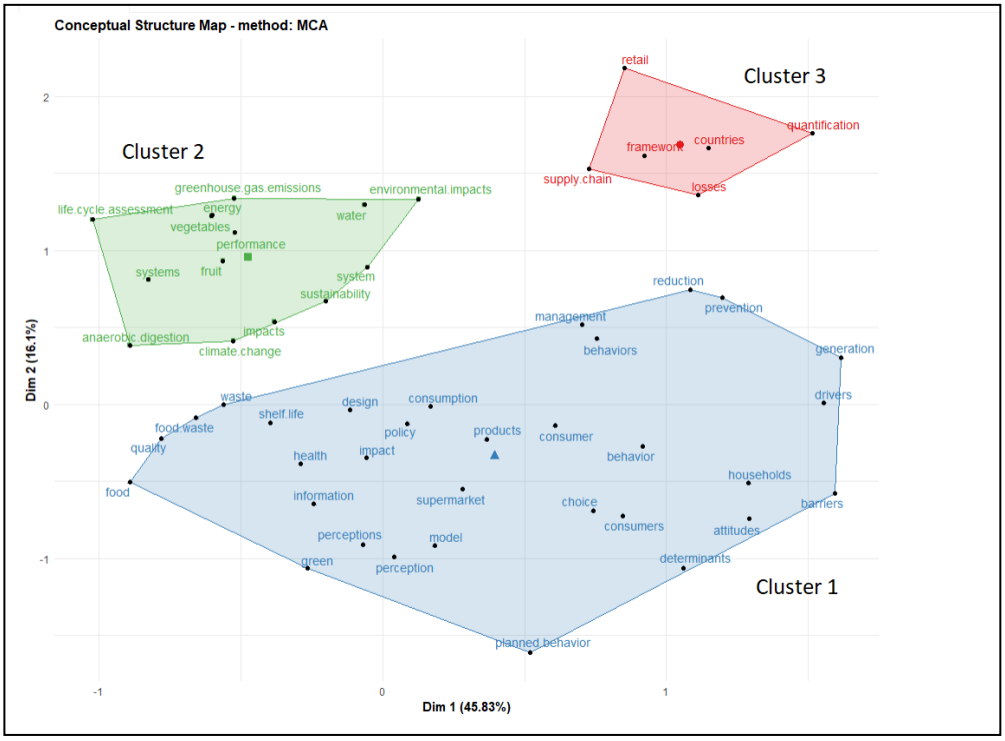

Figure 1. 2. Conceptual structure of the dataset from Multiple Correspondence Analysis. *(MCA)* – "Dim 1"=most important latent dimension and "Dim 2"=second most important latent dimension in terms of. proportion of variances retained by the dimensions represented in the two axes (value in parenthesis).

Cluster 3: The third cluster (in red) includes papers that refer to topics on quantification, retail sector and food losses.

According to the results of the MCA, the articles investigating topics relevant for this work are those included in cluster 1, as it considered all the documents investigating the behavioural factors of consumer food waste. Then, 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. A more detailed description of clusters and topics is conducted in section 4.

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 KeyWord Plus: (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 applied to identify the relevant articles which tested behaviour change interventions to reduce food waste in which studies were selected only if i) their main objective

is reducing consumer food waste from the perspective of changing consumer behaviour; ii) they applied effective intervention impacts evaluation methods; iii) they presented sufficient information of the intervention testing results. The final group contained a total of 20 studies, with 14 documents from the intervention group, 2 papers from the driver group but found to be relevant for the intervention testing, and another 4 extra studies recommended by experts during the first round of manuscript review.

Despite there is no one-fits-all approach to identify the target studies, this study established a selection criterion based on citation count to ensure the inclusion of high-quality studies, which have made a signific impacts to the FW research. Within this cluster documents were selected for discussion according to the following conditions: 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 have not been applied to grey literature.

1.3 Results and Discussion

This review is, to our knowledge, the first systematic assessment of the scientific and grey literature from 2010 onwards, basing on an adjusted MOA framework. This allowed us to depict a general image of the current knowledge on food waste at consumer level and to describe food waste drivers and potential levers – opportunities to systematically reduce food waste resulting from behaviour.

Motivation Opportunity Ability (MOA) framework

Several authors suggested potential theoretical frameworks for food waste drivers, among which, one of the first and most applied over the years is the Theory of Planned Behaviour (TPB). However, this framework limited the analysis only to cognitive drivers related to food waste that was assumed as intentional, or at least non-intentional. (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, which we adopt in this work in order to classify drivers, levers, and interventions with respect 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 as identified by the TPB, Opportunities and

Abilities expand the framework out of 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). For example, time and schedule, materials, technologies and infrastructure influence opportunity by shaping food waste drivers such as portion or package size and discount promotions in shops (Katajajuuri et al., 2014; Stancu et al., 2016; van Geffen et al., 2020a). Abilities refer to the knowledge and skills and individual capacities to solve the problems encountered when changing behaviour, including breaking well-formed habits and routines or countering the arguments of peers (Rothschild, 1999). Therefore, unlike the TPB, the MOA framework considers food waste not as an intended outcome, but as an unintended consequence of iterative decisions and behaviours related to in - and outside home food management practices that are driven both by internal (individual) and external (social and societal) factors.

A further tentative to provide a framework for consumer food waste drivers which is exploited also in this work, is proposed by Boulet et al. (2021) who suggests a three-level perspective. Being adjusted here, the *micro* level has the individual or household as focal entity, the *meso* level relates to the social unit within a community's physical setting, and the *macro* level represents the material and social setting beyond individual control. As in the MOA, this Multi-level Framework for household food waste and consumer behaviour moves beyond cognitive aspects integrating a wide number of external elements and daily routines around food practices.

Given that the MOA can be adopted to analyse consumer food waste in several contexts and countries, this work will build on a revised version of the framework that includes also the three-level perspective of Boulet et al. (2021).

Framing drivers and levers of consumers food waste

As described in the previous section, the food waste literature shifted attention from measurement to consumer behaviour, following the idea that stimulating behavioural change might ensure a significant contribution in terms of food waste reduction. Individual's 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 as the consequence of consumer behaviour differences (Block, L. G. 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). Obviously, some drivers are more important than others in affecting behaviours responsible for food waste in each of these stages in which repetitive, multiple and hidden individual choices are embedded (Setti et al., 2018). When food is prepared out of home, the setting can assume very different forms, going from public food services such as school and hospital canteens, to private food services including restaurants and food markets and several forms of take-out and delivery services. Such complexity requires a better understanding of the drivers and levers, especially to design effective interventions to reduce consumer food waste.

We use the Motivation Opportunity Ability (MOA) framework, which models consumer behaviour as a function of motivation, opportunities, and abilities, to structure our presentation of the drivers and levers of food waste. This structure then informs which interventions, generally understood as actions that are implemented to systematically change behaviours and outcomes, can be worthwhile in reducing consumer food waste.

In the following paragraphs all elements of MOA are presented: drivers, levers and interventions will be identified, analysed and discussed with regard to the different constructs represented in the model. Along with the drivers, levers are classified based on the assessment of the literature, meaning those drivers that can be changed by policy interventions in order to create the desired behavioural change.

Motivations

Table 1.1 includes an overview of drivers and levers with references related to motivations, which represent the intentions of one or more individuals to carry out a set of actions (Vittuari et al., 2020). Their role in avoiding or reducing food waste relies on their positive/negative effects on the propensity to reach a goal (e.g., how people think and feel about wasting food) (Russell et al., 2017; van Geffen et al., 2020b; 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 to reduce food waste are also partly determined by an individual's perception of their 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 food waste reduction motivations (Russell et al., 2017; van Geffen et al., 2020a).

Potential levers related to individual motivations and psychological factors might consider emphasizing food waste-related issues to trigger concern and other personal emotions (positive or negative), for example the use of communication strategies highlighting environmental consequences of food waste to generate better attitudes, to raise awareness and improve consumer perception on their role on food waste reduction.

Table 1. 1. Food waste behavioural drivers and levers – 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 norms; descriptive 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.

A particular set of motivations can be grouped under the concept of social norms, meaning that individual behaviour is also influenced by what other individuals do and what individuals believe is expected of them. The former is referred to as descriptive social norms, beliefs regarding what is "normal" or usually done, e.g. personal perceptions on other consumers' efforts in preventing food waste (Elhoushy, 2020). The latter refers to injunctive norms, beliefs about what is socially approved behaviour, e.g. what an individual thinks others approve of

regarding food waste (Schanes et al., 2018a). A relevant category of injunctive social norms is 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. Potential levers related to personal norms could promote monetary and non-monetary incentives for citizens to reduce food waste.

Table 1.2 provides examples of drivers and levers with related references connected to opportunities, a concept that is defined as the possibility of one or more individuals in accessing external material and non-material resources such as time, technology and infrastructures (MacInnis et al., 1991; Rothschild, 1999). When dealing with food systems, micro opportunity in this study refers to access to a set of material resources such as the technologies and tools, time availability for food-related 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 food and tackle unfinished food help consumers handle food management effectively (van Geffen et al., 2020b), especially during holidays when food catering always come with less organization or even overpreparation. Indeed, lifestyles and routines are decisive in driving households' food waste trends (Hebrok and Boks, 2017) as well as cultural influences, both in terms of cookery and traditions.

Opportunities

Potential levers related to micro level situational factors trigger behavioural change encouraging efficient food planning or storage methods; provide affordable technology and tools (e.g. smart kitchen tools); promote working time organizations leaving more free time to be dedicated to preparation of food (e.g., working from home).

Food environment, as the meso opportunity, here refers to the physical, economic, and socio-cultural context in which consumers perform their food waste behaviours. Recommended levers at the meso point could be food environments improvement for instance various package sizes that can nudge food waste reduction practices.

Table 1. 2. Food waste behavioural drivers and levers - 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 delivering 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 activities. Integrate food waste mitigation into public policy design.

Boulet et al. (2021) suggests understanding opportunities in a wide sense. On the one hand, opportunities manifest at the individual or household level. For example, these include the availability of time to better plan food purchases so as to minimize the risk of wasting food. On the other hand, they include the material and social settings beyond consumer or household level. For example, food provision and waste regulation, such as food safety standards and recommendations (different types of expiration dates, re-usability of leftovers, rules of food donation, food waste taxes) set important boundaries for people's opportunities to reduce food waste, however these interventions usually applied for food safety risk mitigation (Kasza et al., 2019). Also, Canali et al. (2016) suggest considering three groups of legislation and policy-related drivers: those related to agricultural policy and to food quality and marketing standards, those related to food safety, consumer health and information, and animal welfare policies and those related to waste and taxation policies. Those policy factors might directly or indirectly influence consumer food storage, preparation, and cooking behaviour, then generate food waste.

Finally, van Herpen et al. (2019) highlight the role of food infrastructures. These include the availability and the accessibility of stores, their density in a specific area and the typology of products sold.

Potential levers for macro level situational factors and opportunities relate to 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; design public policies fostering incentives for the reduction of household food waste; and differentiating 'best before' and 'consumed by' products in official risk communication, and an extension of package date labels (Yu & Jaenicke 2021).

Ability

Following the definition of MacInnis et al. (1991) and Rothschild (1999), ability represents the capacity of each individual in dealing with the a specific situation, 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 from planning and organisational skills, to purchasing ability and food preparation and storing skills (Bravi et al., 2020; Neff et al., 2019; van Geffen et al., 2020b; Vittuari et al., 2021; Romani et al., 2018). 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. In Table 4 are presented examples of drivers and levers with related references connected to ability.

Table 1.3 provides examples of drivers and levers with related references connected to demographic characteristics of consumers. 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., 2018a). However, while motivation, opportunities and abilities might be changed by tailored interventions, most socio-demographic factors cannot be directly or easily 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 influential factors (van Geffen et al., 2016). Following (van Geffen et al., 2016), age has been found to correlate with the quantity of food waste produced and the attitude of consumers towards waste. Indeed, elderly consumers are found to waste less both for different attitudes towards food as well as a greater knowledge of the impacts of food

waste compared to younger individuals (Qi and Roe, 2016; Schanes et al., 2018b), as well as the personal experience with food scarcity during and after the World War II, especially in Europe (Szabó-Bódi et al., 2018). However, other studies found that differences between older and younger individuals are often not consistent (Koivupuro et al., 2012; Parizeau et al., 2015). Also, regarding the gender difference, evidence 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 the reduction of 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).

On the educational level, despite a lack of shared consensus on this evidence, some authors suggest that a higher level 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 has also been related to food waste levels. Larger households waste more than smaller households in absolute terms (Quested et al., 2013), but they waste less 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-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 are less clear.

Table 1. 3. Food waste behavioural drivers and levers - Ability.

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

Other individual characteristics

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, as present in Table 1.4, there are studies which found no relation between food waste and income (Koivupuro et al., 2012; Qi and Roe, 2016). Additionally, 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). 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 (Setti et al., 2016).

Possible levers could be based upon the promotion of discourses targeted to different generations considering that different age groups are more reactive towards different issues. Also, the attitudes of others family members (partners, friends and family circles) might play a key role in supporting individual behaviours, highlighting the importance of social norms. To conclude, since employed people tend to produce more food waste, actions targeting workplace might represent a focus area.

Table 1. 4. Food waste behavioural drivers and levers – Individual demographic.

Drivers	Levers
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 discourses targeted to different generations considering that some age groups are more reactive towards different issues climate and awareness campaigns compared to others.
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 others 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, actions targeting 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.*

Segmentation and targeting consumers

Segmentation describes the process of dividing something into its parts. In the context of, consumers can be segmented into groups (or clusters) whose members are relatively similar as regards the drivers of food waste and 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 attitudes towards food waste reduction, their sensitivity to social norms, and their access to the necessary tools, the skill levels they have and technologies for food waste reduction.

Crucially, segmentation can be the basis for targeted interventions. Targeting refers to the act of making an intervention more effective by matching one (or multiple) of its aspects to an aspect of its recipients instead of a one-size-fits-all interventions (Teeny et al., 2021). This is also often referred to as matching, tailoring, or personalization: which aspects of an intervention can be matched to recipient characteristics, and in what way, frequently and extensively depends on the type of intervention and the specific characteristics. For instance, a persuasion message can use different styles and frames. Social norm interventions can communicate norms from different social groups. These techniques have been used in persuasion psychology (Dixon et al., 2017; Joyal-Desmarais et al., 2020; Luong et al., 2019), health messaging (Noar et al., 2007; Pink et al., 2021; Schmid et al., 2008), and are more recently considered in nudging (Mills, 2022; Peer et al., 2020), and 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 fitting selection, design, source, or setting of administrating an intervention, is a largely empirical question. While there are some pointers from the available evidence and 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 that were identified as non-responsive to food waste interventions might not be targeted at all, while 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. They can be more fluently processed and attract more attention. Yet, they can also be less effective, crucially if people

become aware that they are targeted, because they appear privacy-invading, manipulative, repetitive, or if they are seen as being based on unfair or stereotypic judgments about the person (Teeny et al., 2021).

Table 1. 5. Consumer segmentation literature findings summary.

Segments identified	Connection with interventions	Potential limitations
UK (Mallinson et al., 2016). Online questionnaire survey.		
Five consumer groups that differed with respect to 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-termist; Indifferent; Consumerist; Eco-responsible.	The work provides a multilateral action plan to reduce household food waste according to the different segments identified.	Methodological limits due to self-reported information.
Denmark, Germany, Norway, Sweden, and the Netherlands (Aschemann-Witzel et al., 2021). Online survey.		
This study investigates relations between price orientation and food involvement of 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. Unsolid assumptions when elaborating the segments.
Poland (Marek-Andrzejewska and Wielicka-Regulska, 2021). Online questionnaire survey.		
Three typologies of consumers 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 woman Narrow focus on young people.

Australia (Borg et al., 2022). In-depth interviews, and food waste audits.		
Three groups of consumers distinguished in light with food planning behaviours: Under planners; Over providers; Considerate planners.	Over providers warrant a priority focus for interventions. Under planners' changing in behaviour will require a shift in choice architecture in food shopping environments.	Survey limited to food providers. Methodological limits with when using self-reported information.
Italy (Vittuari et al. 2020). Consumer in person survey.		
Three groups of consumers identified according to their ability and motivations to reduce food waste: Pragmatic consumers; Thrifty altruists; Aware wasters.	The work identifies food waste mitigating factors: 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 sample can misrepresent some categories of consumers.
Australia (Liu, H., & McCarthy, B. 2022). Consumer in person survey.		
Six lifestyle segments were identified: the freshness lovers, the vegetarian and organic food lovers, the recycle/reuse advocates, the waste-conscious consumers, the label-conscious/sensory consumer and the food waste defenders.	The work bases on sustainable lifestyles and attitudes towards food waste and evaluate these drivers' effect to different levels of food waste.	Self-reported data may include biases in answers

Table 1.5 outlines some studies identified in the scientific literature that used segmentation in the context of food waste. Generally, all segmentation studies are based on survey like 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 actually 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).

Limitations

Despite its added value, the methodology adopted for the construction and the analysis of the dataset also presents 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 these aspects, results related to grey literature documents, the definition of their keywords, and their classification were revised through a supervised analysis, conducted through a 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 of 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. Direct interventions in the dataset, such as changing all the KeyWord Plus "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 inconsistencies 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 review of the text.

1.4 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 towards 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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CHAPTER 2 - Stimulating behaviour change to reduce food waste in the catering and hospitality sector: learnings to design better interventions

This article is ready to submit to the Sustainable Production and Consumption Journal.

Keywords: Consumer food waste; Food waste reduction; Catering and hospitality sector; Food waste intervention; Behavior change.

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Abstract

Extensive evidence indicates that the catering and hospitality sector contributes significantly to consumer food waste (FW) generation and is thus important for addressing global food system challenges. However, consumer FW reduction interventions within this sector remain less understood, compared to other consumer segments such as the household. This study fills this gap by compiling a systematic review, based upon the Motivation-Opportunity-Ability (MOA) framework and the Behaviour Change Wheel. In total, 30 peer-reviewed articles have been screened and examined in detail. Results show that a large share of those studies did not analyse the mechanism underlying the interventions they have tested. How those interventions influenced consumers' behaviour was unclear because no theory was referenced. Environmental restructuring, persuasion, and education were identified as the top three functions to promote FW reduction behaviour. Effective solutions to address catering and hospitality FW include but are not limited to smaller portion provision, educational module, lunch break rescheduling, food servicing style change, permanent plate application, and consumer dietary preference analysis. This review consequently proposes a roadmap for practitioners and policymakers to develop effective interventions which consists of four steps from baseline mapping, tailored intervention designing, intervention testing, to strategy implementation and upscaling.

2.1 Introduction

The last 15 years have witnessed rapid development in food waste (FW) research, particularly after the United Nations (UN) introduced a specific goal of halving consumption stage food waste by 2030 into the Sustainable Development Goals (UN, 2015). The Food and Agriculture Organization (FAO) reported that 1.3 billion tons of food are wasted annually (FAO, 2011), this causes profound economic loss (Ahamed et al., 2016), increases GHG emissions and resource depletion (Scherhaufer et al., 2018) in direct and indirect ways. Simultaneously, malnutrition and other food insecurity issues are still prevalent worldwide, especially in developing areas (FAO, 2021), which have been even aggravated by the unprecedented Covid-19 pandemic (Vittuari et al., 2021). Given the interrelated economic, environmental, and social impacts, FW is manifested as an inefficiency of the food system (Corrado and Sala, 2018) that challenges the development of a sustainable and resilient food supply chain (FAO, 2019).

In general, the consumption stage contributes the highest portion of FW, particularly in developed countries (Beretta et al., 2013; Kummu et al., 2012; Priefer et al., 2016). Moreover, the catering and hospitality sector generates 12% of the overall FW in the EU, ranking third after households and food processing industries (Stenmarck et al., 2016). 13% of the wasted food in China is associated with out-of-home consumption activities (Xue et al., 2021). The problem is even worse in the USA, where the catering and hospitality sector generates 16 million tons of FW, and takes up 26.67% of total waste (ReFED, 2018). However, in contrast to the scale of FW generated in the catering and hospitality sector, the academic evidence on the FW reduction strategy effectiveness is relatively scarce (Xue et al., 2017).

Relevant prevention and reduction strategies play a crucial role in developing a resilient and sustainable food environment (Vittuari et al., 2021). Besides SDGs (UN, 2015), identifying and promoting effective FW management initiatives are also integrated into the EU Green Deal (COMMISSION, 2019) and Farm to Fork Strategy (COMMISSION, 2020) as a crucial component. FW prevention and reduction strategies are recognized as the priorities in the FW hierarchy (Papargyropoulou et al., 2014), with practical activities to reduce consumer FW being proposed across studies. For instance, awareness campaigns to trigger consumer personal emotions (Filimonau et al., 2019; Jagau and Vyrastekova, 2017), the promotion of doggy bags (Giaccherini et al., 2021; Pancino et al., 2021), the donation of unconsumed food (Pancino et al., 2021), the personal engagement of the restaurant managers in FW mitigation strategies (Filimonau et al., 2020a), as well as the provision of agricultural courses (Izumi et al., 2020).

Potential interventions are recommended to be tailored to different individual-level and family-level characteristics (Qian et al., 2021), for example, portion size reduction (Visschers et al., 2020) and menu updating aiming to meet varied dietary preferences (Boschini et al., 2020). However, the effectiveness of such prevention and reduction strategies remains poorly understood (Stöckli et al., 2018).

Taking information intervention as an example, various types of information materials were applied across studies. These FW reduction interventions include the presentation of general FW magnitude or related environmental issues (Jagau and Vyrastekova, 2017; Visschers et al., 2020), food literacy enhancement (Qi and Roe, 2017), the use of an inspiring slogan to encourage consumers to reduce FW (Ellison et al., 2019), and restaurant management regulations improvement (Chang, 2022; Dolnicar et al., 2020). However, those interventions vary in the functional mechanisms underlined to stimulate consumer behaviour change (Michie et al., 2011). Impacts of those interventions on FW reduction are heteroecious as recorded, including actual FW amount decrease (Ellison et al., 2019; Lorenz-Walther et al., 2019; Pinto et al., 2018; Whitehair et al., 2013) and no FW reduction (Jagau and Vyrastekova, 2017; Visschers et al., 2020). Hence, a systematic literature review to compile and synthesises existing empirical evidence on consumer FW reduction interventions may significantly contribute to the promotion of sustainable consumption.

To fill this gap, this study aims to provide an overview for a better understanding of the effective ways to reduce FW in the catering and hospitality sector, by identifying evidence-based and reliable strategies targeting consumer behavioural change. Therefore, this study conducted a systematic literature review to address the following questions: RQ1. What interventions have been implemented and tested in the catering and hospitality sector to prevent and reduce food waste? RQ2. How do these interventions work to stimulate behavioural change? RQ3. To what extent and how effective do these interventions contribute to FW prevention and reduction?

2.2 Methodology and materials

Theoretical framework for FW reduction intervention

The Motivation-Opportunity-Ability (MOA) framework (MacInnis et al., 1991) was initially designed to understand consumers' brand information processing when given promotional information. MOA has been applied in the FW research (van Geffen et al., 2020; Vittuari et al.,

2021, 2020) in light of the broad overview it could provide for understanding consumer behaviour. Specifically, from the interactional perspective among consumer's psychological and norm-related drivers, personal knowledge and skills, and the availability of external resources, MOA sheds light on the FW determinants identification and guides the potential curbing tactics development. Thus, the MOA framework could provide adequate academic support to systematically explore the interventions tested across studies aiming to reduce consumer FW, particularly to the underlying working mechanisms.

Figure 2. 1. The Motivation-Opportunity-Ability framework and behaviour change wheel.

Basing on the connections between MOA and the behaviour change wheel, this study combined these two theories together (**Fig. 2.1**) to build the theorical framework for later interventions analyse. Motivation refers to the individual intention to perform a specific behaviour, which is the psychological consequence stimulated by individual attitudes, norms, and personal perceptions. Hence, motivation strategy could be the intervention that triggers consumers' guilt

when wasting food and raises pro-environmental awareness, then promotes them to be engaged in the FW reduction actions. Ability is defined as the individual capacity to conduct a certain behaviour by taking advantage of the relevant personal knowledge and skills. The ability intervention could work on the FW knowledge enhancement and skills building in avoidance of FW. Opportunity refers to the access and availability of external resources to perform a specific behaviour. Relevant interventions under this case could aim at nudging consumers' behaviour change by changing the choice architecture or removing barriers. The MOA framework points out clear directions towards which behaviour change intervention could be developed. However, the practical levers to stimulate intended changes are still missing.

Michie et al., (2011) proposed a behaviour change wheel based on a series of behavioural frameworks and centralized by the Capability, Opportunity, and Motivation (COM-B) system, which is logically similar to the MOA. The change wheel is encircled by nine intervention functions (as shown in **Fig. 2.1**), which provides a comprehensive guideline to characterize and analyse interventions from the operational perspective. These functions introduce practical levers by which an intervention could be established to stimulate behaviour change. As the MOA helps to identify the working direction of the interventions, the nine functions can unclose the influencing pathways in which specific actions and practices could be developed. This study hence combined the MOA framework and behaviour change wheel for the FW prevention and reduction intervention analysis. Sections below further explored the connections between these two frameworks by allocating nine functions of behaviour change wheel to the three clusters of the MOA.

To be clarified, persuasion and modelling both work on personal intentions as persuasion affects individual attitudes and awareness while modelling works mostly on social norms. Therefore, they belong to the motivation cluster. Restriction inhibits consumers from engaging in competing behaviour by regulations or rules, enablement clears external barriers to performing the target behaviour, environmental restructuring changes the physical and social context, incentivization and coercion both impact consumer behaviour through consumers' natural aversion to economic loss and propensity for economic awarding. These interventions, therefore, fit the scope of the opportunity cluster. As education and training work on knowledge expansion and individual capacity enhancement, they belong to the ability cluster.

Literature selection and review

This study applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to identify the compatible peer-reviewed articles concerning FW prevention and reduction interventions in the catering and hospitality sector. PRISMA was established in 2009 as the guidelines for a systematic review to address conceptual and practical advances. It was initially prevalent in medical research but has been expanded to other areas, for instance, the evaluation of interventions (Moher et al., 2009; Page et al., 2021). Following the instruction of Page et al. (2021), the operational flow following PRISMA consists of three phases: Identification, Screening, and Included. Figure 2.2 presents those phases integrated with the literature selection results of this study.

At the Identification stage, both Scopus and Web of Science (WoS) were used in the literature search. Considering that multiple terms (e.g., intervention, strategy, initiative) could be applied by studies referring to the FW reduction interventions, relevant papers may be neglected if too specific keywords are used. Hence, the eventual searching strings we used are as follows:

Scopus: TITLE-ABS-KEY ("food waste" AND "catering") OR TITLE-ABS-KEY ("food waste" AND "hospitality") OR TITLE-ABS-KEY ("food waste" AND "canteen") OR TITLE-ABS-KEY ("food waste" AND "restaurant") AND (LIMIT-TO (LANGUAGE, "English"))

Web of Science: (TS= ("food waste" AND "'catering") OR TS= ("food waste" AND "'canteen") OR TS= ("food waste" AND "'hospitality") OR TS= ("food waste" AND "'restaurant")) AND Language: (English)

Literature search was carried out in May 2021. A total of 1070 articles were filtered, with 753 from Scopus and 317 from WoS. By excluding 236 duplications, 834 papers were collected for the Screening. The whole inventory has been reviewed based on a brief title/keywords/abstract analysis to determine if the study implies a potential FW prevention and reduction strategy(ies). Consequently, 42 articles have been retained for further evaluation.

At the final filter stage, studies which: i) aim to test an intervention that is intended to change consumer FW behaviour or identify the most effective option that could generate less consumer FW through a comparative study, and ii) provide good results based on solid and reliable intervention impacts evaluation methods were included. Studies do not meet the criteria were excluded, and literature cited by all those 42 studies were evaluated to identify relevant ones. Overall, 30 independent peer-reviewed articles were identified for further analysis.

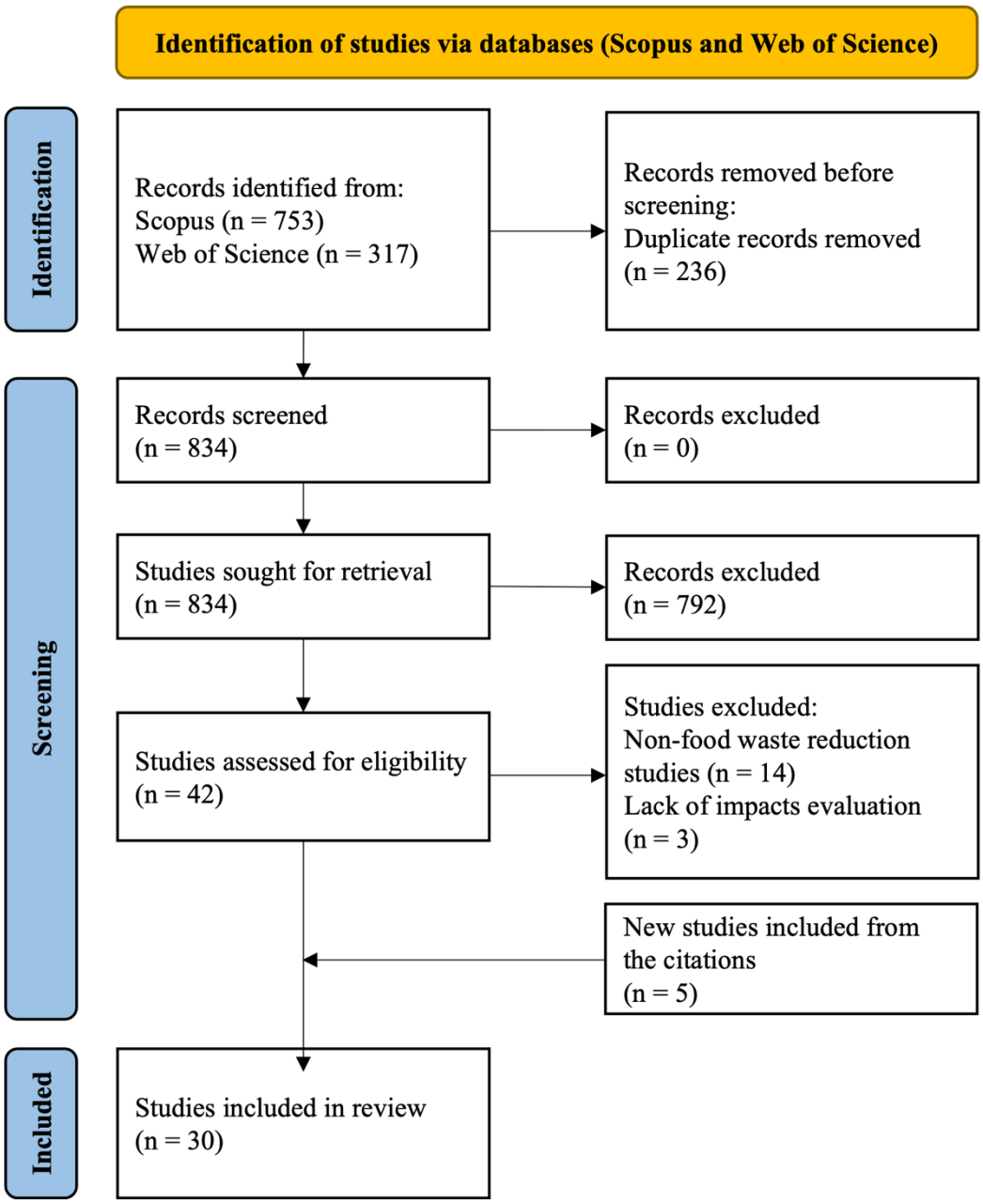

Figure 2. 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses working flow.

2.3 Results

Research profiling

Journals of publications. The 30 studies published in 23 different journals with the impact factors (**IF**, taking the impact factor of 2022 as a reference) ranging from 0.21 to 10.97. Among them, 21 studies published in the journal with an impact factor higher than 3. The top 3 journals in terms of impact factors were *Tourism Management*, *Resources, Conservation & Recycling,*

and *Current Issues in Tourism*. The nursing journals, with the sub-scope of nutrition and dietetics (10 studies), appear a main channel for publications, followed by the journals scoped in agricultural and biological sciences: food science (6 studies), and medicine: public health and environmental and occupational health (6 studies).

Case study focus sector. School canteens are registered as the most frequent settings for FW reduction interventions. Among them, university canteen draws the most attention with 15 articles discussing the effective way to reduce FW, followed by primary, elementary, and middle school (eight studies including one study from Children Centre). In addition, restaurant, and hotel catering sector (including one study from worksite cafeteria) were observed for five studies, and two cases were conducted under a hospital context (**Fig. 2.3 a**).

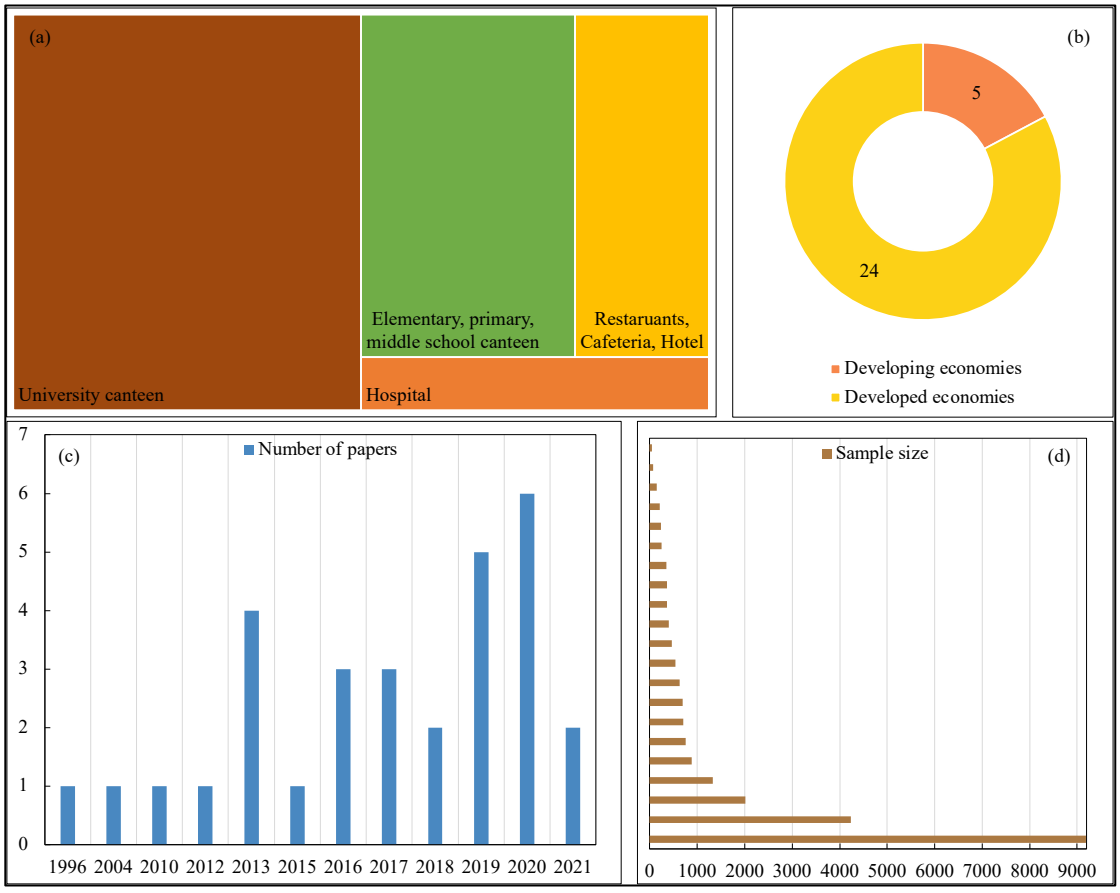

Figure 2. 3. Research profiling. (a) Distribution of studies in different focus sectors. (b) Case study geographical distributions (number of studies). (c) Number of publications per year. (d) Sample size in terms of consumer numbers per study (in ascending order).

Geographical distribution. In terms of geographical focus, a most of the studies were found for the industrialized countries/regions (24 articles, 80%) such as the USA, which accounted for almost 50% of the existing studies (**Fig. 2.3 b**). In contrast, five studies have been carried

out for the developing areas including Thailand, Brazil, Iran, etc. One study missed the relevant data.

Year of publications. The FW reduction research for the catering and hospitality sector was found as early as 1996, with a case study conducted in the school canteen (Getlinger et al., 1996). Then the number remained steady and low until 2012. From 2015 onwards, the publications testing FW reduction in field experiments increased, assumedly due to the release of UN SDGs calling for FW reduction in the sustainable consumption patterns (**Fig. 2.3 c**).

Sample size. Most of the studies (n = 21) report the sample size by counting the number of consumers, participants ranges from 43 to 9180, with six studies reporting a sample group less than 300 individuals, and 10 studies exceed 500. Figure 2.3 d presents the sample size in terms of specific participant number. In addition, several other studies reported sample size with the number of meals served (Jagau & Vyrastekova, 2017; Manomaivibool et al., 2016), the number of hotels (Kallbekken & Sælen, 2013), or families engaged(Dolnicar et al., 2020). Five studies didn't disclose any information regarding the sample size.

Classification and implementation of interventions

Intervention design

Figure 2.4 illustrates how these studies developed the FW reduction interventions. Most frequent experimental designs relied on literature reviews, stakeholder surveys and theoretical analysis to give context-based material in intervention designing. Additionally, several interventions were integrated into the food/nutrition projects. These approaches are separately detailed in the following paragraphs.

Literature review. The prevalent entry-point for intervention design was literature review, 60% of the total studies (n = 18) carried out this desk work. Based on potential intervention proposals or FW drivers identification outcomes, tested interventions emerged as candidates.

Stakeholder survey. The stakeholder survey supports several studies (n = 6) to identify potential interventions. Among them, three studies focus on consumers to uncover their dietary patterns (Ellison et al., 2019; Hamdi et al., 2020; Wansink and van Ittersum, 2013). One study disclosed consumers perceptions towards FW (Yazdankhah et al., 2020). Two other surveys focused on the managers, chefs, or nursing stuffs' perspective (Rathnayake and Dalpatadu,

2020; Strotmann et al., 2017) to identify the believed effective interventions considering their management experience.

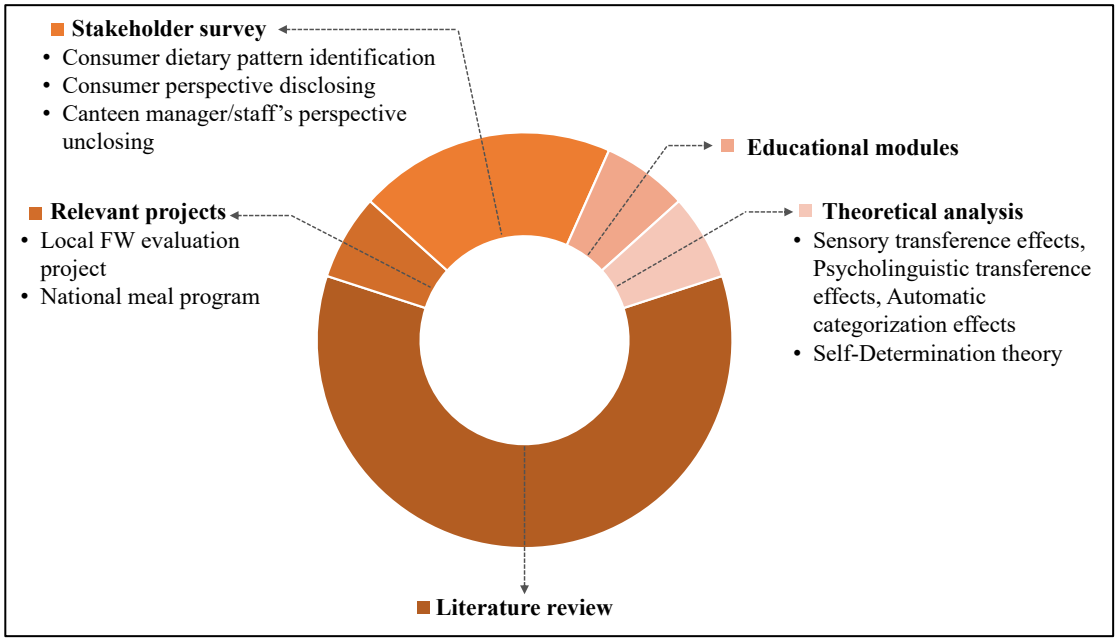

Figure 2. 4. Distribution of the intervention design approaches and examples.

Theoretical analysis. Two studies applied the theoretical analysis to design the interventions. Williamson et al. (2016) combined sensory transference effects, psycholinguistic transference effects, and automatic categorization effects to evaluate the plate materials' impact on consumers' diet. Based on this analysis, they further used a comparative study on consumer FW levels when dining with two kinds of plate. Prescott et al. (2019) investigated adolescent behaviour by applying the Self-Determination Theory, which illustrates the connection between motivation and individual autonomy, competence, and relatedness needs. Based on the understanding on the mechanisms of consumer action, this study tried to meet participants' need for relatedness by incorporating environmental conservation among students and then to promote a healthy consuming behaviour.

Educational modules. Two studies under the school canteen context integrated the FW reduction intervention testing with educational modules, classroom outcomes informed latter intervention design (Manomaivibool et al., 2016; Pinto et al., 2018).

Relevant projects. Two studies tested school canteen research activities organized by projects. One was based a local project aiming to evaluate school canteen FW (Favuzzi et al., 2020), and another was integrated with the National School Meal Program (de Souza et al., 2019).

Intervention classification

To state tested interventions in a structured manner, then inform the pathways they have followed to stimulate consumer behaviour change, interventions have been classified based on the combination of MOA framework and behaviour change wheel (Michie et al., 2011). The allocation of these interventions is shown in Figure 2.5, while intervention descriptions are presented in Table 2.1. Overall, environmental restructuring (21 studies), persuasion (14 studies), and education (9 studies) are the top three functions to evoke behaviour change, together accounting for more than 85% of all interventions. Incentivisation interventions were evaluated in two articles, while other intervention functions (coercion, enablement, and restriction) were tested only once.

Motivation

Persuasion interventions, which trigger consumers' negative attitudes towards FW, have been carried out relatively widely compared to other interventions. In the form of posters, pamphlets/leaflets/flyers, cards, banners, and FW-related informational materials were displayed to influence consumers' FW behaviour. The content was generally introductions and presentations on FW and food insecurity issues (Ellison et al., 2019; Qi & Roe, 2017; Manomaivibool et al., 2016; Dolnicar et al., 2020; Visschers et al., 2020; Whitehair et al., 2013). Modelling intervention guides the consumers to waste less or no food by providing a positive example of mitigating FW. A school canteen displayed posters designed by students who were exposed to the education modules to motivate their peers to reduce FW(Prescott et al., 2019).

Opportunity

Environmental restructuring interventions that aim to change the physical and/or social context, are registered as the most frequent intervention forms. They were mainly expected to nudge consumer behaviour change through changing the choices presentation. Interventions examples are reduced or adjusted portion size provision (Strotmann et al., 2017; de Souza et al., 2019; Kallbekken & Sælen, 2013; Wansink & van Ittersum, 2013; Berkowitz et al., 2016; Freedman & Brochado, 2010; Visschers et al., 2020; Vermote et al., 2018; Lorenz-Walther et al., 2019), smaller food size reminder (Pinto et al., 2018; Jagau & Vyrastekova, 2017), new recipes introduction (de Souza et al., 2019), permanent plates application (Williamson et al., 2016), attractive food names and fancy cafeteria decorations creation (Hamdi et al., 2020), food serving style transformation (Chang, 2022), and tray-less delivery system application (Kim &

Morawski, 2013; Thiagarajah & Getty, 2013). In addition, several studies have tested FW impacts of improved meal preservation facilities (Yazdankhah et al., 2020), self-service flavour station (spices and seasonings) provision (Hamdi et al., 2020), and school rescheduling of lunch breaks (Getlinger et al., 1996; Bergman et al., 2004;).

Restriction intervention aims to cut FW by limiting consumers' opportunity to engage in FW behaviour. Spreads and toppings that could cause consumers to over-order and then waste food were restricted during food ordering (Strotmann et al., 2017). Enablement intervention emphasizes improving individual capacity through increasing means/reducing barriers, giving more attention to the personal agency rather than external influence (R. Michie S., 2011). In a hospital, a new "diet order form" was introduced to the ward management, by which patients could pre-order food for the next day according to their dietary preference (Rathnayake & Dalpatadu, 2020).

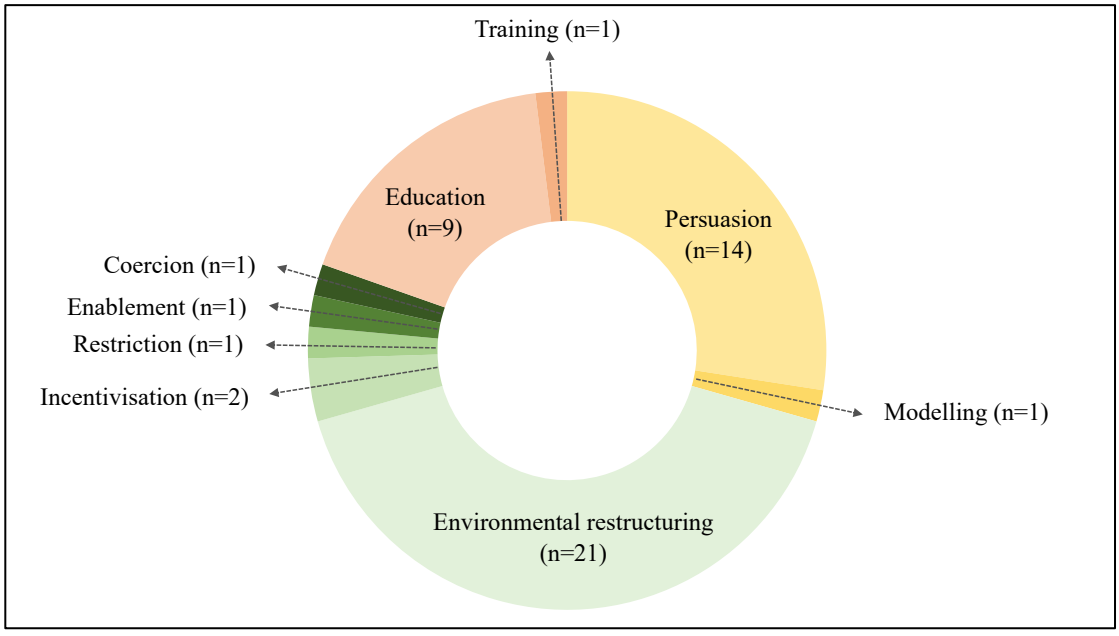

Figure 2. 5. Distribution of food waste reduction interventions.

Incentivisation and Coercion interventions aim to change consumer behaviour by leveraging consumers' preference for rewards and being averse to additional economic costing. Incentivisation intervention encourages consumers to dismiss FW with a price discount (Chang, 2022) or material rewards (Dolnicar et al., 2020). Coercion intervention has been tested through a poster reminding consumers that those who wasted too much food would receive a specific monetary penalty (Chang, 2022).

Ability

Education interventions aim to enhance the understanding of FW-related issues, including but not limited to providing food-related or environmental knowledge. In-class courses (Favuzzi et al., 2020; Prescott et al., 2019), at-home learning (Favuzzi et al., 2020), as well as knowledge sharing posters and pamphlets (Ellison et al., 2019; Yazdankhah et al., 2020) were applied in the previous studies. Relevant knowledge applied in interventions related to food system (Antón-Peset et al., 2021; Manomaivibool et al., 2016; Prescott et al., 2019; Qi and Roe, 2017), multi-impacts of food, FW management (Antón-Peset et al., 2021; Qi and Roe, 2017), and nutrition issues (Martins et al., 2016). Training intervention, which works on imparting individual skills, or enhancing consumers' ability to reduce FW, has rarely tested the impacts. In a university, FW reduction tips integrated into the educational materials, have been introduced to students (Yazdankhah et al., 2020).

Data collection and measurement

This study illustrates the data collection methods applied in those FW reduction intervention studies (**Fig. 2.6**), to identify if direct measurement, FW composition analysis, individual waste measurement (Amicarelli and Bux, 2020), and following-up (long-term) evaluation was applied.

Direct measurement or visual estimation. In this review, we found 24 studies used the actual weighing method to directly collect the FW data. All of them applied digital kitchen scale, no other measurement tools like measuring cup were reported. In addition, six studies visually estimated the FW data, applying digital photography method or done by trained investigators.

FW composition analysis or overall measurement. 12 studies physically separated and weighed FW in terms of food types (meat, vegetable, fish, egg, etc.) or menu items (first course, second course, main dish, etc.). However, more than a half of studies (16 studies) measured the all the wastage together, regardless food types. Two studies applied these two FW quantification approaches together.

Individual FW measurement or cumulative FW measurement. 14 studies carried out a time-consuming FW quantification approaches, by measuring FW data plate by plate. 13 studies measured the daily waste from canteens or restaurants in total, seven of them

further accessed the number of the plates or consumers to calculate the average FW amount (per plate/capita). Three studies applied both strategies.

Following up (long-term) measurement. To test the intervention efficiency after a rather long period of time, two studies conducted the evaluation of the long-term impacts after a time length of 3 months (Martins et al., 2016) and 5 months (Prescott et al., 2019), respectively.

Duration of intervention as the time scope of an intervention, to some extent indicates the degree of intervention intensity (Ross and Begeny, 2015). This study found that, besides two studies conducted a one-time experiment (Qi & Roe, 2017; Wansink & van Ittersum, 2013), other studies implemented the interventions with a time length ranges from 6 days (0.9 week) to 12 months (48 weeks) (as shown in Fig. 2.6). Results shows that 12 studies carried out the interventions within one month (4 weeks). Among them, 3 studies executed intervention less than one week, 6 studies between 1 to 3 weeks. In addition, 7 studies tested the interventions more than one month but less than two months (8 weeks). 6 studies recorded the FW reduction intervention between 2 to 4 months. 3 studies carried out the intervention study more than 4 months.

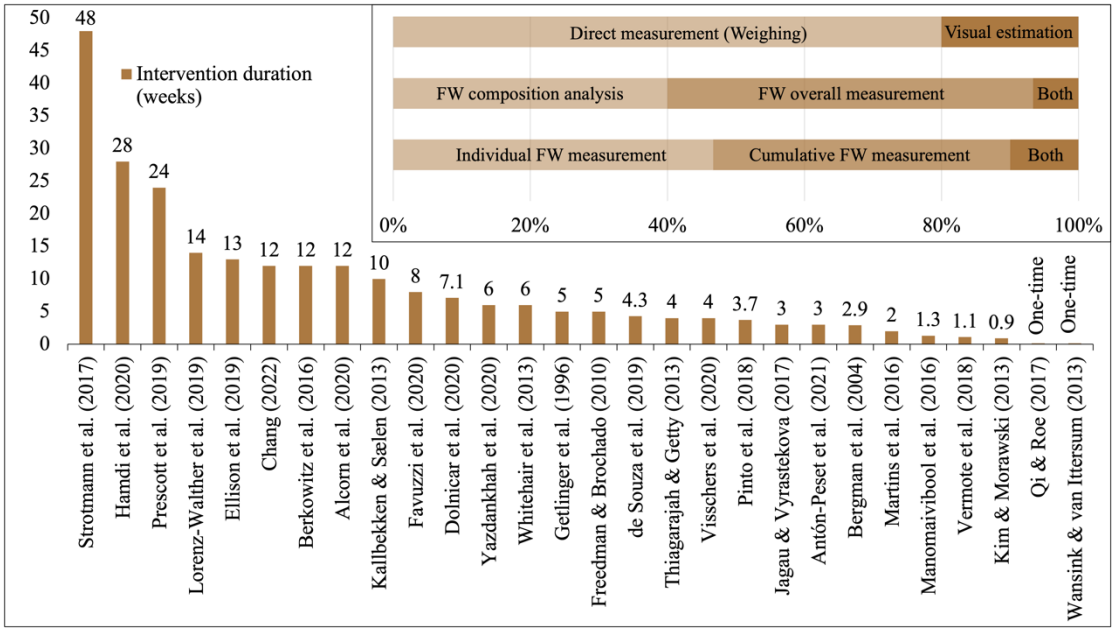

Figure 2. 6. Scopes of intervention durations & Distribution of FW measurement methods (Bar charts represent the proportions of methods applied across studies. From top to down: Direct measurement or visual estimation, FW composition analysis or overall meas.)

Impacts and effectiveness of interventions

To test the effectiveness of the FW reduction interventions, impacts evaluation relied on the FW quantification results. As showed in the bar chart in Figure 2.7, more than half (16 studies) of total studies compared the FW level before and after the intervention. This method required the same dietary context ex-ante and ex-post the intervention to exclude the unexpected external influence. Six studies divided the samples into at least two groups as test and control groups. The former group was dining in the intervention context when the latter kept consuming in the way they did before. A more complicated way to evaluate impacts is the combination of these two approaches, the FW amount difference of both test and control groups before and after the intervention were recorded and compared, eight studies applied this method.

As presented in Table 2.1, portion size reduction has been tested the most (Strotmann et al., 2017; de Souza et al., 2019; Kallbekken & Sælen, 2013; Wansink & van Ittersum, 2013; Berkowitz et al., 2016; Freedman & Brochado, 2010; Visschers et al., 2020; Vermote et al., 2018; Lorenz-Walther et al., 2019), and all performed effectively in reducing consumer FW. Even though reduced portion size has not been practically conducted, Pinto et al. (2018) found that a poster reminding consumers to order a smaller portion of food leads FW reduction. After joining the educational modules, students were more active in the FW reduction campaign and waste less food (Yazdankhah et al., 2020; Prescott et al., 2019; Antón-Peset et al., 2021; Martins et al., 2016), while one study reported that both first and second course waste reduced and side course waste increased (Favuzzi et al., 2020). Moreover, after exposing to a rather content-rich poster with FW basic knowledge, for instance, FW economic and environmental impacts, consumers were prone to eat more food (Yazdankhah et al., 2020; Ellison et al., 2019; Qi & Roe, 2017; Manomaivibool et al., 2016). Besides, serving with a permanent plate (Williamson et al., 2016), moving the recess to before lunch break (Getlinger et al., 1996; Bergman et al., 2004;), consumer dietary preference analysis (Rathnayake & Dalpatadu, 2020; Strotmann et al., 2017), applying tray-less delivery system (Kim & Morawski, 2013), and no-FW reward (Dolnicar et al., 2020), all confirmed effective in changing consumer FW behaviour then curbing FW.

Actual FW reduction results could be retrieved from nearly 80% studies (23 studies), the highest FW amount reduction achieved by per study is recorded and presented in Figure 2.7 in descending order. A case study in primary school reported a FW reduction of 76 g per capita (Antón-Peset et al., 2021) ranks the first, with education sessions consisted of FW definition and its environmental impacts, sustainable consumption, “water in the world” dynamics, etc.

Followed by another elementary case study, which recorded those children who had lunch after the recess wasted 66.5g per pupil less food than those who dined before recess (Bergman et al., 2004). The third highest FW reduction has been registered by another educational modules tested in middle school (Prescott et al. (2019), with a series of food system knowledge was integrated into the courses. For those studies missing actual FW reduction results, consumers wasted 135% more food with larger plates (Wansink & van Ittersum, 2013), a nutrition education session reduced FW up to 33.9% (Martins et al., 2016), and plate size reduction and social cues both reduced approximately 20% FW in hotels (Kallbekken & Sælen, 2013). Besides, patient dietary preference recording decreased the share of patients who left food untouched (Rathnayake & Dalpatadu, 2020), information cards with FW impacts, related social norms, and suggestions of ordering based on individual appetite encouraged more university students (double the ratio) to finish all the food (Manomaivibool et al., 2016), portion size reduction together with reminders about moderate ordering stimulated more students left no food wasted (Lorenz-Walther et al., 2019).

Considering the incoordination in the data collection and intervention impact evaluation methodologies within studies, this study defines the results simplify in three groups: positive, negative, and no signs. “Positive” refers to FW actual reduction observed, and it could be FW quantity or FW ratio decrease. “Negative” represents the increase in these two variables. Besides, several studies claimed no significant results observed, being recognized as “No significant”. Results shows that most of the studies (22 studies) witnessed positive impacts, meaning that the tested interventions are effective in reducing consumer FW and changing consumer behaviour. Besides, four studies recorded both positive and negative impacts, two studies reported both positive and no-significant impacts, and two studies recorded no-significant results, these studies have been clarified below.

Three of four studies that recorded both positive and negative FW reduction impacts come with changes in consumer’s dietary pattern. An education intervention observed first and second-course waste reduction while slide course waste increased (Favuzzi et al., 2020). Students wasted more vegetables and less fruit after a bunch of interventions were implemented (Hamdi et al., 2020). Students wasted more main dishes and less soup when their teachers were present in the canteen to encourage food consumption (Martins et al., 2016). Besides, to combine different interventions and aims to identify the most effective ones, one study in restaurant

found that consumers wasted more food when a related penalty was asked than the control and discount groups (Chang, 2022).

Two studies observed both positive and non-significant impacts. Thiagarajah & Getty (2013) reduced consumer solid waste by introducing a tray-less delivery system into the school canteen, but no impacts were observed on the liquid waste. A comparative study conducted by Visschers et al. (2020) reveals that the combination of posters' displaying and smaller portion provision could reduce FW significantly, while the former intervention failed to change the consumer food-wasting behaviour when tested alone. Two studies only reported no-significant FW reduction in their intervention testing experiments. Despite no significant FW reduction reported by Jagau & Vyrastekova (2017), the posters being displayed in a university canteen, which aimed to circumvent the insufficient planning problem of the customers by reminding students to ask for a smaller portion adapting to their appetite, has stimulated more consumers to pay the same price but order less food. In another university canteen study (Alcorn et al., 2020), no significant FW impacts were observed after a combination of employee sustainability awareness training, serving size reduction, and sustainability activities displaying strategies.

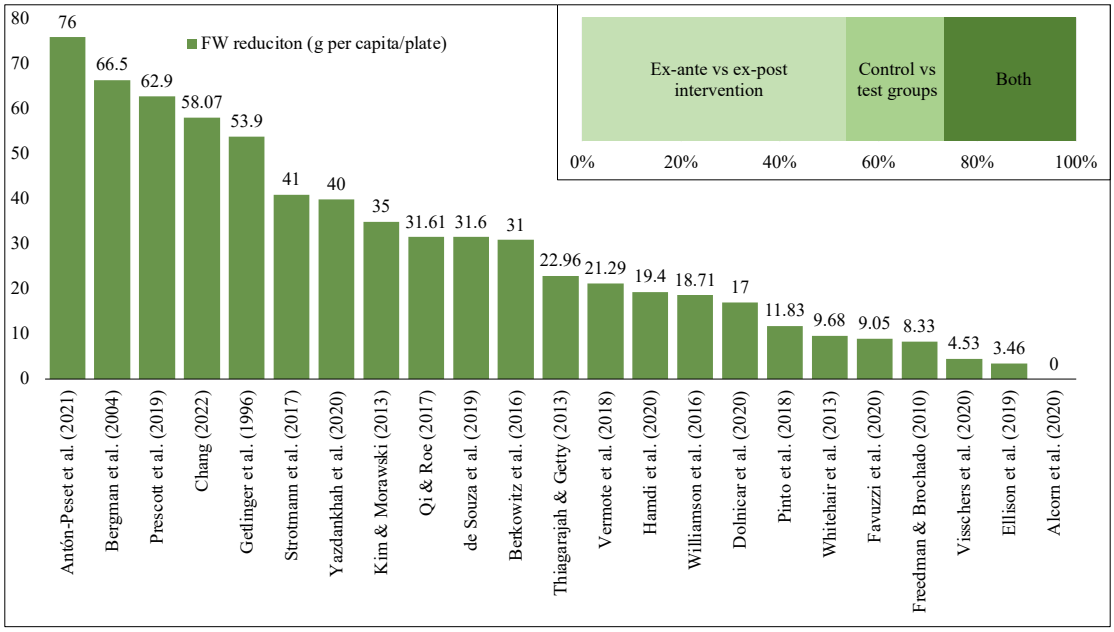

Figure 2. 7. Food waste reduction impacts & Distribution of intervention impacts evaluation methods.

Table 2. 1. Intervention testing studies summary.

#	Authors	Setting	Intervention description	Intervention classification	Food waste impacts
1	de Souza et al. (2019)	Children Centre	New recipes and adequacy of portions	Environmental restructuring	New recipes reduced 31.6 g FW per child. Clean Leftovers reduced 18.55 g FW per child.
2	Getlinger et al. (1996)	Elementary canteen	Moving the recess from post-lunch to pre-lunch	Environmental restructuring	Food waste reduced 53.9 g per student after the intervention.
3	Bergman et al. (2004)	Elementary canteen	Schedule the recess before lunch	Environmental restructuring	Consumers dining before the recess wasted more food than dining after the recess (223.1 g per consumer VS 156.6 g per consumer)
4	Hamdi et al. (2020)	Elementary canteen	Cafeteria Decorations (example: fruit and vegetable rainbow mural); Creative Names (example: Brain Boosting Broccoli); Social Norming Tease Test (displaying the students vote results when offering food); Flavour Station (Provided with spices and seasonings)	Environmental restructuring, Persuasion	School 1: reduced 10.5 g of fruit waste per student, reduced 8.9 g more when inducing the flavour station, vegetable waste increased 19.0 g. School 2: fruit waste reduced 18.9 g per student, vegetable waste increased 15.7 g. Results in school 3 show no significant change.
5	Prescott et al. (2019)	Middle school canteen	6-grade students received the Farm to Table and Beyond, the food system related curriculum, then create a poster to teach the 7th–8th grade students in their school the most important thing they learned in the food systems unit.	Education, Persuasion, Modelling	Food waste reduced from 223.3 g to 160.4 g per capita and to 175.6 g per capita after 5 months.
6	Antón-Peset et al. (2021)	Primary school canteen	Educational module: FW definition and its environmental impacts, sustainable consumption, “water in the world” dynamics, etc.	Education	The intervention group reduced food waste from 177 g to 101 g per pupil per day.
7	Favuzzi et al. (2020)	Primary school canteen	Food education in the flipped classroom (upside-down class) consisted of studying at home and then evaluated by teachers in the class.	Education	FW reduced 9.05 g per student for the first course, 1.63 g per student for the second course. FW increased 5.28 g per student for the slides.
8	Martins et al. (2016)	Primary school canteen	Intervention A: nutrition education sessions in classrooms. Intervention B: teachers were requested to be present during lunchtime to promote children consumption.	Education, Persuasion	Intervention A: food waste reduced in short-term observations. Intervention B: waste of main dish and identical main dish increased in the short-term observation, former reduced in long-term observation.

#	Authors	Setting	Intervention description	Intervention classification	Food waste impacts
9	Pinto et al. (2018)	University canteen	Information posters: points out that the uneaten food will go to the garbage, suggests the student ask for the right amount of food	Persuasion, Environmental restructuring	Reduced 11.83 g per capita
10	Yazdankhah et al. (2020)	University canteen	Educational module was held in the form of pamphlet, poster, and leaflets. Necessary facilities were provided to maintain the food quality, smaller portions, etc. Face to face consultations while eating food by the peers on the tables	Education, Training, Persuasion, Environmental restructuring	FW reduced 40 g per person. Bread waste reduced 4.22 g per person.
11	Jagau & Vyrastekova (2017)	University canteen	Two types of posters aim to circumvent the customers' inadequate planning problem and induce the psychological cost of wasting food by triggering social emotions.	Persuasion, Environmental restructuring	Consumers are willing to pay the same price for less food, but the approximated impact on food waste is not significant.
12	Ellison et al. (2019)	University canteen	Posters display: economic, environmental, and social concerns related to food waste; dining hall weekly food waste amount; call for action to reduce food waste; variety of activities the dining hall implement to reduce food waste.	Education, Persuasion	The treatment group reduced 3.46 g of food waste per student per plate. The comparison group reduced 1.68 g of food waste per student per plate.
13	Qi & Roe (2017)	University canteen	Participants were divided into 4 groups, and each group received different kinds of information. (a) receive general information about the food waste social impacts and the mitigating effects of composting; (b) destination of any uneaten food (compost or landfill).	Education, Persuasion	Consumers reduced 31.61g food waste per capita after receiving food waste info. The group received food waste info alone with being informed that the wasted food will end up by composting wasted more than by landfilling.
14	Thiagarajah & Getty (2013)	University canteen	Switching from a Tray to a Tray-less Delivery System.	Environmental restructuring	A reduction of 22.96 g per patron of solid food waste was observed after the intervention.
15	Manomaivibool et al. (2016)	University canteen	Information cues; information cards; posters and banners carried messages and images	Environmental restructuring, Education, Persuasion	The share of those who could finish all the food had almost doubled.
16	Williamson et al. (2016)	University canteen	Plate Material (disposable and permanent plates)	Environmental restructuring	Food waste 48.25g per student for disposable plate and 29.75 g for permeant plate.

#	Authors	Setting	Intervention description	Intervention classification	Food waste impacts
17	Kim & Morawski (2013)	University canteen	The availability of trays was randomized systematically so that on any given sampling day, trays were removed for only one of the 2 meals.	Environmental restructuring	Diners wasted 76 g per person without tray, and 111 g per capita with tray.
18	Alcorn et al. (2020)	University canteen	Reduce the serving size; Sustainability activities displaying (to consumers)	Environmental restructuring, Persuasion	No significant difference was found.
19	Freedman & Brochado (2010)	University canteen	Reduce the portion size of the French fries, week by week, decreased ~15 g/week for 3 weeks.	Environmental restructuring	French fries' waste amount per diner in 3 intervention weeks (14.05 g, 13.88 g, 11.25 g) was lower than the baseline (19.58g).
20	Visschers et al. (2020)	University canteen	Canteen A: Information only. Canteen B: Information integrated with smaller servings.	Environmental restructuring, Education, Persuasion	No significant difference found in Canteen A, while a substantial reduction in plate waste was found in Canteen B (21.12 g VS 16.59 g).
21	Vermote et al. (2018)	University canteen	20% French fries portion size reduction	Environmental restructuring	French fries waste reduced from 28.88 g per consumer to 7.59 g per consumer.
22	Lorenz-Walther et al. (2019)	University canteen	Reduced portion size was introduced after the baseline measurement, lasted for 12 weeks, then the information poster was displayed, and another FW data collection was carried out one week later	Environmental restructuring	More consumers left no food waste (78% VS 63%). Those who noticed the information poster wasted less food compared to those who didn't (86% VS 77% left no food).
23	Whitehair et al. (2013)	University canteen	A prompt-type message intervention poster	Persuasion	Diners wasted less during and one week after the information intervention.
24	Rathnayake & Dalpatadu (2020)	Hospital	Dietary preferences pre-order - a new ‘diet order form’ to record the dietary preferences of each patient	Enablement	The number of patients consuming all or part of the food has increased.

#	Authors	Setting	Intervention description	Intervention classification	Food waste impacts
25	Strotmann et al. (2017)	Hospital	A mix of interventions has been implemented, including food waste related posters, trained employees, change portion sizes, consumer preferences analysis, limited provision of spreads and toppings, etc.	Environmental restructuring, Restriction	Food waste rate reduced from 19.8% to 12.8% in the hospital cafeteria, reduced from 21.4% to 13.4% in the retirement home. The average waste rate slightly increased in the hospital.
26	Kallbekken & Sælen (2013)	Hotel	Reducing plate size; Providing social cues.	Environmental restructuring	Overall food waste has been reduced. Reducing the plate size reduced food waste by 19.5% and social cues ask guests to take food more than once reduced food waste by 20.5%.
27	Dolnicar et al. (2020)	Hotel	Encourage FW reduction flyer (card) with or without pro-environmental appeal; Reward (a waterproof mobile phone case or an inflatable ball) with or without pro-environmental appeal for never waste food during staying in the hotel.	Persuasion, Incentivisation	The Control group wasted 45g food per capita, Intervention 1a, 1b, 2a, 2b recorded FW of 30g, 28g, 31g, and 28g per capita, respectively.
28	Wansink & van Ittersum (2013)	Restaurant	Lager and smaller plate	Environmental restructuring	Diners with lager plates wasted 135% more food than those with smaller plates
29	Chang (2022)	Restaurant	Service style - Buffet bar VS rolling cart. Moral persuasion in the form of posters ("cherish the earth and treasure its food"). Financial inducements in the form of posters (monetary penalty for wasting food OR discount for zero waste)	Persuasion, Incentivisation, Coercion, Environmental restructuring	Per capita FW reduction ranges from 35.52 g to 58.07 g. Also, FW increase cases have been observed, from 17.7 g to 60.11 g.
30	Berkowitz et al. (2016)	Worksite cafeteria	Introducing five reduced-size entrées	Environmental restructuring	Plate waste was reduced during the intervention period (46 g per plate) compared with the baseline period (77 g per plate)

2.4 Discussion

Given the catering and hospitality sector, this study systematic reviews the experiments which tested behaviour change interventions that aiming to fight against consumer FW. It should be noted that journals with a scope covering nutrition issues are prevalent in the FW reduction intervention studies, due assumingly to that the educational institutions have been registered as the main research sites, and FW problems were often targeted along with nutrition issues here (Kaur et al., 2021). This unbalanced academic distribution also implies the under-researched practical FW reduction actions in restaurants, cafeterias, hotels, and take-aways, with only 5 studies here recorded compared to 23 studies under an educational context. However, FW magnitude here goes far beyond educational institutions, not to mention that 75% of which is avoidable (WRAP, 2013). Overall, in light of the results above, the following parts of this section deeply discuss the tested interventions and provide recommendations for future study based on the synthesis of empirical evidence.

Underlined mechanism identification

Built on the MOA framework and behaviour change wheel, this study critically appraises the intervention developing from the underlined mechanism perspective to the best of our knowledge, which has not been considered in most relevant studies until now. Taking the information intervention as an example, those interventions in the format of posters/booklets/messages/pamphlets/leaflets containing a variety of FW-related content were roughly being regarded as information campaigns (Alcorn et al., 2020; Ellison et al., 2019; Hamdi et al., 2020; Jagau and Vyrastekova, 2017; Pinto et al., 2018; Qi and Roe, 2017; Yazdankhah et al., 2020). The prevalence of the so-called information intervention may be due to its low economic cost and practical features. To be detailed, this study found that information campaigns basically work on different pathways to influence consumer behaviour. For instance, persuasion-related information transmits the general FW issues information to trigger consumers' guilt of wasting food, hence evoke the intention to reduce it (Hamdi et al., 2020; Alcorn et al., 2020). Educational information enhances consumers' understanding of the FW issues by providing knowledge and empowers them to proactively reduce FW (Yazdankhah et al., 2020; Ellison et al., 2019; Qi & Roe, 2017). Environmental restructuring information like reminding consumers to order a reduced size food might dismiss the FW caused by over-ordering (Jagau and Vyrastekova, 2017; Pinto et al., 2018).

However, most of the studies overlooked the process of exploring the reflective mechanisms that would drive consumer behaviour change. The absence of functional pathway identification during intervention developing may generate bias and unexpected outcomes, as the behavioural impacts of different informational contents vary through distinguished stimulating levers (R. Michie S., 2011; Qi & Roe, 2017). The no-significant (Jagau and Vyrastekova, 2017) and even negative impacts (Hamdi et al., 2020) reported in some information intervention-involved studies underline the sense of taking mechanism exploring into regard during intervention development. The absence of detailed analysis of the intervention working mechanism is accompanied by the overlooking of theoretical references during intervention design, only two studies (Williamson et al., 2016; Prescott et al., 2019) clearly stated the reference of theories. Which may hinder the readers from clearly understanding the behaviour change causes and effects (Reynolds et al., 2019), and even place obstacles in the way of reproducing and scaling up potential good FW reduction practices. This review hence underlines the relevance of theoretical considerations during intervention study.

Intervention performance and interactions

Overall, the major of the interventions tested effective in stimulating consumer behaviour change and cutting FW. The following section gives a deep discussion on the intervention's efficiency, in light with key findings that might evoke further academic research.

Individual motivation is stimulated across studies to awaken consumers' intention of performing FW reduction behaviours. However, most of those interventions that tested ineffective in reducing FW were supposed to change consumer behaviour with a function of persuasion (Chang, 2022; Jagau & Vyrastekova, 2017; Hamdi et al., 2020; Alcorn et al., 2020; Visschers et al., 2020; Martins et al., 2016), which has been allocated to the Motivation category interventions. In light of the theory of MOA, consumers may fail to conduct a behaviour even with a high intention but miss a proper opportunity (MacInnis et al., 1991). Moreover, the come-and-eat feature of the catering and hospitality sector (Davis et al., 2018) restricts consumers from managing the uneaten food, which hence ends up being unintentionally discarded. To address this problem, this study suggests the combination of motivation intervention together with opportunity interventions. This study found that consumers tend to change FW behaviour and transfer their dining patterns toward more sustainable styles, when opportunities to reduce FW are available and readily accessible. Examples refer to transforming the servicing style (Kim and Morawski, 2013; Thiagarajah and Getty, 2013), the provision of a smaller portion of

food (Freedman and Brochado, 2010; Vermote et al., 2018; Visschers et al., 2020; Wansink and van Ittersum, 2013), rescheduling the lunch break (Bergman et al., 2004; Getlinger et al., 1996), etc. In addition, Visschers et al. (2020) found that the provision of smaller portion size (opportunity) along with FW information displaying (motivation) reduced consumer FW effectively, while the latter did not result in a reduction in FW when tested alone. It should be noted that the random combination of interventions without a theoretical reference is not recommended. While negative or non-significant impacts were observed in several studies with a mix of activities being carried out simultaneously (Alcorn et al., 2020; Hamdi et al., 2020; Strotmann et al., 2017). Besides, no technology-based solutions tested across studies to reduce FW, which as opportunity-interventions have been applied in food redistribution (Secondi et al., 2020) as well as domestic FW reduction (Mustafa and Azir, 2017).

Ability-oriented interventions intends to change consumer behaviour through knowledge enhancement and skills imparting, the effectiveness of improving individual knowledge has been confirmed among studies (Yazdankhah et al., 2020; Ellison et al., 2019; Qi & Roe, 2017; Prescott et al., 2019; Manomaivibool et al., 2016; Antón-Peset et al., 2021; Martins et al., 2016), while only one study reported the evidence of improving individual skills (Yazdankhah et al., 2020). By empowering the psychological and physical capacities, consumers would naturally develop sustainable consumption habits, then the impacts on FW could last longer. This calls on future researchers to explore easy-to-operate ability building solutions in FW reduction.

Moreover, further attention on the interactions between different interventions are needed, as well as several specific interesting points presented below. Despite all intervention groups wasted less food than the control group, the extent of FW reduction varied (Qi and Roe, 2017). Consumers were willing to reduce more FW when they were informed that the uneaten food would end up by landfilling rather than by composting. The mitigation effects of FW compositing shared with consumer at the same time, might reduce the intervention effects on FW reduction by relieving consumers guilt of wasting food, then cause “innocent” waste. Therefore, this review also recommends further studies to explore the interactions between interventions.

Economic concern is recognized as one of the main factors that can be leveraged to stimulate behaviour change as consumers are naturally averse to extra costing (Vittuari et al., 2020). However, monetary penalty for leaving too much food uneaten along with moral and serving

style changing interventions reported an FW increase (Chang, 2022). Discount for zero wasters and material reward for no FW, on the contrary, both led less FW generation (Chang, 2022; Dolnicar et al., 2020). Less tasty of food causes FW (Qian et al., 2021; Stangherlin and de Barcellos, 2018). To address this problem, Hamdi et al. (2020) arranged a flavour station in the school canteen but witnessed vegetable waste increasing. Meanwhile, Strotmann et al. (2017) limited the availability of these complementary materials to the amount of food ordered, on the other hand, recorded FW reduction. Further research on the efficiency testing of interventions is recommended to be tailored to the consumers' demographics and local catering culture (Filimonau et al., 2020b).

The effect of the intervention may be diminished or eliminated through the transmission of "mediator". Martins et al. (2016) launched a debate within teachers around FW causes and impacts, then they were asked to be presence and promote student food consumption in canteen. However, FW increased among students. Similar results recorded in another educational intervention study. Students wasted less food after taking an agricultural curriculum, however, their FW related posters witnessed FW increase among peers who did not receive any relevant courses (Prescott et al., 2019). While peer influence is believed to be effective (Piras et al., 2022), above evidence suggests future research to be cautious about experiments in which the consumers cannot be directly exposed to the interventions.

Besides, further research attention should be given to the intervention impacts on consumer dietary patterns, not just a qualitative reduction in FW, as there are evidence that the decrease in some types of food waste has come at the expense of increase in other types of waste (Favuzzi et al., 2020; Hamdi et al., 2020; Martins et al., 2016). Future study is better to consider long-term impacts, which have been rarely discussed and assessed in the literature until now, assumingly due to that the follow-up investigation may require extra financial and human resource investment. This review also notices, considering the unique feature in the catering and hospitality sector that samples (consumers) are not fixed, it may be quite challenging to evaluate long-term impacts.

2.5 A roadmap to integrate consumer behaviour change interventions into policy design

Drawing from the existing experiences constituted by reliable implementation methodologies and solid evaluation analysis detected from the academic literature, this study provides practitioners and policymakers with evidence-based principles, following which to implement

and improve practical interventions and scale up to the regional or national strategies fighting against consumer FW.

Firstly, **baseline mapping**. The initial step contributes to building a detailed picture of the existing scenario and serves to set out the evidence foundation and direction of the intervention. Specific attention should be dedicated to identifying targeting population characteristics, particular consumption behaviour, and attitude patterns to disclosing believed solutions and potential factors affecting the effectiveness of intervention implementation from a stakeholder experience perspective. Policymakers and practitioners should be aware of the context factors (Meier et al., 2022) and consumers' social-economic characters that might influence the intervention impacts. This step feeds crucial information to the later intervention study by identifying potential barriers and opportunities for guiding the research following a tailored pathway.

Then, **tailored intervention designing**. Based on the portfolio of the targeting group profile identification and context mapping from the first step, the second step is devoted to the context-related intervention design (Roe et al., 2022). This study recommends starting the design from a theoretical lens to better understand the variables' internal validity. This asks the inferring of the interactions and connections between consumer behaviours with individual personal norms and external dining context (Qian et al., 2021; Karunasena et al., 2021), then further frame the mechanism which underlies the relationship between consumer behaviour and potential levers. By taking local context and all external resources availability into consideration, practical interventions should be designed by adopting and customized to different consumer profiles.

Third, **intervention testing**. To test the feasibility, validity, and improve the efficiency of the interventions designed in the last step, a pilot study is crucial before the final implementation of the strategies. The sample involved in the pilot should be representative and accurately reflects the distribution of the consumer characteristics in catering and hospitality sector. Importantly, ensuring consumer safety and study ethics should always be the top priority during the intervention implementation. Hence, the intervention acceptance among consumers could be integrated with the impact evaluation process. Food business operators at this point are expected to be engaged and form a systemic FW monitoring network (Malefors et al., 2022). The analysis of the trial study should be informed by reliable data collecting and results reporting.

Finally, **strategy implementation and upscaling**. Based on the learnings from previous steps, effective interventions could be integrated into the local regulations and further bring in legislation. The last step thereby aims to enrich the FW reduction interventions, and assess their transferability and scalability, with practical experience from policymakers and practitioners.

2.6 Conclusion

Food waste is one of the significant threats accelerating global food insecurity. This study pays specific attention to the practical FW reduction interventions when residents are dining out. By applying systematic literature retrieving method and based on the integration of the MOA framework and behaviour change wheel, this review compiles and appraises field experiments that aimed to test the effectiveness of FW reduction interventions within the catering and hospitality sector.

This study found that most of the studies were conducted under an educational context, and less attention has been paid to commercial sectors including restaurants, hotels, etc. Intervention underlined mechanism identification is absent generally, which informs future research to take the behaviour influencing pathways behind interventions into consideration. To stimulate consumer behaviour change, environmental restructuring, persuasion, and education classified by the behaviour change wheel are the three domain levers applied across studies to address consumer FW. Smaller portion provision, education sessions, lunch break rescheduling, service style change, serving plate improvement, consumer dietary preference analysis and several other interventions tested effective in cutting FW.

Based on field evidence, this review further provides some attention points to indicate future research. Integration of persuasion interventions with opportunity provision solutions, tailoring FW reduction interventions to individual and local dietary culture, being aware of the interactions between interventions are all recommended. If possible, long-term impacts and consumer dietary pattern changes could also be taken into consideration during intervention evaluation as added value during impacts evaluation. To effectively address consumer FW in the hospitality and catering sector, this review proposes a four-step roadmap, following which policymakers and practitioners could explore practical solutions to cut FW.

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CHAPTER 3 - The role of school meals in promoting sustainable development - What has been done and what should be done

This article is ready to submit to the Appetite Journal.

Keywords: School meals; Sustainable consumption; Intervention;

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Abstract

The role of school meals is to provide students with adequate nutritious food and promote overall health and wellness. While ensuring the realization of traditional goals, how to use school meals to promote sustainable management of school catering, and further promote the transformation of the food system, has attracted the attention of both academics and policymakers. To answer this question, this study aims to explore the potential contributions of school meals on sustainability development, basing on both academic evidence and stakeholders insights. This study first applied PRISMA to map tested interventions aiming to reduce school meal impacts and/or increase benefits. A workshop was then held to bring together stakeholders acting in the school catering to co-design new school meal interventions basing on mutual learning dialogues. This study synthesized evidence from 14 peer-reviewed articles concerning school meal interventions. There are six benefit pillars have been achieved across studies, namely: reduced environmental impacts, improved food consumption, healthier food provision, better waste management, affordable cost, and strengthened social connections. A total of nine interventions are identified from the literature. Among them, new menu introduction and educational modules were tested mostly. Stakeholders workshop identified challenges and possible solutions for school meal development. Results showed that most of the school meal challenges were not yet being addressed through previous research.

3.1 Introduction

Over the decades, school meals evolved with changing priorities for food security (Evans & Harper, 2009; Sonnino, 2009). Today, they are not only valued for sufficient food provision, but also for the diversity of environmental, social and health benefits they could convey (Cohen et al., 2021; dos Santos et al., 2022). School meals were acknowledged as the key game changer in promoting healthy and sustainable food consumption. Not only do school meals provide students with their daily food needs, but the dietary habits they develop here will also influence their health and quality of life in the long term (Craigie et al., 2011; Wang et al., 2021). Unhealthy eating behaviour increases the risk of chronic diseases (Madowitz et al., 2012), as well as loads down the food system with environmental burdens (Clark et al., 2019; Ernstoff et al., 2019; Tuomisto & Teixeira de Mattos, 2011). Also, as one of the major sources of consumer food waste, school canteen food waste has been confirmed by a growing research base that could be indeed reduced through effective school meals related activities (García-Herrero et al., 2019; Lorenz-Walther et al., 2019; Whitehair et al., 2013). Thereby, school meals should act beyond the conventional responsibility of adequate nutrition provision. Health and sustainability concerns should also be integrated.

Interventions to uncover the diverse benefits of school meals have come into practice (Ensaff et al., 2015; Malefors et al., 2022; Vidal-Mones et al., 2022), motivations to lever its role and scale up the policy benefits have correspondingly increased (dos Santos et al., 2022). The extent to which school meals can foster sustainable consumption and further boost food system transition (EU, 2019) **is needed to be explored. The sustainable b**enefits already **achieved** or could be achieved from school meal programs remain poorly addressed.

European Commission encourages and emphasizes the wide engagement of stakeholders in policy designing in light of their crucial role in the success of the European Green Deal (EU, 2019). Hence, the action of promoting sustainable and healthy school meals cannot be performed without the involvement of stakeholders, whose responsibility in school catering governance is essential to better address complex food system challenges (Asada et al., 2017) Engaging stakeholder into the school meal development enriches the intervention creation with the consideration of interests that might affect related actors during the physical implementation, it is of great importance (Chambers et al., 2020). Relative management activities could effectively reduce environmental impacts of food system and stem unhealthy food consumption (Lassen et al., 2004; Lawlis et al., 2016). The involvement of stakeholders in intervention

design could potentially address this problem, their deep understanding of the school dietary environment, as well as adequate experience in school food catering informs and enriches the intervention development (Asada et al., 2017; Lawlis et al., 2017).

Overall, this study aims to provide an evidence synthesis on school meals interventions tested in real life contexts to explore the potential in promoting and boosting sustainability development, to catalogue and co-design the effective forms of interventions based on stakeholder's knowledge and experience. To this scope, the study reports a stakeholder focus group to connect school catering actors, in which stakeholders were empowered to co-develop and co-design innovative ideas in school meal interventions.

A systematic literature review is conducted to explore the forms of school meal interventions, by which the school meal could generate less impact. Then stakeholders from different contexts were engaged to explore summaries and critiques leading to better future practice. The focus group consisted of stakeholders from academia, municipality, and school management. A three-stage stakeholder co-design workshop was held to guide participants step-by-step in identifying evidence-based and reliable strategies and enclosing managerial perspective.

3.2 Methodology

Literature review – peer-reviewed articles

This study applied the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to identify compatible peer-reviewed articles. English documents were retrieved both Scopus and Web of Science (WoS). Considering that multiple terms (e.g., intervention, strategy, initiative) are applied by studies referring to the FW reduction interventions (Elinder et al., 2020; Ensaff et al., 2015; Ruge & Mikkelsen, 2013), we adopted a comprehensive keywords selection. The searching strings we used are as follows:

Scopus: (TITLE-ABS-KEY ("school food*" OR "school canteen*" OR "school catering*" OR "school meal*")) AND (TITLE-ABS-KEY ("intervention*" OR "behavioural change*")) AND (LIMIT-TO (LANGUAGE , "English"))

Web of Science: TS=("school food*" OR "school canteen*" OR "school catering*" OR "school meal*") AND TS=("intervention*" OR "behavioural change*") and English (Languages)

Literature search was carried out in July 2022. A total of 1365 articles were identified, with 633 from Scopus and 732 from WoS. By excluding 524 duplications, 841 papers were collected for

the screening. The inventory has been reviewed based on a title/keywords/abstract analysis to determine if the study conducted a potential practice aiming to improve school meal sustainability. Consequently, 39 articles have been retained for further evaluation. At the final included stage, only studies i) aiming to test a practical intervention to improve school meal sustainability; ii) presenting experiment results based on solid data collection methods; iii) evaluating the interventions impacts with evidence-based results were included. Overall, 14 independent peer-reviewed articles were identified for further analysis. (**Fig. 3.1**).

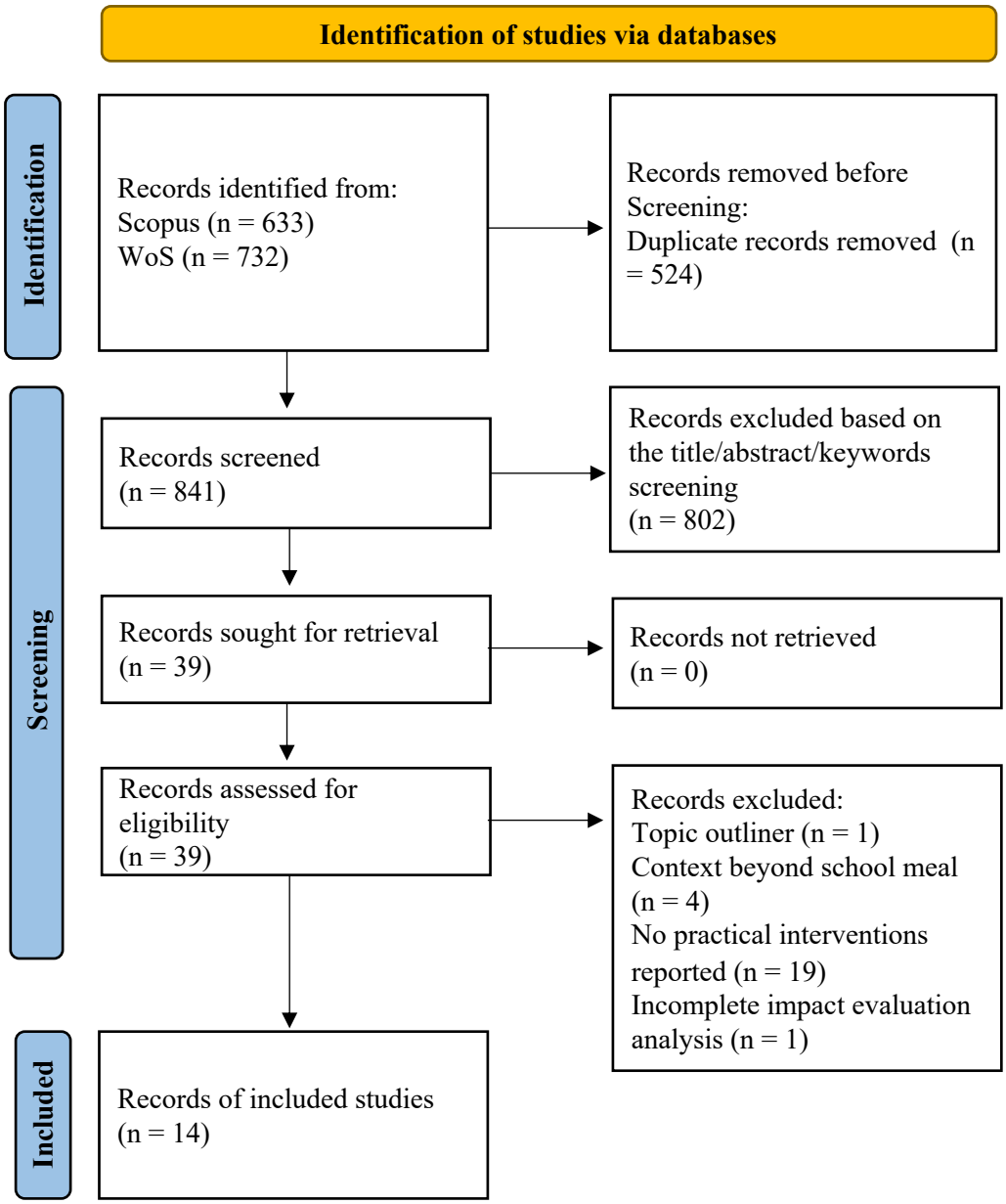

Figure 3. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses working flow.

Stakeholders co-design workshop

Stakeholder workshops, as a way to engage school meals stakeholders, drawn on the insights from relevant actors and influencers by experience sharing and knowledge mutual learning (Desai, 2018; Mitchell et al., 2022). In this study, we conducted a series of stakeholder workshops to set priorities for sustainable school meals and led a joint pathway of solutions co-designing and decision-making (Ramus & Vaccaro, 2017). Hence, workshops here played as a platform for the stakeholders to express opinions, synthesize insights, and co-design plannings for school meals challenges. In addition, self-involvement in the practical school meals strategies design could build community trust in public policy network (Galli et al., 2014; Thaler & Levin-Keitel, 2016)

First, workshops built a shared understanding of challenges and barriers concerning school meals sustainability. Then, given all these problems, solutions were created basing on the integration of scientific methodologies and stakeholders' wisdom. Multiple The stakeholder consortium was comprised of representatives from academia, regional and municipal government, local sanitary service, and regional agri-food system management (see Supplementary Table 1 in Appendix), each brought their valuable experience-based perspectives. The workshops were consisted of three sequential discussion sessions, with the overall objective of understanding the present state of school meals, identifying their sustainability issues, and proposing potential solutions to tackle them. Workshops were conducted in June and July 2022. Participants' views were transcribed and collated by the authors.

Workshop 1_School meals sustainability issues mutual learning. The stakeholder kick-off workshop served to provide stakeholders with scientific knowledge of behaviour change intervention, while collecting and exploiting their experience and understanding regarding school meals sustainability. The workshop guided stakeholders through the journey 'From priorities to interventions design', including the steps to be taken (i.e., stakeholders scouting, co-design practices, local adaptations). During the workshop, stakeholders were acquainted with basic knowledge of intervention definition and implementation. One science-based intervention was presented to provide concrete illustration as a practical example. The workshop held a brainstorming session on the problems faced by the school meals and reached

consensus on their improvement goals. The specific objectives of the 1st workshop are detailed below:

- Foster the understanding of behaviour change interventions among stakeholders.
- Understand the local school canteen food environment.
- Define school challenges and envision sustainable management strategy for school canteens.

Workshop 2&3_School meals solution co-designing. The last two workshops focused on further deepening the stakeholder's understanding of the intervention, and co-designing school meals solutions. Aligned with the school meals improvement goals identified in the first workshop, the latter two workshops aimed to bridge the gap between theory and practice with the following objectives:

- Propose behaviour change interventions.
- Enrich the intervention proposals with the practical experience from stakeholders.

3.3 Results and Discussion

Research Profiling

Published journals. The 14 articles were published in 11 journals, with the impact factors (IF) varying from 1.9 to 13.7 based on the Journal Citation Reports 2021 from Clarivate. The top three journals are Resources, Conservation and Recycling, Science of the Total Environment, and Waste Management. Seven studies were published in journals in the field of Environmental Sciences, four studies were published in the journals concerned Nutrition & Dietetics area, and four studies were published in journals majoring in the category of Public, Environmental & Occupational Health (**Fig. 3.2 a**). It should be noted that journals with a scope covering environmental issues are prevalent in the school meal intervention studies, due assumingly to that the major of those studies focus on school meal environmental impacts reduction and effective food waste management. Addressing environmental issues is certainly important, but adequate nutrition provision, health meal promotion, as well as social connection building, how school meals could contribute to these benefits needs more attention as well.

Geographic distribution. As indicated in Figure 3.2 c Sweden and Spain are recorded as the top two countries/regions that practically reported school meal interventions, with more than

35% of these studies conducted in these two nations. Denmark and USA are both recorded two studies, and one study in Brazil is the only one tested in a developing economy. EU Member States recorded 9 studies (more than half) in total including one study from Italy. This unbalanced geographical distribution of academic research echoes concerns about children's nutritional issues as well as general food insecurity challenges in unindustrialized regions.

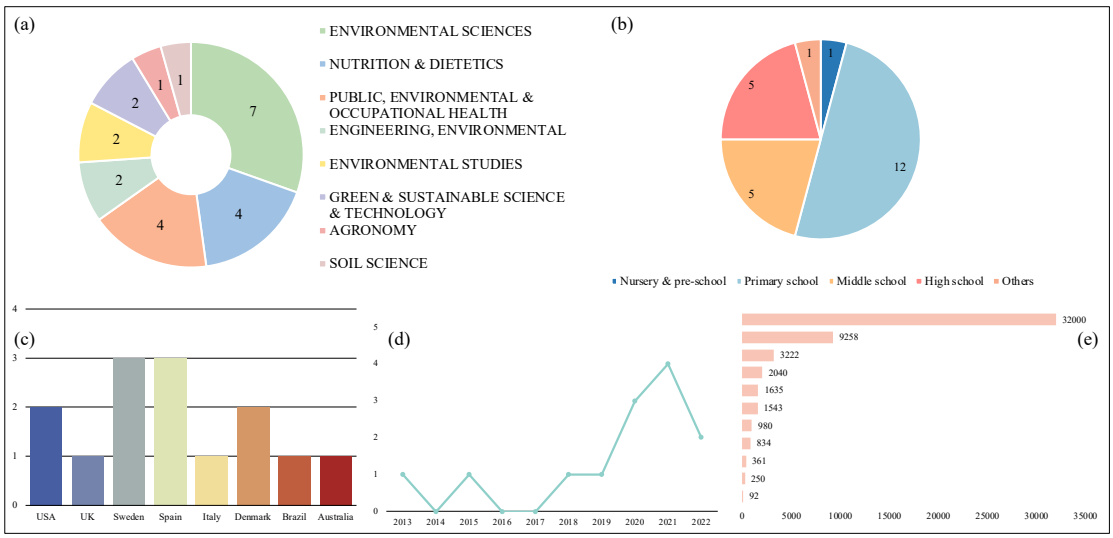

Figure 3. 2. Research Profiling. a) Journal scopes; b) Research context; c) Research origin; d) Published year; e) Sample size.

Case study contexts. Given the intervention implementation context, there are 12 studies that experimented strategies aiming at improving primary school students' meals or related activities, while both middle and high schools registered five studies. Nursery and preschool, as well as adult education institution both recorded one study each. Overall, five studies tested interventions across school types, and middle school is targeted in all these five studies (**Fig. 3.2 b**).

Sample size. Except one study does not disclose the sample size (Vidal-Mones et al., 2022), and two studies report the sample population in terms of the number of schools (Batlle-Bayer et al., 2021; Wolfenden et al., 2019), most of the studies (11 articles) recorded the number of students (or the number of observations) involved in the intervention study. As showed in the Figure 1e, sample population ranges from 92 to 32000 students/observations across studies. Six of them conducted the intervention with a population exceed 1500 (**Fig. 3.2 e**).

Publication year. Year 2013 witnessed the first school meal intervention study published, even before the release of 2015 UN SDGs. After then, relevant school meals intervention

research has progressed slowly. Years 2014, 2016, and 2017 recorded no study. In the past three years, despite the enforcement of strict sanitary restrictions globally, which mainly aimed to prevent the spreading of Covid-19 but suspended field research as well (Riccaboni & Verginer, 2022), the number of articles increased sharply (**Fig. 3.2 d**). As the literature retrieval was conducted in September of 2022, the number of articles published this year did not count subsequent articles.

School meals interventions

Intervention design and originality

This study disclosed how all tested interventions were designed and to what extent the governance support was involved. Put simply, governance support, stakeholder cooperation, literature reviewing as well as relevant project activities testing have been defined as the pathways through which school canteen interventions were designed (**Fig. 3.3**).

Governance support is of great important to the upscaling and legalization of effective school meals. Results shows that more than 40% of total studies were governance supported. Two studies held municipality-supported stakeholder talks (Elinder et al., 2020; Eustachio Colombo et al., 2020). School management and administrators together with meal planner were invited to the school meal sustainability discussion. Eustachio Colombo et al (2020) applies linear programming to optimize food list for nutritional adequacy and minimal climate impact, new school meals were then invented based on this list. Four studies tested regional or national projects/policies (Batlle-Bayer et al., 2021; Kluczkovski et al., 2021; Ruge & Mikkelsen, 2013; Wolfenden et al., 2019). Those projects or policies were about low carbon meals provision (Batlle-Bayer et al., 2021; Kluczkovski et al), strategies dealing with children obesity problem (Ruge & Mikkelsen, 2013), and national dietary guidelines (Wolfenden et al., 2019). Government-backed intervention studies generally have large sample sizes except one student cooking workshop (Ruge & Mikkelsen, 2013), which benefits more precise estimations of intervention effects and strategies legalization.

Four studies tested interventions in cooperation with stakeholders. Andersen et al (2015) reported an expert workshop, those experts major in human nutrition, gastronomy, food economy and environmental issues as well as children dietary behaviour. An innovative school meal defined as New Nordic Diet was invented consequently. Burgess-Chanpoux et al (2018) held a consumer taste testing session with questions on children's knowledge, attitudes, and

behaviours regarding legumes. Dish contained legumes were created by these children who joined in this session. Tested legume entrees were designed adopted to the session outcomes in cooperation with chef. Mutual learning between academics and chef has been applied in two studies (Malefors et al., 2022; Vidal-Mones et al., 2022). Academics provided chef with intervention proposals, and selected the final tested ones based on their discussion and knowledge sharing.

The conventional way of literature reviewing has been applied in three studies (Antón-Peset et al., 2021; Elnakib et al., 2021; Ensaff et al., 2015). Interventions aiming to improve school meal sustainability were emerged as candidates from the review of previous studies. Favuzzi et al (2020) integrated school meal experiments into an academic project which aims to evaluate school canteen food waste.

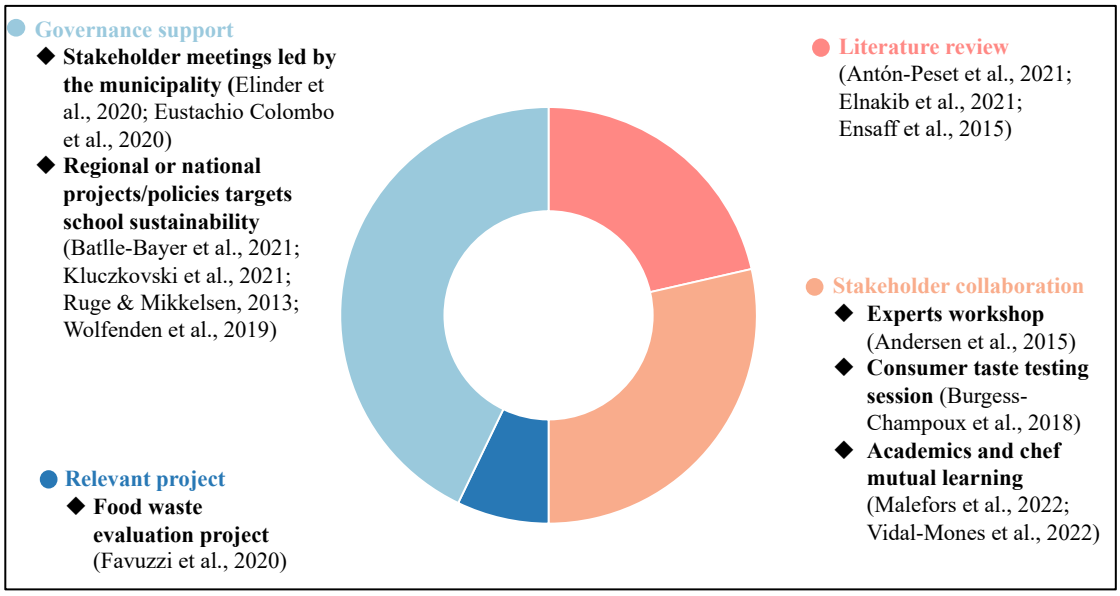

Figure 3. 3. Distribution of intervention design approaches.

Intervention description, data collection, impacts comparison

Interventions that introduced new menus were most often tested (35.3%, Table 3.1). The duration of new menu interventions ranged from 4 weeks to 40 weeks. One vegetable-only menu intervention took 40 weeks (200 school days) ranks as second longest interventions regardless of its type. Introduced menus were either formulated during an expert workshop (Andersen et al., 2015) or stakeholder talks (Elinder et al., 2020; Eustachio Colombo, Patterson, Lindroos, et al., 2020). Traditional menus were improved with legumes inclusion (Burgess-Champoux et al., 2018) or meat products exclusion (Kluczkovski et al., 2022).

Educational modules have been applied in several studies (17.6%), they generally aim to provide food-related knowledge, and consequently change students' dietary behaviours to reduce food waste (Antón-Peset et al., 2021; Favuzzi et al., 2020; Vidal-Mones et al., 2022). Educational sessions tend to take less time compared to new menu introduction, ranging from 4 to 12 weeks. Unlike the prevalence of information awareness in related contemporaneous studies (Stöckli et al., 2018), only two studies tested information delivery-based interventions. Both studies aim to reduce consumer food waste but varied in poster contents. Malefors et al (2022) used table talkers to highlight food waste issues and displayed canteen food waste status in a seven-week intervention, while Vidal-Mones et al (2022) spent 12 weeks to provide consumers with food waste reduction tips or appetite status reminders.

Table 3. 1. Interventions classification and description.

Description	Duration	Reference
New Menu (35.3%)		
New Nordic Diet (NND) meals including a mid-morning snack, an ad libitum hot lunch meal and an afternoon snack are provided to children. This meal follows the principles of Health, gastronomic potential, sustainability, and Nordic identity.	12 weeks	Andersen et al., 2015
One-week low-carbon meal proposed by the Municipality of Barcelona is provided	NA	Batlle-Bayer et al., 2021
Legumes are included in the entrée	2 weeks	Burgess-Champoux et al., 2018
Four-week meal plan and a food list are provided by Municipality, new menu is optimized to meet localization, nutrition, and carbon emission criteria	4-6 weeks	Elinder et al., 2020; Eustachio Colombo et al., 2020
Sustainable meals which exclusively compose plant-based foods are provided	40 weeks	Kluczkovski et al., 2021
Educational module (17.6%)		
Educational sessions are provided with relevant food system knowledges	3-12 weeks	Antón-Peset et al., 2021; Favuzzi et al., 2020; Vidal-Mones et al., 2022
Informational poster (11.8%)		
(a) Table talkers, which communicate messages on the issue of food waste are placed on the tables as well as the top of the serving station; (b) Plate waste tracker shows the guests how much food they wasted and its impact.	7 weeks	Malefors et al., 2022
Menu displaying, tips to eat apple, ask how hungry the students are	12 weeks	Vidal-Mones et al., 2022

Catering service improvement (5.9%)		
(a) Tasting spoons are applied on the canteen serving line to allow guests to taste the dish before taking too much food; (b) Guest forecasting tool is applied to predict future demand then adjust food production	7 weeks	Malefors et al., 2022
Consumer choice architecture changing (5.9%)		
(a) Daily special vegetarian meal is served by disposable pots; (b) Salad sandwiches are packed with stickers and promoted by poster; (c) Fruit pots are tagged with stickers and labels; (d) Fruits are displayed in the shape of pyramid and promoted with window sticker	6 weeks	Ensaff et al., 2015
Employee training (5.9%)		
The training included best practices for implementing low-cost or no cost changes to the lunchroom through Smarter Lunchrooms Movement (SLM) strategies	NA	Elnakib et al., 2021
Policy implementation support (5.9%)		
(a) One support officer is allocated to each school; (b) School principals and parent committees are engaged; (c) Canteen manager training; (d) Tools and resources are provided; (e) Academic detailing; (f) Feedback, recognition and marketing initiatives are provided	80 weeks	Wolfenden et al., 2019
Student cooking workshop (5.9%)		
Students cook their own school food and then transfer the food to classroom	1 week	Ruge & Mikkelsen, 2013
Employee participation (5.9%)		
Employee are engaged to inform students with daily menu and how the best way to eat apple	12 weeks	Vidal-Mones et al., 2022

Aiming to reduce food waste, Malefors et al (2022) improved catering service. The tasting spoons were expected to reduce mainly plate waste as consumers could avoid taking too much food that the taste they don't prefer. Guest forecasting tool on the other hand could help canteens to prepare food based on actual demand and reduce serving waste. Changing consumers' choice architecture like using disposal pots or stickers has been applied in a school canteen to promote vegetable and fruit consumption Ensaff et al (2015).

Employee training with the aim of effectively managing the canteen was tested in one study (Elnakib et al., 2021). Vidal-Mones et al (2022) tested the effect of a staff intervention to student meals on food waste over a 12-week period. Students were invited to a one-week cooking workshop to establish new educational links between schools and local producers and thereby contribute to students' food literacy (Ruge & Mikkelsen, 2013). To support the policy implementation which aims to promote healthy food items on the school menu, several

strategies have been applied across primary schools. This intervention took 18 months (80 weeks) starting from the baseline period and ranks as the longest school meal intervention in this study (Wolfenden et al., 2019).

Intervention sustainability benefits

The aspects of sustainability targeted by these interventions vary across interventions. We draw on indicators targeted by those interventions and show how they impact the performance of these indicators. Results show that there are six benefit pillars covered by those school meal interventions, namely: environment, nutrition (consumption), health, waste management, cost, and social. Intervention impacts were presented in Figure 3.4 have been harmonized for the observed percentage reduction in indicator values.

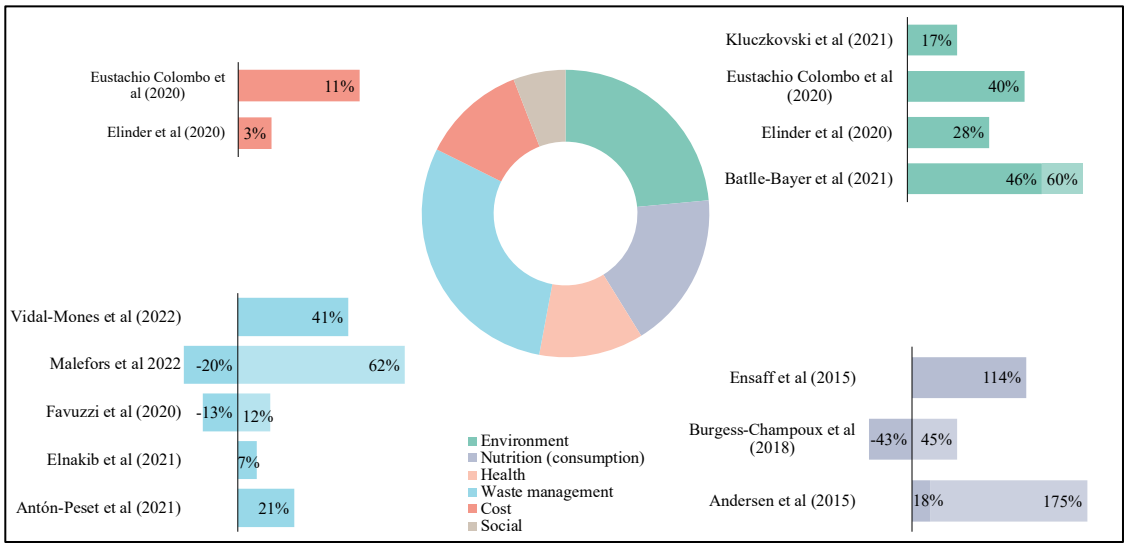

Figure 3. 4. Intervention impacts on benefit pillars and study distributions.

There are five studies tested interventions aiming to improve waste management efficiency of school meals (Antón-Peset et al., 2021; Elnakib et al., 2021; Favuzzi et al., 2020; Malefors et al., 2022; Vidal-Mones et al., 2022). Except one study also takes serving waste into consideration (Malefors et al., 2022), other studies only targeted consumer plate waste. Waste management indicator applied was commonly food waste but measured in varied units. Antón-Peset et al (2021) and Malefors et al (2022) measured wasted food per guest. Elnakib et al (2021) carried out the data collection with sub-indicators of fruit waste, vegetable waste and milk waste, total waste was hence summed. Favuzzi et al (2020) and Vidal-Mones et al (2022) quantified discarded food of each course separately. The highest reduction of food waste amount has been recorded as 62% as the serving waste has been reduced after the introduction of a plate waste

tracker (Malefors et al., 2022). However, this study also witnessed the highest food waste increase after the provision of tasting spoons in terms of serving food waste. Moreover, the reference group also reported food waste reduction. Vidal-Mones et al (2022) reported a 41% food waste reduction impact under nudging strategies. After a 3-week educational session on food waste, such as ways to reduce it, students wasted 21% less food per day (Antón-Peset et al., 2021). Education modules applied in the form of flipped classroom, however recorded both food waste reduction (12%) for the first course and increase (13%) for the side course. An employee training intervention witnessed 7% total food waste reduction.

School meal environmental issues were discussed by four studies (Batlle-Bayer et al., 2021; Elinder et al., 2020; Eustachio Colombo et al., 2020; Kluczkovski et al., 2021). Three of them also consider secondary benefits, for instance, economic issues (Elinder et al., 2020; Eustachio Colombo et al., 2020) and health benefits (Kluczkovski et al., 2021). The three papers are registered as all studies targeting multiple sustainability aspects through a single intervention. The environmental indicator targeted is mainly greenhouse gas emission (Elinder et al., 2020; Eustachio Colombo et al., 2020; Kluczkovski et al., 2021), while Batlle-Bayer et al (2021) applied a rather detailed indicator list consisting of blue water footprint, primary energy demand and land use, and the global warming potential. The adoption of new food lists and menus effectively reduced the environmental impact of school meals in terms of greenhouse gas emissions (40% in Colombo et al., 2020 and 28% in Elinder et al., 2020). A sustainable cholesterol-free menu reduced up to 17% of greenhouse gas emissions (Kluczkovski et al., 2021). One-week low-carbon meal plan intervention performed best, as the results show environmental impact reduction from 46 to 60% depending on indicators.

Three studies document interventions' impact on food consumption (Andersen et al., 2015; Burgess-Champoux et al., 2018; Ensaff et al., 2015). Apart from Burgess-Champoux et al (2018) giving a specific focus on legume entrée consumption, the other two studies tested intervention impacts on multiple food types (Andersen et al., 2015; Ensaff et al., 2015). After including legumes in five entrées, Macaroni and Cheese witnessed the highest intake reduction of 45% from 93g to 53g, while the highest entrée consumption increase was registered as 45% in Pasta with Meat Sauce from 130g to 189g (Burgess-Champoux et al., 2018). Andersen et al (2015) applied a new menu (New Nordic Diet) and recorded food intake increase across food types, with the highest increase of 175% in herbs consumption and the lowest increase of 18% in nuts and seeds as well as fat fish and fish products intake. Ensaff et al (2015) recorded the selected

food item selection ratio and witnessed a series of interventions changing consumer choice architecture has promoted food consumption successfully, selection increased by 114%.

Two studies that adopted new food lists and menus both considered the cost of the menu and showed that the new menus were more affordable (Elinder et al., 2020; Eustachio Colombo et al (2020).

School meals sustainability challenges

Stakeholders expressed concerns about fruit and vegetable consumption and/or waste among students, especially those in primary school (C1 and C3, Table 3.2). This should be a critical consideration for promoting school meals sustainability, which relies on increased consumption of fruits and vegetables to support better nutrition among children (Eustachio Colombo, Patterson, Elinder, et al., 2020; World health organization, 2021). Both fruit and vegetable considered difficult for students to consume, leading to potentially poor nutrition and increased food waste. Low awareness of fruit and vegetable consumption among students was regarded as one of the main factors exacerbating this problem (C3). However, solutions to address the fruit and vegetable consumption were rarely tested in the previous studies. Only Burgess-Champoux et al (2018) improved school meals menu with the inclusion of legumes to evaluate its impacts on students' consumption. Besides, while several studies examined interventions aimed to reduce food waste (Antón-Peset et al., 2021; Elnakib et al., 2021; Favuzzi et al., 2020; Malefors et al., 2022; Vidal-Mones et al., 2022), the extent to which such interventions influenced fruit and vegetable consumption remains largely unknown.

Menu and cooking culture diversities drew stakeholders' attention as well. The variety of fruit provisions were limited in school meals (C4). Their cooking style tended to include few fruits and vegetables (C5). The traditional school meals appeared to be less interest in including vegetables and legumes (C6). The concerns raised here are closely related to the issues highlighted earlier about low student fruit and vegetable consumption. Studies conducted by Burgess-Champoux et al (2018) and Kluczkovski et al (2022) have provided innovative solutions for designing more appealing vegetable and legume-based menus, such as incorporating legumes into entrées or offering exclusively plant-based meals. In addition, Ensaff et al (2015) used more attractive arrangements and placements of vegetables and fruits (Paakki et al., 2019) and has effectively increased targeted items selection.

Eating in school canteen is now regarded as an important opportunity for students to socialize and build relationships (Illøkken et al., 2021). Regarding social issues, stakeholders believed that family involvement in school meals was rather low and should be enhanced (C8). Besides, the disconnections between preschool and primary school in alimentary education should be well addressed (C7). Stakeholders further indicated that the first year in primary school might be extremely important for students' food education. However, previous studies haven't explored these crucial social dimensions of school meals. Particularly, for lower-income families, school meals provide students with adequate nutritious food, which thereby reduces social inequalities (Bakhshinyan et al., 2019; Illøkken et al., 2021). Apart from school all of those aforementioned challenges, stakeholders also recognized that to practically conduct school intervention, staff competence in data collection and their daily turnover might affect intervention performance (C9, C10). In addition, the long-term evaluation is encouraged (C11).

Table 3. 2. School meal sustainability challenges.

Description	Targeted in literature
Fruit and vegetable consumption/waste	
C1 Fruit and vegetable consumption difficulties among primary school students	Burgess-Champoux et al., 2018
C2 Low awareness in fruit and vegetable consumption among primary school children	-
C3 Vegetables are wasted more than fruit	-
Diversities in menu and cooking culture	
C4 Limited fruit provisions in terms of fruit types	-
C5 Less use of fruit and vegetables in cooking culture	Burgess-Champoux et al., 2018; Kluczkovski et al., 2020
C6 Low acceptance of menu with vegetables and legumes	Ensaff et al., 2015
Social connection	
C7 Food related education is unconnected between preschool and primary school	-
C8 Low family involvement in school activities	-
Intervention implementation	
C9 Staff competence in data collection	-
C10 Staff turnover during intervention implantation	-
C11 Intervention works in short-term, not long-term	Wolfenden et alk., 2019

(Data source: compiled by the authors based on information collected at the workshop)

School meals challenges solutions

Following the identification of school meals challenges, the stakeholders participated in subsequent discussions to co-design practical solutions to tackle them. There were no solutions identified for challenges C4 and C11. Considering potential solutions for C4 may require a

more diverse fruit supply, it's beyond the extent a school meals intervention could reach. C11 concerns the intervention implementation issues, not focus on school meals. Hence, both challenges were not target in this section.

Appealing fruit or vegetable-based dishes were recommended to tackle fruit and vegetable consumption issues (Paakki et al., 2019; Pollard et al., 2002). For instance, morning snack made of fruit-based ice cream and lentil veggie burgers. Activities to make students more familiar with food were believed as a promising strategy for promoting healthy food consumption (Wolfenden et al., 2019). Specific solutions that could facilitate this objective could be vegetable tastes familiarization training to increase vegetable acceptance (Fildes et al., 2014; Hoppu et al., 2015; Nekitsing et al., 2018).

Table 3. 3. School meal intervention proposals.

Description	Targeted groups	Targeted challenges
Increasing healthy food consumption		
Fruit salad or morning snack made of fruit-based ice cream	Students	**C1, C5, C6**
Vegetable and legume cooking workshops	Students	**C1, C3, C6**
Training for familiarizing with vegetable tastes	Students	**C1, C3, C6**
New recipes containing legumes	Students	**C5**
Lentil veggie burgers as a complete sandwich (i.e. with bread, salad, tomatoes)	Students	**C5, C6**
Competition on most beautiful burger or best vegetables and legumes recipes	Students	**C5, C6**
Reducing food waste		
Providing smaller size of food	Students	**C3**
Integrating into alimentary sessions		
Food education together with taste adoption sessions	Students, particularly first year students.	**C7**
Integrate food-related topics into current civic education session	Students	Extra benefits
Consumer and staff training		
Staff training and involvement	Canteen staff	**C9, C10**
Awareness-raising (social-environmental) campaign	Students	**C2**
Enhancing social connections		
Peer influence for first year students	First year students	Extra benefits
Inviting students' families to the cooking and recipes competitions	Students and their families	**C8**

(Data source: compiled by the authors based on information collected at the workshop)

Cooking workshops positively increased nutrition knowledge in children (Jacob et al., 2020) by providing hands-on experience, thereby, these workshops were considered to be a useful

tool for promoting the consumption of vegetable and legume foods among students. In addition, organizing competitions on the aesthetics of burgers (Paakki et al., 2019) and the creativity of vegetable and legume recipes could also be effective in promoting their consumption. Such events motivate students to experiment with and exposure to unfamiliar food options (Wolfenden et al., 2012) while sparking their interest, ultimately could lead an increased consumption of these nutrient-rich foods. Besides the recipe competitions, daily school meals were encouraged to include legumes (Rosi et al., 2019). To tackle food waste issues, it's recommended to provide smaller size options and let students decided to choose the needed amount. Previous studies have verified the effectiveness of this solutions (Berkowitz et al., 2016; Lorenz-Walther et al., 2019).

Stakeholders highlighted the importance of integrating food education into school curriculum considering its crucial role in promoting healthy habits and enhancing food literacy (Jung et al., 2019). As such, food education sessions could be a valuable strategy for promoting sustainability in school meals. Integrating food education modules with food taste adoption sessions was assumed to be effective in promoting nutritious and health food consumption. Awareness-raising campaigns were effective in school-based strategies (Pinto et al., 2018). In line with this, stakeholders have suggested to conduct campaigns to highlight social and environmental impacts of food choices. Staff training and their active involvement can be beneficial in school meals sustainability building. Peer influence can play a significant role in shaping food consumption patterns among students (Chung et al., 2021; Stok et al., 2016). Peer-led interventions could be promising strategies for promoting health diets in school meals. Family involvement affects school meals social impacts as well, inviting families to school activities can help facilitate school meals sustainability as they tended to influence students' lifestyle (Sevil et al., 2019).

3.4 Conclusion

The role of school meals is to provide students with adequate nutritious food and promote overall health and wellness. While ensuring the realization of traditional goals, how to use school meals to contribute to the sustainable development and management of school catering, and further promote the transformation of the food system, has attracted the attention of academics and policymakers. By mining evidence-based practices from previous literature and disclosing stakeholders' perspectives, this study compiles a systematic literature review and enriches the results with stakeholders' experience-based opinions.

This review found that major interventions are identified from the literature, among them, the new menu, educational module, and informational poster are registered as the top three hotspots in terms of study numbers. A large portion of those interventions was governance supported. They are either initiated by stakeholder talks or attached to municipal, regional or national projects. Results show that interventions empowered by governance were mainly carried out among a rather large sample population. This sets the stage for detailed impact analysis and effective strategies legislation. Apart from this, stakeholder dialogue, for instance, knowledge mutual learning workshop, is also one of the common approaches used to identify specific interventions.

Results outline that school meal interventions primarily achieve six benefits: less environmental impacts, increased food intake, healthier food provision, effective waste management, affordable cost, and strengthened social connections. Regardless of the indicators applied, those interventions more or less achieved one or more certain targets. Less environmental impacts like greenhouse gas emission reduction and effective waste management like food waste reduction were two of the main objectives. Healthier food provision and strengthening social connections, on the other hand, need more academic attention.

Stakeholders express various concerns or expectations for school meal development. However, based on a rough comparison to those interventions from the literature, most of the school meal challenges are not yet being addressed. For example, low awareness of vegetable and fruit consumption among students, limited fruit provisions in terms of types, no educational connections between preschool and primary, low family involvement in school activities, etc. Practical interventions to deal with these challenges were proposed. Among them, student vegetable and legumes recipes competition, fruit salad or morning snack of fruit-based ice cream, and taste training with vegetable samples are all believed to be effective in certain targets.

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FINAL CONCLUSION

This research advanced the understanding of consumer food waste through the application of Motivation-Opportunity-Ability framework, examining both household and catering and hospitality sectors. The main outcomes reveal that consumer behavioural drivers related to food waste are complex, tackling strategies should be thereby tailored to different consumer profiles and settings. This study also highlights the need for cooperation among stakeholders to achieve sustainable consumption of food.

The first research goal was to ***understand specific factors that affect individual behaviours to generate FW at household***.

A systematic literature was conducted, with the aim to critically appraise behavioural drivers and levers of household food waste (**Chapter 1**). Relevant literature was collected from a bibliometric literature review from a large dataset of both scientific papers and grey literature. Experts' opinions and feedbacks from the European Consumer Food Waste Forum (ECFWF) were integrated following the growing international commitment. This review combined 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). Basing on an adjusted MOA framework, this study framed drivers and levers of household food waste. The complexity underlying consumer FW requires tailored and diversified actions to stimulate behavioural change. Hence, this study further conducted consumer segmentation studies review with respect to consumer profile characteristics and then informed the identification of high food waster groups. Despite limitations that might exist due to unsolid data collection methods like personal reported survey, consumer segmentation might lead future studies toward a rather tailored way to address FW.

The second research goal was to ***analyse the effective ways to reduce FW through behaviour change perspective given the catering and hospitality sector***.

This study applied the PRISMA method to focus on practical behaviour change interventions for reducing food waste in the catering and hospitality sector (**Chapter 2**). The integration of the MOA framework and behaviour change wheel has been utilized to unveil the complexity of intervention developing process and underlying mechanism identification. Main findings of this review highlighted the imbalanced academic studies distribution in this sector, with most studies were conducted under an educational context while less attention has been paid to commercial sectors including restaurants, hotels, etc. Intervention underling mechanism

identification was absent among studies, which poses challenges on successful strategies upscaling and legislations, as one successful intervention may not be effective for other groups of people or tested in a different context. Environmental restructuring, persuasion, and education were registered as the most common mechanisms to change consumer FW behaviour. Smaller portion provision, education modules, lunch break rescheduling, service style change, serving plate improvement, consumer dietary preference analysis were among the interventions found to be effective in tackling consumer FW. To effectively address consumer FW in the hospitality and catering sector, this review proposed a four-step roadmap, following which policymakers and practitioners could explore practical solutions against consumer FW.

The third research goal was to ***provide an evidence synthesis on intervention study that incorporate stakeholder insights focus on school meals***.

The role of school meals is to provide students with adequate nutritious food and promote overall health and wellness. While ensuring the realization of traditional goals, how to use school meals to contribute to the sustainable management of school catering, and further promote the transformation of the food system, has attracted the attention of academics and policymakers. To answer this question, **Chapter 3** aims to mine the forms of school meal interventions by which the school meal could generate less impacts. This study first applied PRISMA to map tested interventions aiming to reduce school meal impacts and/or increase benefits. A workshop was then held to bring together stakeholders in the school catering industry to co-design new school meal interventions basing on mutual learning dialogues. Stakeholder perspectives were retrieved from a three-stage stakeholder dialogue, by which step by step to lead intervention study and stakeholders mutual leaning. This review synthesized evidence from 14 peer-reviewed articles concerning school meal interventions. A total of nine interventions are identified from the literature, among them, the new menu, educational module, and informational poster ranked as the top three. A large portion of those interventions was governance supported. They are either initiated by stakeholder talks or attached to municipal, regional, or national projects. This study outlined that school meal interventions primarily achieve six benefits: reduced environmental impacts, improved food consumption, healthier food provision, better waste management, affordable cost, and strengthened social connections. Stakeholders expressed various concerns or expectations for school meal development with most of the school meal challenges are yet not being addressed by academic research. Correlated interventions were proposed basing on their experience in school meal management.

Methodological developments

The application of the MOA framework allows for a more structured understanding of the complex causes of consumer FW, revealing potential behaviour change intervention hotspots to reduce FW at the consumption stage. The combination of the MOA framework and behaviour change wheel helps to better identify underlying mechanisms by which interventions reshape consumer behaviours.

The MOA framework explains human behaviour consequently caused by the interactions among motivation, opportunity, and ability. Motivation and ability both refer to individual factors while opportunity is related to external resources, which can be rather broad and ambiguous to understand. This study further classified opportunity factors into three levels: micro, meso, and macro. This classification was based on the concept that micro factors take the individual or household as focal entity, the meso level represents the social unit within the physical setting of a specific community, and the macro factors consider the larger societal and material influences beyond the individual. The reshaped MOA framework was then applied to identify drivers of household consumer FW. In this case, opportunity factors were consequently divided into three clusters. Micro factors included availability of tools and/or technologies, time, schedule, and lifestyle while food environment belongs to meso level. Food provision for consumers to buy appropriate food at appropriate intervals conveniently and legal and regulatory frameworks were distributed to macro group. Based on this, the drivers of household consumer FW were clearly clarified. Levers for nudging consumer behaviour change were thereby tailored according these three levels.

Research agenda and policy implications

By reviewing studies which documented household consumer food waste drivers, and further identifying relevant levers that could stimulate consumer behaviour change, this study proposed 6 attention points for the future research.

First, more empirical studies are required to unveil the role of each specific drivers and levers as well as their relationships. Second, this work introduces the concept of “lever” as a specific action to tackle specific food waste drivers. Future research could rely on this concept to design more effective food waste reduction interventions and to better estimate their impacts. Third, future research should consider tailoring data collection targeting different consumer profiles to identify the groups with high likelihood to waste food. Fourth, 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.

In the meantime, drawing from the evidence-based outcomes from literature, this study provided practitioners and policymakers with practical pathway to develop and test tailored FW strategies. Firstly, baseline mapping. The initial step contributes to outline a detailed picture of consumer profiles from a certain sector. Main actions should be the identification of targeting population characteristics, understanding of consumption behaviour, etc. Stakeholder insights are highly recommended to be integrated into the background understanding through disclosing believed solutions and potential factors that might influence the performance of interventions. This step aims to inform the later intervention study by identifying potential barriers and opportunities for guiding the research following a tailored pathway. Then, tailored intervention designing. The second step aims to develop tailored interventions basing on the portfolio of the consumer profile unveiling and context mapping from the first step. This study recommends developing interventions through a theoretical lens to better understand the connections between levels and consumer behaviours. Then further frame the intervention working mechanism that could potentially stimulate consumer behaviour change. Intervention development should be adopted and customized to different consumer profiles while taking local context and all external resources availability into consideration. Third, intervention testing. A pilot study is crucial to the strategy implementation aiming to test the feasibility, validity, and improve the efficiency. The sample involved in the pilot should be representative and with respect to the consumer characteristics. Ensuring consumer safety and study ethics should always be the top priority during the intervention implementation. Intervention acceptance among consumers could be integrated with the impact evaluation process as well.

The analysis of the trial study should be informed by reliable data collecting and results reporting. Finally, strategy implementation and upscaling. Based on the learnings from previous steps, effective interventions could be integrated into the local regulations and further bring in legislation. The last step thereby aims to assess intervention transferability and scalability and explore the potential to be legislated.

Limitations

Despite logically connected, three case studies for different FW generation settings were done independently of each other. There may be biases in the literature review due to database differences causes by different keywords used and the timing of literature retrieval, also considering that the household FW driver review took grey literature into consideration while others did not. While the integration of the grey literature provides 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 address these limitations, this study applied a rather broad set of keywords for literature identification. For instance, keywords for the household and catering and hospitality cases did not include phrases that restricted the scope of the settings, such as "household" or "canteen." Literature selection thereby relied heavily on manual identification to avoid missing relevant literature that used vague keywords or abstract. Specific keywords like "intervention" were not used to identify literature in the catering and hospitality case, as relevant studies may use alterative terms like “strategy”. Instead, the scope of the search was expanded to all FW studies within the entire catering and hospitality industry, then during manual evaluation of title, abstract, keywords and full text, related studies were identified based on specific searching criteria. Additionally, results related to grey literature documents, the definition of their keywords, and their classification were revised through a supervised analysis through manual control of the consistency of the keywords applied to automated extraction algorithms.

Consumer segmentation research review was conducted to provide potential insights on tailored FW reduction strategy development. Current relevant works were all based on surveys to classify and profile consumers. Limitations thereby might exist due to unsolid data collection methods. Tailored strategy development should be further explored basing on reliable date collection methods. Furthermore, considering the complex of FW issues across settings, a harmonized framework to measure FW across sectors is urgently needed. It is of great important

to the upscaling and legislation of successful FW reduction strategies as well. This study presents intervention studies both aimed to reduce consumer FW and promote canteen sustainability development. However, due to the data analysis and results presentation inconsistences among studies, this study did further consider an intervention performance evaluation. The intervention efficiency should be further explore applying methodologies like effect size analysis.

Appendix - Chapter 3

Supplementary Table 1. Profiles of participants involved in the workshop.

Organisation	Number of participants	Role
Emilia-Romagna regional department of public health, and collective prevention	2	Member of the general direction
Emilia-Romagna local sanitary service	15	Nutritionists and doctors responsible for the regional school meal design
Emilia-Romagna regional service of innovation, quality, promotion and internationalisation of the agri-food system	1	Management of school-related projects
University of Bologna – Department of Agricultural and Food Sciences	2	Scientific supervision on the intervention co-design

Data source: compiled by the authors.

Supplementary Table 2. School meals studies description and summary.

#	Authors	Journal	Geographic context	Sample population	Objective	Design	Data collection method
1	Andersen et al (2015)	British Journal of Nutrition	Denmark	Primary school - Third and fourth grade students	Investigate the effects of serving new school meals on the dietary intake of certain foods.	New Nordic Diet (NND) was developed by experts in human nutrition, gastronomy, food economy and environmental issues, food culture and sensory science, as well as by experts with knowledge about children and their food habits and preferences.	Web-based Dietary Assessment Software for Children (WebDASC): a self-administered internet-based interactive food record tool for children.
2	Antón-Peset et al (2021)	Sustainability	Spain	Primary school - Fourth grade students	Analyse the impacts of an educational intervention on food waste.	Based on the previous research.	Wasted food has been weighed and distinguished with first course, second course, bread and dessert.
3	Batlle-Bayer et al (2021)	Science of the Total Environment	Spain	High school students	Minimize the GHG emissions by introducing low-carbon meals consisted of food products with low emissions during the production.	The municipality of Barcelona has set an intervention for the academic year 2020–21: introducing low-carbon meals in public schools.	The information of current meals was retrieved from the schools' websites. The net and uncooked amount of food were based on the recommendations from the Catalan Agency of Health. The net cooked and gross food composition were calculated, using the food weight yields from literature.
4	Burgess-Champoux et al (2018)	Health Behavior and Policy Review	USA	Primary school - 6 grade students	Test whether modifying school meal entrées increased legume consumption.	Taste tests of legume-containing menu items were conducted among school children. Results then informed the modification of the menu. Five legume entrées were developed with the assistance of a volunteer chef basing on school menu items.	Standard entrée serving weight was calculated by averaging the weights of approximately 10 servings. The weight of uneaten food for each student was recorded using a kitchen scale.

#	Authors	Journal	Geographic context	Sample population	Objective	Design	Data collection method
5	Elinder et al (2020)	Sustainability	Sweden	Primary school students	Optimize meals for minimum deviation from the current food supply while reducing greenhouse gases and ensuring nutritional adequacy without increasing cost.	A meeting was held with the meal services administration (including management, administrators, and meal planner) in the municipality of Uppsala. Selected schools had been identified by the municipality's meal manager as having the highest measured climate impact associated with their school meals.	The kitchen staff, instructed and supervised by the chefs, executed food waste and consumption measurements based on a template with written instructions for measuring food waste and school lunch consumption.
6	Elnakib et al (2021)	International journal of environmental research and public health	USA	Elementary and middle schools	Assess changes in food waste after employee training strategies.	NA	Measure each individually wasted food item on the tray with a scale.
7	Ensaff et al (2015)	Nutrients	UK	Secondary school	Examine the effect of changing food choices on food intake.	NA	Students' selections were recorded by a cashless system with the data of food item code, alongside the time and date of purchase.
8	Eustachio Colombo et al (2020)	Nutrition journal	Sweden	Primary school	Develop a GHGE-reduced, nutritionally adequate, and affordable school lunch menu.	NA	The information of four-week menu was provided by municipality.
9	Favuzzi et al (2020)	International Journal of Environmental Research and Public Health	Italy	Primary school	Assess the food waste amount changes among students after an educational session.	Consisted in the project with one of the objectives of evaluating FW in local school canteens.	Food waste was weighed by kitchen scale, and separately with first, second, and slide course.

#	Authors	Journal	Geographic context	Sample population	Objective	Design	Data collection method
10	Malefors et al 2022	Resources, Conservation and Recycling	Sweden	Primary, middle and high school	Reduce food waste in school catering.	Four interventions were selected by the public catering managers in collaboration with the researchers	Weighed food waste by kitchen scales and recorded data in a standardised format.
11	Vidal-Mones et al (2022)	Waste Management	Spain	Primary, middle and high school	Test intervention impacts on food waste reduction	Interventions were initially inspired from literature and adjusted by canteen coordinators on the proper format to be implemented.	Food waste was weighted with an electronic scale distinguished by first course, second course, dessert and “other waste”.
12	Kluczkovski et al (2021)	Nutrients	Brazil	Nursery and pre-school; elementary, secondary, young adult, and adult education	Evaluated the environmental impact and nutritional viability of a low carbon meal.	Aimed at improving the quality of school meals, the Sustainable School Program (SSP) implemented low-carbon meals, twice a week at the local schools.	Nutritional information and adequacy was calculated using validated food composition tables and National School Feeding Program requirements, the level of processing was considered using NOVA classification, and greenhouse gas emissions were estimated using food life cycle assessment validated data.
13	Ruge & Mikkelsen, 2013	Acta Agriculturae Scandinavica, Section B–Soil & Plant Science	Denmark	Primary school - 6 grade students	Test how LOMA could contribute to health promotion and social inclusion.	Municipal project - The LOMA-Nymarkskolen Project applies a local approach to cooking, learning and food-sourcing strategies based on a municipal report on youth health.	Questionnaire survey with questions regarding food literacy based on their own perceptions.
14	Wolfenden et al (2019)	Health Promotion Journal of Australia	Australia	Primary school	Improve the implementation of a state-wide canteen policy by encouraging schools to remove unhealthy food and beverages from menus and replace with healthy items.	Fresh Tastes @ School was mandated by the NSW Government for implementation in all primary and secondary Government schools. The strategy was based on the principles of the Australian Dietary Guidelines.	Trained dietitians, blinded to group allocation, assessed the menus using the quick menu audit tool to classify menu items as ‘‘green’’, ‘‘amber’’ or ‘‘red/banned’’.