



Review

Household organic waste: Integrate psychosocial factors to define strategies toward a circular economy



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ABSTRACT

Fast and uncontrolled population growth, combined with increasing urbanisation and the negative effects of modern lifestyles, has left cities facing numerous challenges. One of the challenges is the production of urban waste on a large scale. According to goals established in Directive (2008/851, all European Member States should ensure that biowaste is separated at the source by December 31, 2023. This directive aims to improve household and organic waste programmes and ensure a progressive transition towards a circular economy. In this context, the active participation of citizens is fundamental. This paper aims to identify, analyse, and integrate into a comprehensive framework, how psychosocial factors have been presented in the literature. Socio-demographic characteristics and communicational/educational interventions on household organic waste are also examined, along with how circular economy principles can be applied to organic waste management. A systematic literature review was performed to develop the new framework. The results of the study highlight that researchers who have published on the subject have mainly focused on infrastructural issues, and only 23% of the reviewed articles addressed one or more psychosocial factors. Moreover, household, organic waste separation behaviour is influenced by levels of education as well as perceived convenience and social norms. On the other hand, the results show that it is not possible to state with scientific precision the effective impact of communication and education campaigns on this type of behaviour. The proposed framework is useful to guide policymakers in defining strategies for waste prevention. Furthermore, researchers and practitioners can benefit, since scientific knowledge on household organic waste has been summarised and conceptualised, providing recommendations for future research paths.

1. Introduction

Of the 4 billion tonnes of food produced annually in the world, about 40% is lost or wasted, representing a cost of almost US\$1 trillion to the economy (FAO, 2014). In the European Union (EU), food waste reaches around 88 million tonnes per year. Of that amount, it is estimated that households contribute 53%, while 40% comes from the agri-food industry, and 5% from catering (FUSIONS, 2016). Although there is no universal definition, the Food and Agriculture Organisation (FAO) makes a distinction between food loss and food waste. While food loss refers to losses that occur throughout the production chain, food waste corresponds to the end of the food chain. The former can be described as the production, post-harvest, transport, and storage phases (representing 54% of losses). The latter (46%), on the other hand, occurs mainly in industrialised countries (FAO, 2019). Waste is related to excessive

standards and rules, to sanitary or aesthetic concerns, and consumer preferences and habits (Gustavsson and Stage, 2011).

The focus of this paper is household, urban, organic waste, referred to as anthropogenic waste. This originates from households and restaurants (Sharma et al., 2020), representing, on average, 28%–64% of total urban solid waste (Sanjuan-Delmás et al., 2021). It is a type of waste that can be potentially reused and recovered by applying the principles of the waste hierarchy and the circular economy (Teigiserova et al., 2020). However, only 17% of all EU biowaste is composted or digested, while the bulk ends up in landfills or incineration (EEA, 2020). This is the watermark of a typical, linear system (extraction, production, and disposal). Biowaste in landfills is particularly worrisome since it contributes to environmental damage, namely soil and groundwater pollution (Men et al., 2018). In this context, health damage to the population, such as allergies and mutations (Kadhom et al., 2020), and

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economic damage (Cheng et al., 2020) are proven results.

This state of affairs is indeed far from the prescribed waste management policy, solidly anchored in a waste hierarchy and outlined in Directive (2008)/851, where the reduction and recycling of biowaste is a case in point (Sanjuan-Delmás et al., 2021). To fulfil the goals set out in that framework, all EU Member States will have to implement plans to reduce, and collect separately, household food waste by December 31, 2023. This set of objectives is unachievable without solid and active participation and involvement of the citizenry.

Nevertheless, behavioural changes do not take place automatically. Fundamental to this endeavour are the attitudes, behavioural routines, and the specific design of the "home" and the urban environment. The importance of these psychosocial aspects is referred to in some studies in the literature of the last decade. For instance, Mylan et al. (2016) and Andersson and Stage (2018), underline the fundamental relevance of the household context as an important place to understand the dynamics of consumption and waste, and ultimately indicate pathways for change. Coderoni and Perito (2020) have also assessed how the sociodemographic and psychological characteristics of Italian consumers may influence their decision to purchase food from wasted ingredients in the supply chain. Furthermore, Knickmeyer (2020a) has investigated the main social factors which influence household, recycling behaviour, and the key, motivational factors for changing practices. Lehtokunnas et al. (2020), meanwhile, emphasise the need for a social shift and changes in daily practices. This implies a transition to a circular economy in the context of household food waste practices and waste management requirements, coupled with new technologies, infrastructure, and innovations.

Despite the growing interest of academia and public managers in understanding the impact of psychosocial factors on household, organic, waste prevention and separation behaviours (Knickmeyer, 2020a), most studies in this area seem to focus on infrastructure solutions, such as the development of engineering systems and waste treatment facilities (Luttenberger, 2020). In this sense, no review has systematically analysed the importance of psychosocial factors, sociodemographic characteristics, intervention actions, and circular economy principles in the context of organic waste management. This paper aims to fill those gaps by reviewing the presence of these variables in the literature and, most importantly, seeks to answer how these dimensions are applied in real settings.

Thus, the following four dimensions were analysed: psychosocial factors (convenience and social norms), socio-demographic characteristics (age, income and educational level), intervention actions (communication and educational campaigns), and the principles of circular economy and logistics applied to the management of household organic waste.

Therefore, the main contributions of this article can be summarised as follows:

- Identify and analyse the psychosocial factors, the sociodemographic characteristics, and the main interventions that were incorporated in the 74 reviewed articles which comprise the final sample.
- Investigate the interrelationship between sociodemographic characteristics and psychosocial factors in order to understand whether these factors can influence the waste sorting behaviour of citizens. Furthermore, analyse the main contributions that interventions can provide to improve waste separation programs and move toward a circular economy, with the aim of fulfilling the objectives established in Directive (2008)/851.
- Explore how the management of organic waste has been approached by scientific research from the perspective of the circular economy. Moreover, investigate both the relationship between the collection type and the treatment given to waste, and how this relationship impacts the achievement of the objectives of Directive (2008)/851.
- Propose a framework that illustrates how to integrate dispersed knowledge, related to barriers and drivers of recycling behaviour.

This will hopefully draw attention to the importance of psychosocial factors, and help policymakers and program designers to define waste prevention and separation strategies that are more suitable to the extremely diverse contexts of the citizens. Propose recommendations for future research in the field.

Thus, Section 2 describes the systematic methodology used in this article. Section 3 performs a descriptive analysis based on the 4W (When, What, Where, and Which). Section 4 presents a qualitative analysis of the main psychosocial factors and sociodemographic characteristics mentioned in the articles that comprise the final sample. Emphasis will be given to the main interventions programs proposed by the reviews and how the circular economy is addressed. Section 5 presents the framework elaborated, based on the articles analysed. Finally, conclusions and recommendations for future research are to be found in Section 6.

2. Methodology

This literature review is divided into four stages (see Fig. 1). The first step is the Identification of articles, and the second step is their Screening. These steps are based on the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) research protocol (Moher et al., 2009). The third step, Eligibility, and the fourth, Framework, follow the model of Carvalho et al. (2019).

2.1. First stage: identification

2.1.1. Data collection

Only articles written in English, from 2016 to 2021, were selected through the Science Direct (SD) database (unit of analysis).

The primary search considered the following keywords: "waste management system", "sustainable consumption", "household food waste", "consumer behaviour", "behaviour change", "consumer preference", "food waste", "circular economy", "campaigns", and "separate collection". The search criteria were "Title, abstract or author-specified" in SD, resulting in a total of 506 research articles and 79 review articles, as presented in Table 1.

2.2. Second stage: screening

2.2.1. Data screening

In this stage the analysis firstly focused on the review articles, followed by the research articles (as presented in Table 1). The exclusion criteria were applied equally to both types of papers.

- Criterion 1 - At this stage duplicate articles were removed. Then, an analysis of the title, abstract, and conclusion of the selected articles was performed, resulting in new exclusions.
- Criterion 2 - The articles which analysed sectors outside the scope of this study, namely electronic, hospital, textile, animal and civil construction waste, were removed.
- Criterion 3 - In the papers which focused only on infrastructure solutions, such as engineering systems and waste treatment plants for the improvement of the organic waste sector, psychosocial factors were not explored.

Table 2 was created to synthesise the information described above, in which it is possible to see, according to the type of article, how many were excluded by each criterion. Finally, the number of articles that make up the final sample is presented; 74 articles were selected, due to their affinity with the scope of this work, 11 of which are review articles and 63 are research articles.

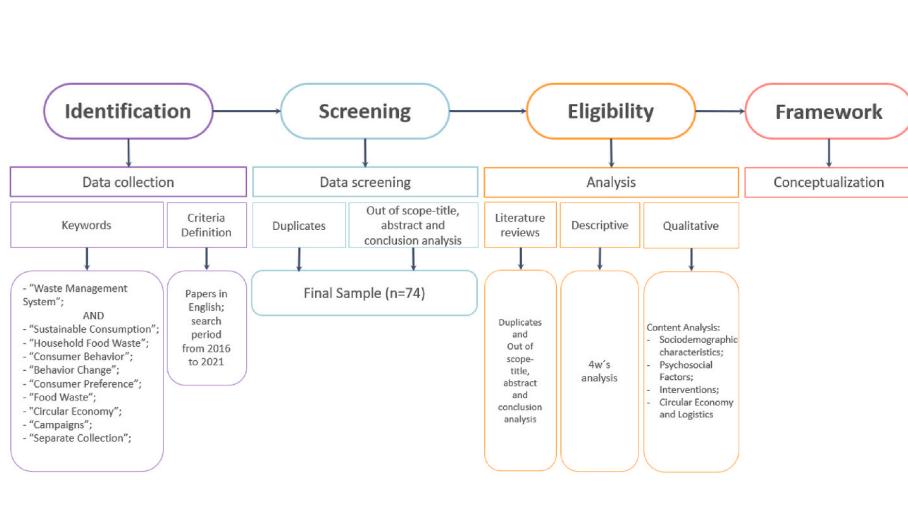


Fig. 1. Structure of the research methodology.

Table 1
The number of articles obtained through the combinations of keywords.

Nº	Keywords	Database	Nº of research articles
1	waste management system AND sustainable consumption	Science Direct	188
2	waste management system AND household food waste	Science Direct	59
3	waste management system AND consumer behavior	Science Direct	40
4	waste management system AND behavior change	Science Direct	64
5	waste management system AND consumer preference	Science Direct	10
6	waste management system AND food waste AND circular economy	Science Direct	52
7	waste management system AND campaigns	Science Direct	34
8	waste management system AND separate collection	Science Direct	59
Total			506

Table 2
Exclusion criteria and the final number of articles.

Type of articles	Criterion 1	Criterion 2	Criterion 3	Nº of articles selected
Review Articles	13	27	28	11
Research Articles	179	40	224	63
Final Sample	—	—	—	74

2.3. Third stage: eligibility

2.3.1. Literature review

At this stage, the review articles selected for analysis were identified, according to their affinity with the scope of this work (see Table 2). The information contained in these articles was first described and classified using the criteria established in the work of Barbosa-Póvoa et al. (2018); stated research objectives, research methodology analysed, whether a systematic review was conducted, the number of articles and documents reviewed, and time period covered. The type and origin of waste and the focus of the selected articles were also analysed.

2.3.2. Descriptive analysis

A 4 W (When, What, Where, and Which) analysis was conducted to understand the scope of the 74 articles selected in the previous step, as it provides an important framework to help explore key issues. The analysis was structured using the following questions:

- Q1- When were the articles published?
- Q2- What are the main journals that have published articles on urban waste management at the urban domestic level?
- Q3- Where has research on urban waste management in the household scope been developed?
- Q4-Which are the predominant methodologies identified in the articles selected in this systematic review?

To answer Q1, the articles were divided by year of publication. Q2 identifies the SD journals in which the different articles were published. Then, to answer Q3, the countries where the researchers and their institutions are located are presented. Finally, the predominant research methodology is verified in response to Q4.

2.3.3. Qualitative analysis

The content analysis has followed a deductive approach, based on the following dimensions and sub-dimensions: i) psychosocial factors (convenience and social norms, were named based on the work of Knickmeyer (2020b)); ii) socio-demographic characteristics (age, income and educational level), iii) communicational and educational interventions regarding household organic waste, and iv) the principles of circular economy and logistics applied to the management of household, organic waste. From the deductive approach, all 74 articles were analysed on these dimensions and when some conclusions arise from this analysis an inductive approach was followed so that conclusions could be taken. Based on these analyses, it was possible to infer from the relative importance and interaction between socio-demographic characteristics and psychosocial factors in order to understand whether they influence waste separation behaviour. In addition, the use and evaluation of communication and education programmes was also examined. This step is in line with the research of Tranfield et al. (2003) in recognizing the importance of linking themes in the research process.

2.4. Fourth step: creation of a framework

A framework was developed, based on the articles analysed, in order to support organic waste management, intended mainly for researchers, policymakers, and practitioners in the field of waste and

communication. The framework is divided into four dimensions and nine sub-dimensions, where it is possible to identify the drivers that enhance, and the barriers that hinder, the achievement of recycling behaviours. Furthermore, gaps in the literature and data on which there is no consensus among authors, are identified.

As a result, this framework is expected to be helpful in guiding policymakers in establishing waste prevention strategies. Moreover, as scientific knowledge on household organic waste has been summarised and conceptualised, it could inspire future research directions.

3. Results

3.1. Literature reviews published between 2016 and 2021

From [Table 3](#), it is possible to identify the eleven review articles selected for analysis, according to their affinity with the scope of this work. The largest number of review articles in the last 5 years (4 out of 11) were published in 2019. This shows a growing interest from the academic community in the topic of household waste management. The methodology applied was commonly a review of the literature (6 out of 11), followed by a systematic review (3 out of 11), and only two articles did not clearly show the methodology used ([Calabro and Satira, 2020](#); [Moh and Abd Manaf, 2016](#)). In general, the articles used more than one database, highlighting ScienceDirect, Web of Science and Scopus, followed by Google Scholar, IEEE Xplore digital library, and ACM digital library. Three of them did not provide this information. Seven articles specified the date range, from 1975 to 2019, and four did not limit the date. The number of documents reviewed varies between 10 ([Corrado and Sala, 2018](#)) and 565 ([Merli et al., 2018](#)). Three articles did not mention the number of documents and articles reviewed. As for the origin of the waste, three out of the eleven researched solid and organic waste from the domestic environment ([Calabro and Satira, 2020](#); [Knickmeyer, 2020a](#); [Moh and Abd Manaf, 2016](#)), one analysed domestic waste together with agricultural waste ([Corrado and Sala, 2018](#)), one combined industrial and domestic waste ([Morone et al., 2019](#)), two explored only agricultural waste ([Mak et al., 2020](#); [Santagata et al., 2021](#)), one investigated commercial and industrial waste ([Petit-Boix and Leipold, 2018](#)), and one brought together household, organic waste, with commercial, industrial and agricultural waste ([Lemaire and Limbourg, 2019a](#)). Two articles did not specify the origin of the waste ([Melaré et al., 2017](#); [Merli et al., 2018](#)).

Regarding the type of waste, six researched organic waste ([Corrado and Sala, 2018](#); [Götz et al., 2016](#); [Leipold and Petit-Boix, 2018](#); [Lemaire and Limbourg, 2019a](#); [Mak et al., 2020](#); [Santagata et al., 2021](#)), three explored organic waste along with plastic, paper and glass ([Paolo S Calabro Paolo and Komilis, 2019](#); [Knickmeyer, 2020a](#); [Moh and Abd Manaf, 2016](#)), one researched only solid waste ([Melaré et al., 2017](#)), and one did not specify the type of waste ([Merli et al., 2018](#)).

When considering the focus of the articles, it was possible to put them into four groups. The first group explored waste, food loss (FLW), and the correlation with urban organic waste management ([Lemaire and Limbourg, 2019a](#)).

The authors suggest intervention actions focused on preventing FLW, such as consumer awareness, education campaigns, and synergistic actions among governments, society stakeholders, and retailers in order to mitigate FLW while reducing the amount of waste generated. The second group included the largest number of articles (6 out of 11). The authors focused on how circular economy theory can be applied, and can contribute to, making the urban, organic, waste management system more sustainable in the environmental, economic, and social pillars ([P S Calabro and Satira, 2020](#); [Corrado and Sala, 2018](#); [Mak et al., 2020](#); [Merli et al., 2018](#); [Petit-Boix and Leipold, 2018](#); [Santagata et al., 2021](#)).

Overall, they conclude that preventing the generation of food waste should be the most important goal to achieve, not only in itself, but also because of its dependence on fossil resources. The third group tried to understand the definitions, concepts, and recent technical-scientific

advances related to waste management ([Melaré et al., 2017](#); [Morone et al., 2019](#)). The authors acknowledge that the development of new technologies is indispensable, both in order to map and understand the current situation, and to support and provide concrete and relevant information for public managers and citizens in general. The fourth group analysed the importance of understanding the influence of psychosocial factors on household waste separation behaviour (solid and organic) ([Knickmeyer, 2020a](#); [Moh and Abd Manaf, 2016](#)).

Group four is the closest to the purpose of this article. In the research developed by [Moh and Abd Manaf \(2016\)](#), it was evident that underlying one of the most critical challenges faced by waste prevention and separation programmes is the promotion of waste separation routines at the source. The authors highlight that citizen participation in these programmes depends on a complex and varied set of factors, including convenience, social norms, and the development of environmental awareness, namely through education and communication campaigns. Despite recognizing these dimensions, no precise way to identify how they interrelate and how they effectively impact the motivation of citizens to engage, or not, in these programs, was proposed. [Knickmeyer \(2020a\)](#) examined the influences of social factors on household recycling behaviour and the main motivations for behaviour change. Social factors are defined by the author as "all the influences which affect the behaviour of an individual or group". These are analysed in four different dimensions, such as demographic characteristics, external (convenience) and internal (moral, social norms, and habits) psychological factors, economic, and political factors. According to [Knickmeyer \(2020a\)](#), the transition of household waste management from a linear economy to a circular economy will only occur with strong engagement from the citizens, primarily at the source separation stage. Thus, central to that objective is the need to precisely understand the influence of psychosocial factors on waste separation behaviour. However, it is recognized that it is still an under-explored topic. The researcher carried out a broad literature review in line with this reflection, in which 166 documents were analysed. It is possible to have an overview of the main psychosocial factors that influence the separation behaviour of household waste through this analysis. However, as in the work of [Moh and Abd Manaf \(2016\)](#), it was not possible to see, in an integrated way, how the correlation between these factors occurs and how they are reflected in the separation and disposal behaviour of household waste.

Throughout the review, information and communication campaigns at different levels (from neighbourhood specific to nationwide) are often recommended and sometimes pursued. However, none of the papers reviewed actually describe how psychosocial factors could be applied. Nor, more importantly, do they mention the importance of testing and measuring the intervention models.

This systematic review aims to fill this gap in the literature by designing a framework. It is intended to serve as a useful tool to guide policymakers in defining waste prevention strategies. Researchers and practitioners can also benefit from it, as scientific knowledge on household organic waste will be summarised and conceptualised. With the proposal of an integrated and systematic analysis, this literature review aims to update the findings and research challenges specified in the above reviews.

3.2. Descriptive analysis

The four questions are answered, and the results are presented in order to characterise in detail the final sample of the 74 selected articles.

The response to Question Q1 – "When were the articles published?" can be seen in [Fig. 2A](#). The articles were published from 2016 to 2021. The number of articles exploring the management of household organic municipal waste has been increasing over the last five years, peaking in 2020 with 19 published articles. Importantly, in the year 2021, an increase in the number of research articles was observed, relating COVID-19 to food waste (at different levels of the supply chains). Most of these publications, that focused on food waste, do not explore household food

Table 3

Compilation of data from the review articles.

Research focus and objective	Waste Source (household/commercial & industrial/agriculture/municipal/not-specified)	Type of waste (organic/plastic/cardboard/glass/not-specified)	Review type	Number of documents	Time horizon	Database	Psychosocial factors	Region	Year
This article asks whether environmental assessments conducted so far within the EC, are really in line with EC principles	Commercial & Industrial	Organic	Literature review	101	1975–2017	Science Direct and Web of Science	The authors recognize that psychosocial factors are still poorly studied	Germany	2018
The main objective is to clarify how researchers approach and frame the circular economy	Not- specified	Not- specified	Systematic review	565	n.a	Web of science and Scopus	Not mentioned	Italy	2017
This article covers recent technical-scientific advances related to urban waste management	Household	Organic/plastic/cardboard	n.a	n.a	n.a	n.a	Yes	Italy	2020
This study aims to elucidate how the circular bioeconomy can be achieved through the sustainable management of food waste	Agriculture	Agriculture	Literature review	n.a	n.a	n.a	Yes	China	2019
This article illustrates the importance of social factors in the management of urban waste	Household	Organic/plastic/cardboard	Exploratory literature review	166	1999–2018	Science Direct and Research Gate	Yes	Spain	2019
The paper constitutes a detailed summary of recent literature on the concepts, product categories, causes, solutions, and research challenges surrounding food loss and waste management	Household/Commercial & Industrial/Agriculture	Organic	Literature review	95	2008–2018	Google Scholar	They are mentioned superficially	Belgium	2019
It describes and compares the approaches adopted related to the generation of food waste on a global scale and in Europe, and subsequently analyzes the impact of interventions and policies	Household/Agriculture	Organic	Literature review	10	2005–2017	Scopus Scientific	Not mentioned	Italy	2018
Assesses national solid waste management needs in the Malaysia	Household	Organic/plastic/cardboard/glass	n.a	n.a	n.a	n.a	Yes	Malaysia	2016
This work reviewed recent scientific production about food waste recovery pathways in a bioeconomy perspective	Agriculture	Organic	Systematic review	55	2014–2019	Scopus/books and indexed	Not mentioned	Italy	2019
Provide an overview of available data on the physical and chemical composition of household waste	Household/Industrial	Organic	Literature review	97	1990–2014	Web of Science, Google Scholar and Science Direct	Not mentioned	Denmark	2016
Map the world scenario of research in decision support systems aimed at solid waste management	n.a	Solid-waste	Systematic review	87	2010–2013	IEEE, Scopus, Science Direct, Web Knowledge, Web of Science and ACM	Not mentioned	Brazil	2016

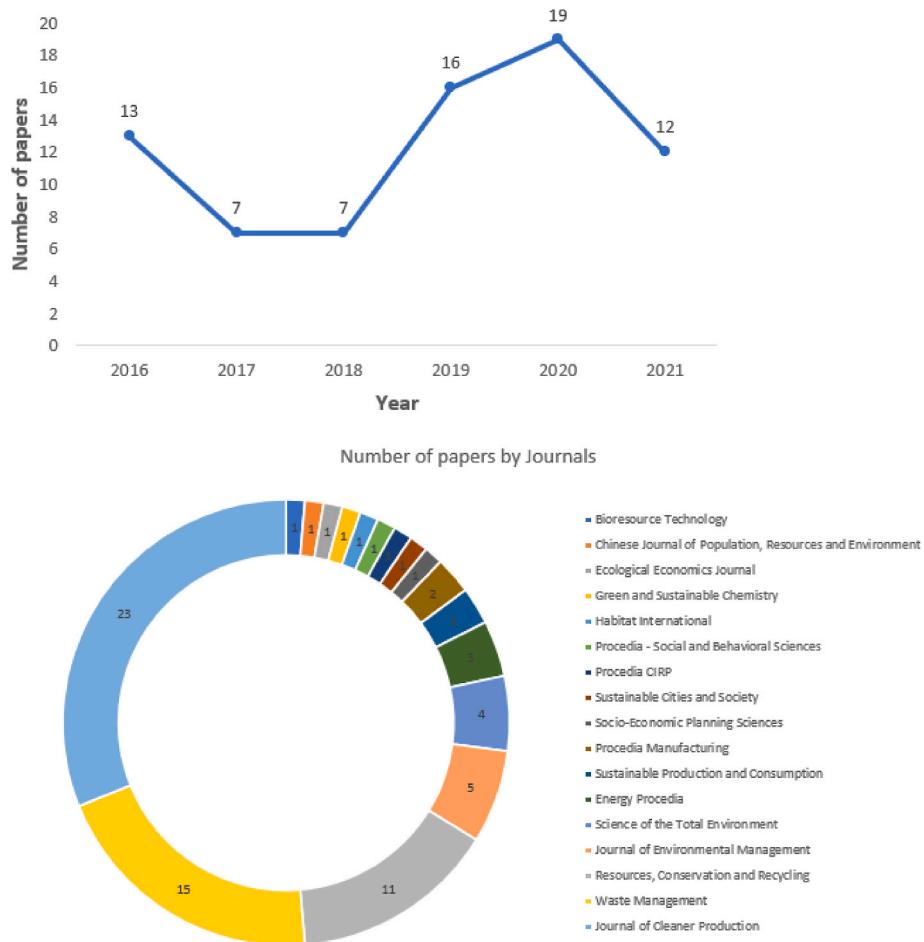


Fig. 2. Graphical answers to the questions Q1 and Q2. (A) Number of Articles published between 2016 and 2021 and (B) the main journals that have published articles on the management of organic waste at the household level.

waste management. An example is the work of [Vittuari et al. \(2021\)](#), where the authors studied the impact of measures, introduced to contain the COVID-19 outbreak, on key behavioural factors underlying household food waste generation.

Question Q2 – “Which are the main journals in SD that have published articles about urban organic waste management at the domestic level?” is better illustrated in Fig. 2B, which shows the seventeen main journals: *The Journal of Cleaner Production* is the most published (23 out of 74), followed by *Waste Management* (15 out of 74), and *Resources, Conservation & Recycling* (11 out of 74). The articles published in these three main journals have predominantly heterogeneous themes. *The Journal of Cleaner Production* has the most plurality of themes. It is possible to identify three main ones:

- (1) The interconnection between food waste and organic waste management,
- (2) The main types of treatment provided for household organic waste, and
- (3) The contributions arising from the application of the circular economy in the recovery and reuse of household organic waste.

In *Waste Management*, the focus of the articles is on understanding, developing, and implementing urban waste management systems which aim to bring about future environmental, economic, and social improvements. However, it is relevant to note that social concern is mentioned (almost exclusively) in studies conducted in developing countries, substantiated by important issues such as the informal recycling sector and the role that waste collectors play in these societies.

In the journal *Resources, Conservation & Recycling*, it can be observed that there is a very active community which is attempting to stimulate interaction between urban waste management systems at the household level with environmental and economic systems.

To answer question Q3 – “Which countries have developed research on the management of organic household waste?”, the analyses of the corresponding authors’ countries of origin (see Fig. 3) confirmed a strong focus on Europe (40 out of 74 articles), with Italy the most prominent (11 out of 74 articles), followed by Spain (7 out of 74 articles). From this result, and according to the theoretical framework analysed in this review, one can hypothesise that European interest in improving the urban waste management sector is directly associated with the EU waste management plan. This has encouraged cities and communities to develop and apply strategies based on circularity on an urban scale, waste management being the most popular ([Petit-Boix and Leipold, 2018](#)).

Finally, in response to Question Q4 – “What is the predominant methodology identified in the articles selected in this literature review?”, detailed analysis revealed that almost 60% of the analysed publications applied the case study methodology. This result serves as an indicator of the current concern and practical importance of research in waste management in order to find efficient and adequate solutions, which are predominantly relating to the infrastructures and technological innovation.

The second most used methodology refers to the life cycle analysis (LCA). This approach was employed to compare different waste management scenarios and their main environmental impact. Subsequently, it was found that six articles used the literature review methodology,

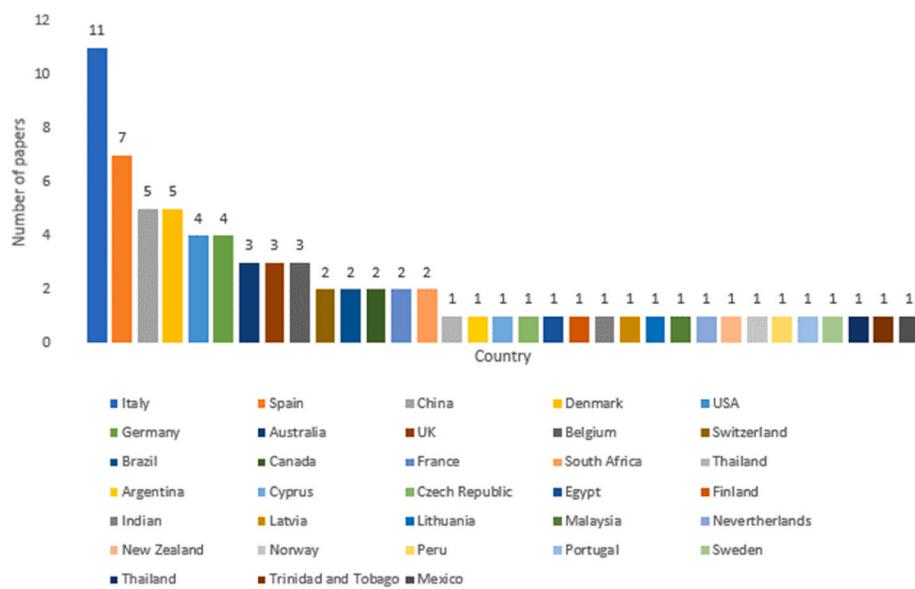


Fig. 3. Countries of origin of the corresponding authors of the analysed articles.

and three employed simultaneously the case study and LCA methodologies. These three data collection methods are mainly related to case study articles, which may be an indicator that the authors are seeking to identify the main influences and barriers that hinder citizens' active participation in waste reduction and separation programmes.

The other articles applied the methodologies of systematic reviews, Regret Theory, Planned Behaviour Theory, and Social Life Cycle Assessment (SLCA). Ten of the 74 articles did not refer to the methodology chosen, as shown in Fig. 4. It is important to underline that no study was identified that used the Life Cycle (LCC) and Benefit-Cost Analysis (BCA) methodologies. As already stated by Mak et al. (2020), there are few research studies on food waste using LCC methodology and it is a field to be explored.

To better understand how the data was processed, a deeper analysis was conducted. It can be said that the data was analysed mainly through quantitative approaches. The main types of Data Analysis Methods used were Statistical Analysis ($n = 22$), Mixed Quantitative and Qualitative Data Analysis ($n = 10$), Material Flow Analysis ($n = 8$), and Scenario Analysis ($n = 8$).

4. Qualitative analysis

4.1. Sociodemographic characteristics

When examining the relationship between sociodemographic features and citizen participation in waste separation programs, it can be concluded that most of the analysed studies point out that these factors actually do have an influence, especially on waste separation at the source. The article published by Calabró and Satira (2020) is the exception. According to these authors, age, education, and income do not seem to be major determinant factors for recycling, except in countries where recycling projects are not well established, where a higher level of education level is noted to be a positive influence.

From Table 4, it is possible to identify the major, sociodemographic characteristics found in this systematic literature review. There is an agreement among the authors that rising "incomes" are a precursor to increased waste. According to Knickmeyer (2020a), the improvement in living standards and incomes, especially in developed and industrialised countries, reflects the increase in resource consumption and waste generation. Indeed, it is these same citizens (with higher incomes), who are more willing to pay for food waste management services (Liang et al., 2021). However, in the detailed article analysis, it was not possible

to find data that suggests that these citizens are also the ones who separate the most, or not, waste at the source; this relationship is not explicit.

As for the relationship between waste separation behaviour and educational level, Borrello et al. (2020) state that in countries where recycling programs are not well established, citizens with college degrees are more likely to participate in these programs. In addition, Mwanza et al. (2018) have observed a positive correlation between a higher level of education and recycling behaviour.

Regarding the influence of different age groups and the motivation of citizens to participate in recycling programs, there is no consensus among the authors. According to Oliveira et al. (2018), the over 65 age group in Portugal has had less contact with education campaigns, training, and awareness related to selective collection and, hence, has more difficulty in changing their habits. On the other hand, Ibáñez-Forés et al. (2018) state that elderly people tend to participate more in selective collection programs for recyclables. While, for Ghisellini et al. (2016) people most sensitive to environmental issues are in the 30–49 age group.

4.2. Psychosocial factors

4.2.1. Convenience

The results presented in Table 5 (see Appendix 1) indicate convenience as a key factor in driving citizen participation in household waste separation programs (Lawrence et al., 2020). Most of the studies associate convenience with the distance to be covered to the ecopoints. Only in the studies by Moh and Abd Manaf (2016) and Knickmeyer (2020a) is it suggested that convenience is related to the internal environment of the "residence". These authors recognize the importance of an appropriate space inside the residence so that the waste is separated and stored correctly for later collection.

According to Oliveira et al. (2018), most citizens who are willing to separate waste will only do so if they have easy access to the ecopoints. This means that the specific "residence", and urban environment design, may influence behavioural intentions through perceived, behavioural control, according to Almazán-Casali et al. (2019). Furthermore, Chen and Gao (2020) highlight that the physical distance from each residence to an ecopoint is one of the key indicators used to evaluate citizen access and willingness to participate in source, waste separation programs. This challenge is even greater with regard to household, organic waste, as it is considered a difficult separate storage waste (Borrello et al., 2020). To

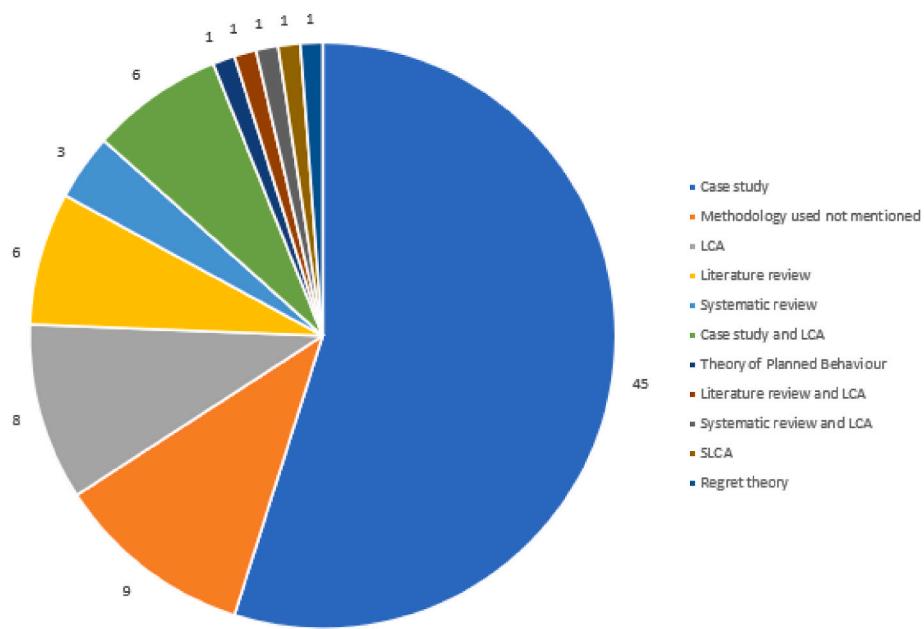


Fig. 4. The predominant methodology in the articles that make up the final sample of this literature review.

Table 4
Sociodemographic characteristics and waste management.

Authors	Income	Age	Education
Almazán-casali, Alfaro, and Sikra		X	
Andersson and Stage	x	X	x
Bees and Williams	x		
Calabró and Komilis	x	X	x
Sadeleer, Brattebo and Callewaert	x	X	x
Ghisellini, Cialani and Ulgiati	x		
Ibáñez-Forés et al.	x	x	x
Knickmeyer	x	x	x
Leal et al.	x	x	x
Lee	x	x	x
Leray, Sahakian and Erkman	x	x	x
Liang et al.	x	x	x
Pai, Ai and Zheng		x	
Roca i Puigvert et al.	x	X	x
Torrente-Velásquez et al.	x	X	x
Oliveira et al.	x	X	x
Yu and Li	x		
Zorras	x		

overcome this inconvenience, collection systems must be appropriately planned, especially in the context of collection frequency (Knickmeyer, 2020b). Nevertheless, Pai et al. (2019) emphasise that convenience can be framed beyond aspects related to infrastructure and service provision, and is also seen as an important psychological factor that varies according to individual perception.

Besides this, from the analysis of the articles, it can be concluded that most of the studies state, but do not prove, using scientific and systematic methods, that convenience may influence behaviour. Furthermore, they do not demonstrate why "when the situation is made easier for them, there are still people who do not behave in the right way" (Gaspar et al., 2012). As a result, further empirical studies need to be developed.

4.2.2. Social norms

When examining the influence of social norms, many authors have indicated that they are a determinant behavioural factor, since they refer to the expressed (dis)approval of others (Knickmeyer, 2020b). This means that behaviours may be motivated and influenced by neighbours or other household members (Zhang et al., 2019). When studying a

voluntary recycling program, Lawrence et al. (2020) concluded that social norms positively impacted the decision of citizens who engaged in the program. Some theories are applied with the purpose of predicting what it is that motivates citizens to participate in recycling programs. The Theory of Planned Behaviour (TPB) is one of the most popular and well-established psychosocial models for understanding and predicting human behaviour (Mak et al., 2020). Ajzen (1991) proposed that intention is the main predictor of behaviour. In general, according to Sharma et al. (2020), once aware of a problem, the citizen may need a "push" to move from intention to action. Although TPB theory is a reference for studies on household waste separation behaviour, further research, such as that by Zhang et al. (2019), has identified model limitations. Zhang et al. (2019) indicate that the willingness for behaviour to turn into action is also affected by other factors, for instance, accessibility to facilities and governmental stimuli. In this sense, Chen and Gao (2020) conclude that intervention on those barriers, along with positive stimuli from public policies, can have a direct impact on waste separation. Similarly, Sharma et al. (2020) recommend that it is essential to increase the public visibility of household, urban waste management programs in order to indirectly influence citizen behaviour, making them more open to other interventions, recognized as social norms.

The analysis of convenience (section 4.2.1) and social norms, only state in a conceptual way how these theories are supposed to impact waste prevention and separation. Thus, there is an absence of studies in the literature that scientifically and systematically prove and quantify how these theories influence the performance of "pro-ecological" behaviour (Gaspar et al., 2012).

It is important to underline that other factors that are important to environmental psychology and sociology, such as attitudes and behavioural intentions, are not mentioned or discussed due to their absence in the reviewed papers.

4.3. Interventions

As far as interventions to promote recycling behaviour are concerned, communication and education campaigns are the most cited. It is important to highlight that the similarities and differences between the concepts of communication and education campaigns are not examined at all in the articles analysed. Yet, it was observed that these

concepts are cited in similar contexts and purposes, namely directed at disseminating information and raising citizens' sensitivity toward sustainability (see Table 6 in Appendix 2). For clarification, the terminology of different campaigns in this article is based on the work of [Dagilienė et al. \(2021\)](#) and [Fuss et al. \(2018\)](#), in which communication campaigns refer to mass media, such as television, radio and social media. Education campaigns correspond more to actions developed within a more specific scope.

4.3.1. Communication campaigns

Communication campaigns have a crucial role when it comes to prevention and separation of household waste programs, as mentioned by 31 out of the 74 articles analysed. Most of these articles investigated solid and organic waste concurrently, and only eight articles explore organics waste specifically ([Aldaco et al., 2020](#); [Alvarez, 2020](#); [Lee, 2017](#); [Leray et al., 2016](#); [Leverenz et al., 2019](#); [Liang et al., 2021](#); [Mourad, 2016](#); [Tonini et al., 2020](#)).

There is a relative consensus among the authors that communication campaigns are vital tools in the dissemination of both urban waste prevention and separation programs (solid and organic) and information that aims to instruct, raise awareness, and prompt citizens to make a change in behaviour in favour of the environment. However, in these same articles, it was not possible to discover how campaigns are planned, what the strategies defined in the media plan are, who the target public is, and what the results were. It is relevant to emphasise that only four articles have cited (without detailing) the media used. The first study was performed by [Fuss et al. \(2018\)](#), in which they exemplify that communication campaigns were broadcast in the media in order to disseminate information about the importance of recycling, and that more specific actions were jointly carried out in certain neighbourhoods, such as community cleaning competitions and bazaars. The second article was from [Sharma et al. \(2020\)](#), where they explicitly state how important it is to intensify campaigns in order to raise awareness of the challenges that the waste management sector has faced during the COVID-19 crisis, and that this should be done through advertisements, newspaper articles, and social media. Following this, [Zorras \(2020\)](#) recommends that the authorities in Cyprus develop efficient waste management strategies, with a focus on citizen awareness through social media (citing: Facebook, Twitter, Instagram, Youtube, and LinkedIn channels) and the daily press. Finally, [Dagilienė et al. \(2021\)](#) highlight the importance of media at the primary classification stage of waste. The authors report that through Lithuanian communication vehicles (for example, radio, television series, and movies for children which address the subject of selective waste collection), residents are constantly informed about developments and innovations in waste management systems.

To provide a vision of how the authors perceive the role of communication campaigns, the articles were divided into two groups. In the first, the authors understand that communication campaigns are essential to increasing and improving citizen awareness and understanding of waste recycling ([Bees and Williams, 2017](#); [Bergeron, 2016](#); [Chen and Gao, 2020](#); [De Gisi et al., 2017](#); [Ferronato et al., 2019](#); [Ibáñez-Forés et al., 2018](#); [Mwanza et al., 2018](#); [Sereenonchai et al., 2021](#); [Sharma et al., 2020](#)). In the second, the authors are more focused on the general public-target campaign content. According to these authors, communication campaigns involving overly broad topics (such as advertisements and print and television commercials) should be avoided, since they are less effective than campaigns with more specific themes and more local content ([Alvarez, 2020](#); [Bees and Williams, 2017](#); [Edjabou et al., 2021](#); [Leray et al., 2016](#); [Leverenz et al., 2019](#); [Tonini et al., 2020](#); [Zorras, 2020](#)). Nevertheless, [Knickmeyer \(2020b\)](#) stresses that communication campaigns about waste prevention and separation programs should be understandable, easily accessible, and transmitted through appropriate communication channels.

Another relevant issue observed during the analysis of the articles is that in the same recently investigated period from 2016 to 2021, most

studies mention campaigns focused on recycling, and only two mention communication campaigns targeting the circular economy. In the first article, [Weber et al. \(2019\)](#) state that communication campaigns should target messages to minimize and eventually eliminate waste arising from the non-circular mode of production and consumption. In this same sense, [Aldaco et al. \(2020\)](#) emphasise that a circular economy framework will induce changes in the patterns of marketing campaigns, promoting more sustainable food consumption and less waste. The authors mention the very successful marketing campaign led by the Intermarché¹ supermarket chain that has a strategy to sell carrots that are "ugly", but "good on the inside" at a discounted price. According to [Mourad \(2016\)](#), this type of campaign has spread in Europe and the United States, which has motivated many companies to adopt similar initiatives. Furthermore, these campaigns are still aligned with the waste hierarchy in which prevention is always the best path.

4.3.2. Education campaigns

There is a relative consensus among the authors that education campaigns positively influence the prevention and separation behaviour of households with regard to urban waste. According to [Ikiz et al. \(2021\)](#), waste reduction plans usually include educational initiatives. As [Bertanza et al. \(2021\)](#) emphasise, before and during the adoption of a new collection system, it is important to promote several educational campaigns in order to raise environmental awareness among citizens. This strategy is recognized as key to the effectiveness of the whole process. [Azevedo et al. \(2021\)](#) also see education campaigns as vital to the success of recycling programs in Germany. Similarly, [Dagilienė et al. \(2021\)](#) underline the importance of extending educational campaigns beyond educational institutions, involving social organizations and public companies through lectures, ecological projects and events, for instance. According to [Almazán-Casali et al. \(2019\)](#) educational campaigns must highlight the benefits of efficient organic waste management for general health (lower risk of diseases caused by waste), the environment (using home compost), and the economy (additional income), thus stimulating community adherence to waste separation and collection programs ([Sukholthaman and Sharp, 2016](#)). In addition to these benefits, [Leal et al. \(2021\)](#) assert that the population should be "educated" to reduce the amount of waste generated in households.

It is relevant to emphasise that, of the 74 articles analysed, only two mention effective, educational actions directed towards household, urban, organic waste. In the first, [Teigiserova et al. \(2020\)](#) recommend that consumer education be focused on overturning aesthetic criteria and understanding labels, especially the difference between "best before" and "use by" terminology for food products. In the second article, [Liang et al. \(2021\)](#) underline that educational campaigns should be performed so as to influence citizens to become sub-buyers (making better buying and consumption plans), to teach food reuse techniques and storage skills in order to reduce waste and, consequently, the disposal of household food waste.

Moreover, [Zhang et al. \(2019\)](#) make an unusual and curious observation. They emphasise the negative consequences of a late investment in environmental education, mentioning the China case, which has only recently incorporated environmental education into their national curriculum. According to the authors, adult Chinese generations received a very superficial, environmental education. As a consequence, habits have been created without taking into consideration environmental protection, resulting in a kind of behaviour that is hard to change. They provide as an example the habit of not separating waste before disposal, which continues to negatively influence younger generations and undo the benefits of environmental education at school. In a similar context, [De Gisi et al. \(2017\)](#) showed that environmental education campaigns are being implemented first with the students, and then with the parents,

¹ Is the first brand of *Grupo Os Mosqueteiros* [The Musketeers Group], operating for over 40 years in the retail market throughout Europe.

in the study case developed in Italy.

However, it is vital to elucidate that, although education and communication campaigns are repeatedly cited as significant tools for behaviour change (Edjabou et al., 2021; Feronato et al., 2019; Zorras, 2020), those responsible for implementing waste prevention and separation programmes must not limit themselves to rationalistic and somewhat naïve models. The assumption that educating people about environmental issues will directly lead to more pro-environmental behaviour does not hold with regard to waste related behaviour (Esmaeilian et al., 2018) or in any kind of behaviour (Smith and Mackie, 2015). Furthermore, it is opportune to recognize that whilst these types of campaigns are regularly outlined and listed as crucial instruments in intervention, it was not possible to identify in any of the analysed articles (even in the Case Studies) how these campaigns were planned and what results were expected and obtained after they were launched. Equally, no article has scientifically proven how these campaigns have effectively contributed to the improvement of waste prevention and collection programs towards the fulfilment of the objectives established in Directive (2008)/851. Lastly, neither was any work found concerning how these campaigns are perceived and what the repercussion is in the different social groups researched.

4.4. Waste management in a circular economy perspective

As Petit-Boix and Leipold (2018) state, the concept of circular economy has been overwhelmingly applied to waste management. According to these authors, waste management is one of the most practised urban strategies (strongly focussed on investments in infrastructure and technical solutions of the Circular Economy (CE), primarily in Europe.) Regarding organic waste, these authors conclude that it has received the least attention from the research and technical community.

The basic premise of the CE model aims to overcome the linear standard of production, consumption, and disposal of resources by proposing an in-loop system. To help illustrate the CE concept, the Ellen MacArthur EMF - Ellen MacArthur Foundation (2017) has developed the Butterfly diagram, which allows for an integrated view of the main pillars and tools of the model. Technical nutrients and biological nutrients (the focus of this review) are the two primary categories into which the detailed management of the materials flows is divided. The first concept involves the technical cycle, in which products must be designed to have their shelf lives extended and to circulate in excellent condition, without being reintroduced into the biosphere. In contrast, the second concept refers to materials that can be reintroduced into the biosphere, constituting the biological cycle (Petit-Boix and Leipold, 2018).

In the biological cycle, household food waste is a key area, since it is one of the main sources of urban waste (Liang et al., 2021). Therefore, Corrado and Sala (2018) recommend that it is important to differentiate between avoidable and unavoidable food waste, even though these authors recognize that this classification is not universal and can be influenced by different cultural and behavioural aspects. In this article the concept of unavoidable waste is considered to be the organic parts which are usually not consumed, for example, fruit and vegetable peels, as defined by Corrado and Sala (2018). While, for avoidable waste, the concept defined by Luttenberger (2020) is employed, which includes that from household kitchens, restaurants, buffets, and retail establishments, as well as waste from food processing factories. It is crucial at this point to briefly distinguish between the main cultural motivators and attitudes that contribute to food waste. Regarding unavoidable waste, two main causes can be highlighted: cultural factors and the absence of a universal concept (Corrado and Sala, 2018). While for avoidable waste, the influences are more heterogeneous. It concerns the failure by consumers to plan when shopping, the affordable value of the food, the non-understanding of the labels, the influence of marketing strategies, the absence of technical knowledge to reuse the leftovers, the rejection of products considered aesthetically inappropriate, and finally, also by

cultural factors (Lemaire and Limbourg, 2019b).

Furthermore, for household organic waste to remain in the proposed biological cycle of CE, two practices are crucial: separation at source and selective collection (illustrated in Fig. 5). These processes are a fundamental precondition for the success of recycling programs, as they enable the waste to be reused and transformed, for example, into compost (no restrictions on use), energy (through the anaerobic digestion process), and input for the production of new products (Klavenieks and Blumberga, 2017). On the other hand, waste from the undifferentiated collection has restrictions on use, frequently transformed into energy (through the incineration process) and compost (with restrictions on use) or sent to landfill.

The article analysis revealed the three most mentioned collection strategies: the door-to-door system, the Pay-As-You-Throw (PAYT),² based on the volume, and the option of ecopoints located in the streets. In the study by Calabò Paolo and Komilis (2019), the results revealed that citizens who separate waste to be collected through the door-to-door system have a higher awareness of recycling and are more satisfied with the city waste management system, when compared to citizens who have to deposit their waste in the ecopoints located on the streets. Otherwise, in the research of Abdel-Shafy and Mansour (2018), the authors recommend the volume-based PAYT disposal model as a solution to optimise the local waste management system, with the perspective of achieving “zero waste disposal” and thus generating economic, environmental, and social benefits. They conclude that the adoption of the PAYT method enables waste to be reused and recycled in a cost-effective and socially acceptable manner, while at the same time promoting progress towards the circular economy.

Concerning the valorisation strategies to deal with the separated organic waste, there is no technical nor political consensus. Detailed analysis revealed composting as the most widely referenced and chosen, followed by anaerobic digestion and waste recovery as a value-added co-product. This option is justified since the management strategy helps to replace the use of chemical fertilisers, and consequently reduce environmental impacts, namely global warming, ecotoxicity, eutrophication, and depletion of fossil fuels (Xiang et al., 2020). At the household level, Babbitt et al. (2021) assert the importance of encouraging the practice of home composting as an alternative to organic waste disposal in bins. From another perspective, there are studies such as those by Mangialardi et al. (2016); Feronato et al. (2019); and Teigiserova et al. (2020) in which it is suggested that investments must be encouraged to valorise the waste, for example, the circular bioeconomy. Xiang et al. (2020) also state that to achieve the CE ideal, organic waste must be recycled and transformed into value-added products, but first, it is vital to develop an integrated management system, starting with the waste separation step at the source, moving on to collection, preparation, processing, monitoring, and ending with the final product distribution step. de Sadeleer et al. (2020), on the other hand, propose a different strategy, whereby organic waste is transformed into energy.

In order to understand how the fields of organic waste management and circular economy intersected in the 74 selected articles, the twelve articles that addressed these two subjects were mapped in Table 7 (see Appendix 3). Four out of the twelve articles focussed on waste management, seven emphasized food waste, and one highlighted food loss. According to the analysis performed, it can be stated that the relationship between organic waste and the circular economy is more evident in the works developed within the scope of food waste than in waste management. Regarding the origin of organic waste, most of the articles address more than one source, and only two researched exclusively organic household waste.

As for circular economy strategies, five out of seven articles focusing on food waste recommend the valorisation of waste (mainly as an input,

² The residents are charged for waste collection based on the number of bags used (Abdel-Shafy and Mansour, 2018).

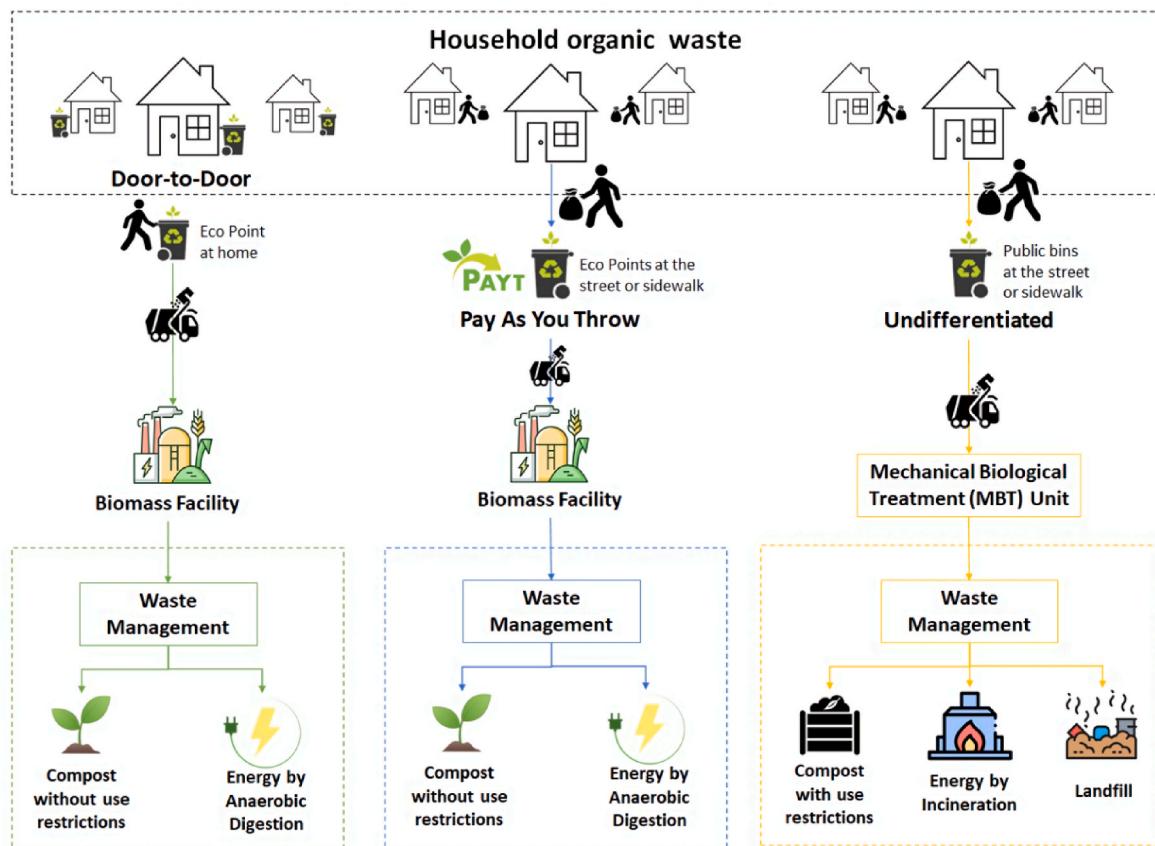


Fig. 5. Type of collection and the final product.

returning it to the production process), one recommends transforming food waste into energy, and one does not present any CE strategy. The strategies proposed by three of the four articles that focused on waste management are more centred around the reuse and valorisation of this waste through composting processes and as raw material for industrialised products, respectively. The authors caution that, in the municipal waste sector, not enough research is being done to adequately quantify and demonstrate the advantages of CE. And finally, one article supports the conversion of food waste into energy.

In short, one cannot disagree with the contention made by [Gardiner and Hajek \(2020\)](#) that it is necessary to go beyond waste management strategies, the imperative being the definition of economic tools, such as taxes and incentives, and eco-innovation policies to promote the change in society towards a circular economy model. In this sense, [Sharma et al. \(2020\)](#) add an interesting insight when they suggest that “public policymakers and entrepreneurs must consider the current crisis as an opportunity to solve the waste issue, not only treating it as an environmental issue, but also as an economic perspective for which new sustainable business models, based on the circular economy principle, are needed” ([Sharma et al., 2020](#), p.11).

5. Conceptual Framework and recommendations for future research in the field

In order to achieve the objectives put forward by the EU, profound changes in behaviour and infrastructures must be pursued. This is fundamental in order to comply with the objectives set out in Directive (2008)/851. In this sense, it is essential to understand the dimensions that can enhance (+) or hinder (-) the behaviour and attitudes of citizens towards the environment.

This paper uses a systematic literature review to develop the framework shown in Fig. 6 to support organic waste management,

intended primarily for researchers, policymakers, and stakeholders in waste management. The framework is divided into four dimensions and nine sub-dimensions, identified in section 5. This framework integrates into a systematised and summarised manner all the dimensions and sub-dimensions studied, and how they enhance (+) or hinder (-) the achievement of the objectives set out in Directive (2008)/851, promoting a holistic view of the area. Furthermore, gaps in the literature and data, where no consensus exists among authors, are identified, characterising research paths open to exploration.

By analysing this framework more closely, it is possible to understand that many different dimensions and sub-dimensions impact the achievement of the objectives of Directive (2008)/851 in an integrated way. Achieving efficient management of household organic waste, in line with EU policies, requires investments in infrastructures, technological innovation and, above all, strategies aimed at shifting the behavioural frameworks of citizens with regard to the prevention and correct disposal of this waste. Therefore, due to the complexity and plurality of the area, it is fundamental that implementation strategies and improvements in this field are developed by multidisciplinary teams.

- **Interventions** - communication and education campaigns in the literature are considered key to changing consumer behaviour with regard to the prevention and separation of household organic waste. Despite this, it was not possible to understand how these campaigns were planned and implemented. Moreover, it was not possible to quantify the impact of these campaigns in consumer behaviour change. Thus, it is recommended that campaigns are applied to increase organic waste collection, since empirical evidence shows a positive correlation with consumer behaviour. However it is also important to further investigate what the actual impact of

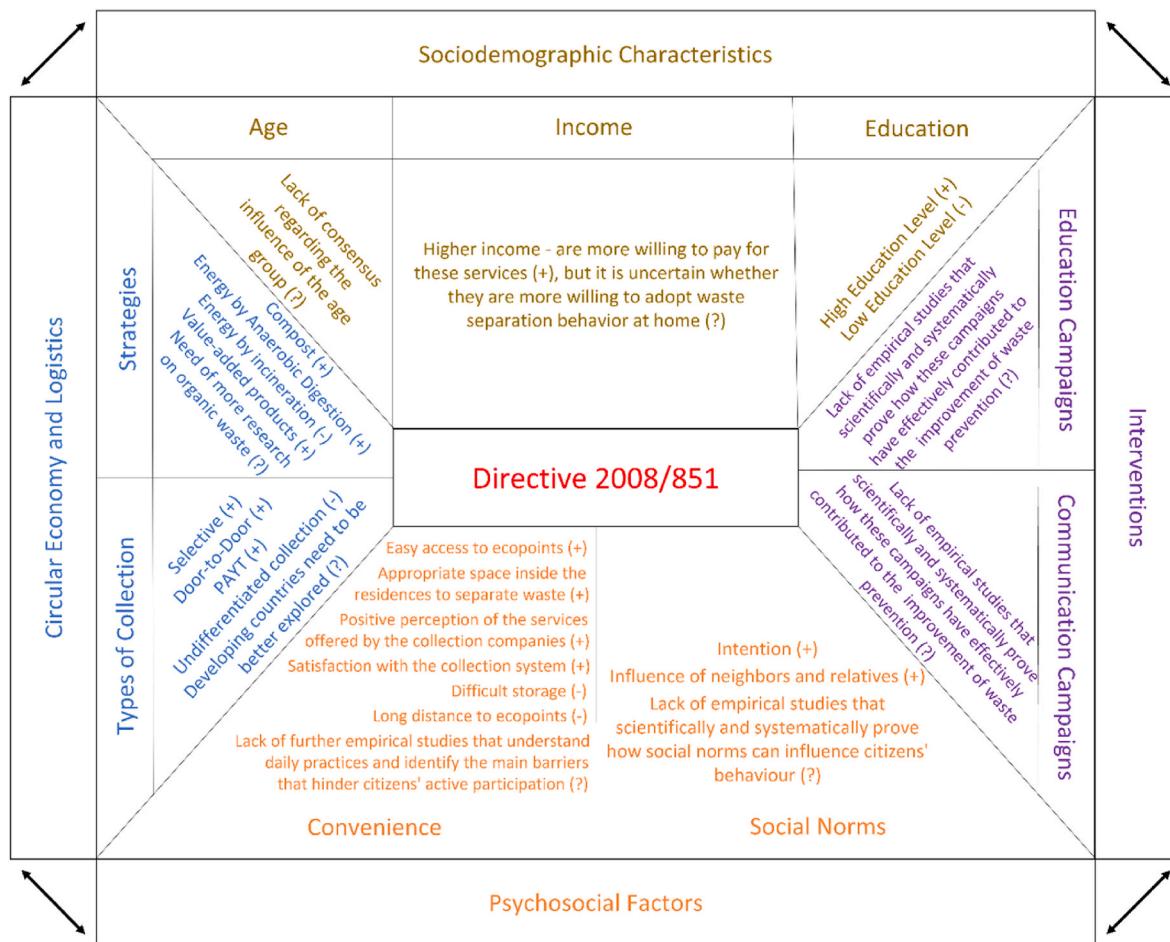


Fig. 6. Conceptual framework.

communication and education campaigns is and how to make them more cost-effective.

- When designing campaigns socio-demographic characteristics should be considered. Target public should be evaluated according to their education, income and age. Higher level of education positively influences consumer behaviour. Thus, it is recommended that more effective and specific communication and education campaigns are developed for this target audience, mainly aiming at the prevention and correct disposal of this waste. As for the income level, it can be stated that citizens with higher incomes are more willing to pay for food waste management services. However, it was not possible to find data that confirms whether these citizens are the ones who separate waste at source or not. Since this relationship is not explicit, future studies in this field are required to better campaign design.

There is disagreement among the authors on the impact of age groups, therefore future research on how age is influencing campaigns is a major research avenue.

- Circular economy and logistics are key aspects to ensure efficient waste collection. Therefore, it is recommended the development of communication and education campaigns aimed at children and adults on the importance of correct separation of domestic organic waste. In addition, it is important to highlight that even though waste management is one of the most practised urban circular economy strategies, organic waste remains the type of waste that has received less attention from the scientific community. Nevertheless, this is a relevant research area to be explored. Finally, the number of papers discussing household organic waste management is predominantly

researched in Europe. Analysis of this issue in developing countries is of utmost importance.

- Psychosocial factors should be considered in campaigns design considering convenience and social norms. Convenience and social norms were pointed out as a key factor in driving citizen participation in household organic waste prevention and separation programmes, so campaigns should consider convenient ways of collecting organic waste and social norms. However, in general, articles do not quantify the impact of convenience and social norms in the citizens' behaviour. Similarly, they do not explain why, even when in more convenient contexts, some people are not willing to participate in these programmes. These aspects open doors for further research. Finally, this framework aims to be a tool to:
- Public policymakers, because it provides the opportunity to identify, in a systematic and integrated approach, the drivers that promote, and the barriers that hinder, the achievement of the objectives established in Directive (2008)/851. The knowledge of these drivers and barriers and their interactions will allow for the creation of national and local strategies.
- Stakeholders in waste management, since it allows the theoretical, systematic, and integrated knowledge, outlined in the framework, to serve as a basis for these professionals to develop increasingly effective practical actions towards achieving the objectives set out in Directive (2008)/851.
- Researchers, as it integrates dispersed knowledge, which provides researchers with a holistic and integrated "view" on household organic waste management, and within that, to identify the main gaps existing in the field.

6. Conclusion

This paper aims to analyse the importance of psychosocial factors, sociodemographic characteristics, intervention actions, and circular economy principles in the context of organic waste management through a systematic literature review. To the best knowledge of the authors, this has not been addressed by previous reviews. As for the main results, it was concluded that: (1) researchers have been focused primarily on waste management infrastructure issues, and only 23% of the articles addressed one or more psychosocial factors; (2) citizens with higher levels of education are more willing to adopt more proactive recycling behaviour and citizens with higher incomes are more willing to pay for food waste management services. There is no consensus among the authors regarding the influence of age group on food waste management; (3) convenience is the key factor in driving citizen participation in prevention programs and separation of household organic waste; (4) behaviours regarding recycling practices can be motivated and influenced by the individual's own intention, and by neighbours and companions; (5) selective waste collection is the basic condition to achieve the targets set forth in Directive (2008)/851; (6) it is not possible to state whether recycling behaviour is affected by communication and education campaigns.

Based on the previous conclusions a new framework has been proposed to guide policymakers and practitioners in defining waste management strategies. This, together with an in-depth analysis, resulted in recommendations for future research in the field: (1) organic waste is the type of waste that has received the least attention thus it is a relevant research area to be explored; (2) the papers exploring household organic waste management are mainly conducted in Europe, so other geographic locations should be explored; (3) there is a need to apply scientific and

systematic methods for the quantification and proof that psychosocial factors, such as convenience and social norms, influence waste separation behaviour; (4) the influence of income and the age group in the household organic waste management should be analysed; and finally, (5) to investigate with scientific precision the effective impact that communication and education campaigns have, and how to make them more cost-effective.

Authors contributions

Erika Celestino: Conceptualization, Investigation, Writing – original draft; **Ana Carvalho:** Supervision, Conceptualization, Writing – review and editing; **José Manuel Palma-Oliveira:** Supervision, Writing – review and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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Appendix

Appendix 1

Table 5
The relation between convenience and waste management.

Nº	Authors	Waste Source	Type of waste						How
			Glass	Cardboard	Plastic	Metal	Organic	Others	
1	Oliveira et al.	Household	Yes	Yes	Yes	Yes	No	No	In this article, convenience is related to the infrastructure factor, specifically the quantitative assessment of the number of containers that need to be installed to achieve the goals of selective collection of packaging waste
2	Breadsell, and Morrison	Household	Yes	Yes	Yes	Yes	Yes	No	In this article, the authors emphasise that residents are willing to change their waste management practices if there is support from the community and adequate facilities to do so
3	Puigvert et al.	Household	Yes	Yes	Yes	Yes	No	No	Making recycling more convenient in terms of the required resources and effort and making this convenience apparent have a positive impact on the degree of recycling.
4	Yu and Li	Household	No	No	No	No	Yes	No	Convenience impacts significantly improving the social sustainability of urban waste management
5	Chen and Gao	Municipal waste	No	No	No	No	No	No	The availability of facilities can influence behavioral intentions through perceived behavioral control. The physical distance from each house to a facility, such as a recycling bin, is one of the key indicators used when assessing access.
6	Babbitt et al.	Household	No	No	Yes	No	Yes	No	Convenience is a key factor for consumers to adopt household waste separation
7	Bergeron	Household	Yes	Yes	Yes	Yes	Yes	Iron	Infrastructure (e.g., collection points) is an effective factor improving the Geneva's household waste separation practices
8	Bees and Williams	Household	Yes	Yes	Yes	Yes	Yes	No	The lack of contents near the residence is a barrier that makes it difficult to separate the residue at the source
9	Mwanza	Household	No	No	Yes	No	No	No	Having convenient waste collection options influences households to participate in recycling programs
10	Calabrà and Komilis	Household	Yes	Yes	Yes	Yes	Yes	No	The shorter the distance, the greater the level of collection service provided
11	Pai et al.	Household	No	No	No	No	Yes	No	Participation in recycling programs varies within a city depending, for example, on perceived convenience

(continued on next page)

Table 5 (continued)

Nº	Authors	Waste Source	Type of waste						How
			Household/ Municipal	Glass	Cardboard	Plastic	Metal	Organic	Others
12	Almazán-Casali et al.	Household	No	No	Yes	No	Yes	Plastic films	Convenience is a vital element that drives Paynesville resident's preference for garbage collection services
13	Lawrence et al.	Household	Yes	No	Yes	Yes	No	No	The ease at which recycled items could have been deposited was found to be the most essential factor.
14	Meng et al.	Household	No	Yes	Yes	Yes	No	No	One of the most important influencing factors in the selection of residents for the garbage disposal routes in the perception of the convenience of the disposal routes
15	Ikiz et al.	Household	No	Yes	Yes	No	Yes	No	Garbage disposal is typically much more convenient, with a garbage chute on each floor, although many new buildings now include chutes for multiple waste streams
16	Bertanza et al.	Municipal waste	Yes	Yes	Yes	Yes	Yes	Batteries/Wood	Door-to-door collection is considered a convenience practice that has a positive impact on improving recycling programs in terms of proximity and frequency
17	Calabrià and Satira	Household	No	Yes	Yes	No	Yes	No	The authors emphasized the relationship between the perceived desirability of recycling (in terms of, for example, accessibility to recycling facilities) and the economic and environmental benefits
18	Knickmeyer	Household	No	Yes	Yes	No	Yes	No	One of the most important factors to increase household waste separation behaviour is convenience. The perception of convenience depends on the individual who is desired to participate in the sorting system
19	Moh and Manaf	Household	Yes	No	No	No	Yes	No	Source separation and recycling among households require their willingness to separate waste for recycling and supporting infrastructure for them to do so, with consideration of their socio-economic conditions as well as it is not possible to develop a recycling system that fits all

Appendix 2**Table 6**
Compilation of articles which cited the communication and education campaigns.

Nº	Authors	Communication			Education		Methodology	Country	Year
		Yes/ No	How	Yes/ No	How				
1	Oliveira et al.	No	No	Yes	Educational campaigns are briefly mentioned as an important awareness-raising action.	Case Study	Portugal	2017	
2	Puigvert et al.	Yes	Providing wrong and confusing messages to citizens can make it difficult for them to participate in recycling programs. However, the study states that when individuals receive comprehensive information the desire to participate in recycling programs changes radically.	Yes	Public education is essential to the success of any waste management program.	Case Study	Spain	2020	
3	Aldaco et al.	Yes	The Circular Economy will bring about changes in marketing actions by reinforcing the negative impact of food waste and loss on and promoting sustainable food consumption.	Yes	It is essential to reinforce educational campaigns on the importance of reducing food waste in school programs.	LCA	Peru	2020	
4	Tonini et al.	Yes	A communication campaign is considered adequate when information reaches the people who need it, in a clear and understandable way	No	No	LCA	Belgium	2020	
5	Mourad	Yes	Intermarché led a very successful marketing campaign to sell carrots that are "ugly" but "good in the inside" at a discounted price, many companies in Europe and the U.S. started exploring similar initiatives.	Yes	Relatively long-term change in cultural and social expectations, encouraged by education, may alter business practices and regulation.	n.a	France	2016	
6	Chen and Gao	Yes	Communication campaigns are needed to improve individual understanding and awareness of environmental protection and waste recycling.	Yes	Educational campaigns should cultivate a civic sense in society regarding sustainability issues and empower change through civic education, awareness and citizen participation.	Regret theory	China	2020	
7	Ng and To	No	No	Yes	Educational campaigns are important to promote systems thinking in families.	LCA	UK	2020	

(continued on next page)

Table 6 (continued)

Nº	Authors	Communication		Education		Methodology	Country	Year
		Yes/ No	How	Yes/ No	How			
8	Sharma et al.	Yes	The communication and awareness campaign needs to be intensified to make people aware of challenges that the waste management sector is facing during COVID -19 crisis and this could be done using advertisements, campaigns, newspaper articles/social media campaigns, etc.	Yes	Educational campaigns should begin to emphasise circular economy concepts.	Case Study	Indian	2020
9	Ghisellini et al.	No	No	Yes	Increase investments in education campaigns to support eco-industrial parks.	Literature Review	Italy	2016
10	Zhang et al.	No	No	Yes	Failure to promote environmental education campaigns can harm more than one generation.	Case Study	New Zeland	2019
11	Keng	Yes	No	Yes	Partnerships between government sectors, municipal councils and organizations are essential, especially in educating the community for proper waste separation.	Case Study/LCA	Malaysia	2020
12	Teigiserova et al.	No	No	Yes	It is essential to invest in education campaigns that inform consumers and commercial operators about the difference between the "better before" and "use by" terminology on food labels.	n.a	Denmark	2019
13	Taleb and Al Farooque	Yes	The successful implementation of PAYT needs to be supported by a communication campaign that highlights effective actions against illegal diversion, while creating adequate and lasting incentives for families.	No	No	Case Study	Egypt	2020
14	Edjabou et al.	Yes	Ongoing communication campaigns with a focus on awareness are needed. Also those that encourage increased public awareness in relation to waste reduction and citizen participation in recycling schemes.	No	No	LCA	Denmark	2021
15	Mozo	Yes	An EU platform on 'Food Losses and Food Waste' is available providing information on EU actions to tackle food waste, a repository of good practices in food waste prevention, communications materials to help raise awareness and a food waste resources library.	Yes	It is imperative to develop education campaigns for everyone involved in the food chain with the aim of mitigating food waste at all levels.	LCA	Spain	2021
16	Zorpas	Yes	It is important to use different means of communication to create interactive activities related to sustainability. These activities can aim to motivate and raise awareness among citizens using, for example, social media (Facebook, Twitter, Instagram, Youtube channels, and LinkedIn).	Yes	Considering that most EU Member States already have a waste management system in place, even the most developed systems, it is still essential to continue investing in environmental education campaigns.	LCA	Cyprus	2020
17	Bertanza et al.	No	No	Yes	Before and during the progressive adoption of the new collection system, the waste management company promoted several educational campaigns in order to raise citizens awareness for the environmental issues, this being recognized as a key factor for the effectiveness of the whole process.	Numerical indicators and mass balance	Italy	2021
18	Azevedo et al.	Yes	The company responsible for the collection, Limpatech, is not easy to be accessed and does not have a website to facilitate communication with the local community.	Yes	The lack of public campaigns to improve education for sustainability is one of the negative points facing the Macaé waste management system. Contrary situation to what happens in Germany.	Case Study	Brazil	2020
19	Ferronato et al.	Yes	In Romania high investments are needed in communication campaigns to raise awareness and motivate the population to separate the waste.	Yes	Environmental awareness and public willingness to participate in recycling programs are still low, although they are increasing through general environmental campaigns and educational activities.	Case Study	Italy	2018

(continued on next page)

Table 6 (continued)

Nº	Authors	Communication		Education		Methodology	Country	Year
		Yes/ No	How	Yes/ No	How			
20	Dagiliene et al.	Yes	Providing information emphasizing the importance of primary ranking through the media, radio, newspapers and social media is critical. In the region's media, residents were constantly informed about the development of waste management systems, innovations and relevance (eg radio series on the environmental theme in the "green channel" and ecology section; computer games on selective collection; children's films about selective collection; electronic map of sorting containers).	Yes	Cooperation with academia (universities, schools, kindergartens or other educational institutions) is highly developed through participation in lectures, ecological projects, educational sessions and events.	Case Study	Lithuania	2021
21	Weber et al.	Yes	Communication campaigns should aim to minimize and eventually eliminate all types of waste that result from the non-circulating mode of production	No	No	Case Study	Spain	2018
22	Sereenonchai et al.	Yes	Communication campaigns were developed to increase citizen awareness of sustainability.	Yes	Education campaigns should be a good match between the roles, ages and responsibilities of senders and recipients: teachers matched with students, local leaders with workers, and religious leaders with older adults.	Case Study	Italy	2017
23	Calabro and Satira	Yes	Separate collection gives superior results, but needs a strong commitment to the customer, which can be achieved mainly through communication and educational campaigns.	Yes	Separate collection requires a strong customer's commitment and long-term information, and educational campaigns are needed for obtaining the desired results.	n.a	Italy	2020
24	Mak et al.	No	No	Yes	Education campaigns are commonly implemented in recycling projects to encourage citizen participation.	Literature Review	China	2019
25	Knickmeyer	Yes	The best practice to overcome prevailing recycling barriers (knowledge, attitudes, perceptions) is to develop communication campaigns aimed at raising awareness.	Yes	Educational and informational programs are essential for improve recycling successfully.	Literature Review	Spain	2019
26	Lemaire and Limbourg	Yes	Propose the creation of awareness-raising communication campaigns such as: 'Love Food Hate Waste' in Great Britain, 'Stop Waste Food' in Denmark, 'Too Good for Waste' in Germany, 'Qui jette un oeuf, jette un boeuf' in France, 'Don't Even Waste a Little Ofa Flour' in Catalonia and 'Zero Waste Movement' in Portugal.	Yes	It is important to include education campaigns in the curriculum of schools from the first cycle to achieve a change in attitude and thus reduce food waste.	Literature Review	Belgium	2019
27	Moh and Manaf	Yes	Awareness campaign strategies should focus on recycling, as sorting waste for recycling remains an uncommon practice among Malaysians.	Yes	Environmental education campaigns, when initiated in first-cycle schools, have the potential to positively impact long-term behavior, as it increases the capacity for understanding to address issues related to the environment, such as the importance of the practice of separating the waste.	n.a	Malaysia	2016
28	Mwanza	Yes	Communication campaigns aimed at continually raising awareness and informing about the proper management of solid waste and environmental issues are important actions for the success of recycling projects in communities.	Yes	There is a positive correlation between information through public campaigns and education and recycling rate campaigns.	Literature Review	South Africa	2018
29	Babbitt et al.	No	No	Yes	Educational campaigns should aim to teach consumers about the meaning of labels and food safety.	Case Study	USA	2021
30	Bees and Williams	Yes	Lack of information about recycling schemes was a barrier identified in both cities studied. Separate collections of food waste, together with communication and awareness campaigns on the economic, environmental and social impacts of food waste, should be carried out simultaneously to minimize household food waste.	No	No	Case Study	UK	2017

(continued on next page)

Table 6 (continued)

Nº	Authors	Communication		Education		Methodology	Country	Year
		Yes/ No	How	Yes/ No	How			
31	Almazán-Casali et al.	No	No	Yes	Educational campaigns highlighting the health, environmental and economic benefits of waste management can help increase community adherence to waste collection programs and clarify household preference for specific aspects of collection services, such as levels of waste separation, collection frequency and acceptable cost of services.	Case Study	USA	2019
32	Lawrence et al.	No	No	Yes	A very effective education programme was conducted that linked a major problem plaguing the community with recycling as the solution.	Case Study	Trinidad and Tobago	2019
33	Ibáñez-Forés et al.	Yes	The dissemination and improvement of communication and awareness campaigns throughout the city are fundamental aspects that can improve the recycling rate.	No	No	Case Study	Spain	2017
34	Ibáñez-Forés et al.	Yes	The application of communication and awareness campaigns aimed at increasing the population's participation rate in the selective collection program is a priority tool to increase the rate of waste collected in this way and, thus, improve the system's overall effectiveness.	No	No	Case Study	Spain	2018
35	Fuss et al.	Yes	To increase citizens' awareness, it is important that they have access to communication campaigns and public activities developed for this purpose, such as (information disseminated in the mass media, participation in exhibitions, community cleaning contests, and community meetings, recycling).	Yes	It is essential that schools implement waste awareness programs.	Case Study	Germany	2018
36	Liang et al.	Yes	Asking to take the leftovers home is embarrassing, as it violates the prevailing social norm. To alleviate the leftover problem, for example, waiters could make reasonable suggestions when guests order too many dishes and inform customers about the restaurant's delivery service for food they haven't finished eating. Such an approach could be accompanied by an advertising campaign under government orientation so that "adequate consumption and sufficiency" becomes a new and desirable trend.	Yes	Education campaign should be carried out, to influence residents to become under-buyers (making better plans for purchasing and consumption), and to learn better food storage skills, to reduce food waste generation.	Case Study	China	2021
37	Leray et al.	Yes	Our results revealed that some factors, such as communication campaigns, can influence consumption and increase food waste.	No	No	Case Study	Switzerland	2016
38	Leverenz et al.	Yes	The authors claim that advertisements for the general public, with very general themes, are less effective than more specific advertisements with more local content.	No	No	Case Study	Germany	2019
39	Lee	Yes	This study suggests that the influence of food retailers on household food waste is not limited to marketing promotions, but also extends to the ways they may shape households' grocery shopping patterns.	Yes	Public education campaigns were important in guiding citizens towards the introduction of mandatory waste segregation and volume-based pricing policies.	Case Study	USA	2017
40	Bergeron	Yes	It can be argued that the combination of infrastructure (eg collection points) and persuasive communication campaigns (eg awareness campaigns) are effective interventions to improve Geneva's household waste separation practices.	No	No	Case Study	Switzerland	2016
41	Gisi et al.	Yes	With the communication plans and the environmental education campaigns, the aim was to make citizens and students aware of the topics covered both on the island and at school level.	Yes	Environmental education campaigns were implemented in order to increase the students (and then, parents) awareness.	Case Study	Italy	2017

Appendix 3

Table 7

Mapping of articles that cross the themes of organic food waste management and circular economy.

Nº	Authors	Keywords	Focus: waste management and food waste and loss	Waste Source (household/commercial & industrial/agriculture/municipal not-specified)	Methodology	Circular Economy Estrategy	Country	Year
1	Mourad	Food waste/Food surplus/Waste prevention/Sustainability/Recycling/Re-use	Food waste	Household/comercial & industrial/agriculture/	Case study	Circular economy as a concept	France	2016
2	Klavenieks and Blumberga	Waste management/Baltic States/Landfill diversion	Waste management	Municipal waste	Case study	Circular economy as a concept	Latvia	2016
3	Mangialardi et al.	Waste Management/Pneumatic Refuse System/Density/Metropolitan Area	Waste management	Municipal waste	Case sudy	Value-added products (cascade procedure)	Italy	2016
4	Petit-Boix and Leipold	Circular economy/Industrial ecology/Urban Sustainability	Waste management	Commercial & Industrial	Literature review	Circular economy as a concept	Germany	2018
5	Corrado and Sala	Food loss/Food waste/Estimation/Sustainable Development Goal 12/Circular economy/Waste framework directive	Food waste	Household/Agriculture	Literature review	Value-added products (cascade procedure)	Italy	2018
6	Mak et al.	Circular bioeconomy/Food recycling/valorisation/Sustainable waste management/Life cycle assessment/Bio-based chemicals/products	Food waste	Agriculture	Literature review	Energy	China	2019
7	Lemaire and Limbourg	Food loss and waste/Sustainable development goals/SDG 12.3/Food waste prevention	Loss waste	Household/Commercial & Industrial/Agriculture	Literature review	Energy recovery and biosphere recovery	Belgium	2019
8	Santagata et al.	Food waste/Circular economy/Bioeconomy/LCA/Energy accounting	Food waste	Agriculture	Systematic review	Value-added products (cascade procedure)	Italy	2019
9	Aldaco et al.	COVID-19/Food loss waste (FLW)/Life cycle assessment (LCA)/Eating habits/GHG emissions/Nutritional impact	Food waste	Household	Case study	Value-added products (cascade procedure)	Peru	2020
10	Tonini et al.	Stakeholder/Waste collection/LCA/Local impacts/Multi-criteria decision analysis/Circular Economy	Waste management	Household	Case study	Energy recovery and biosphere recovery	Belgium	2020
11	Keng	Organic waste/Food waste/Composting/Life cycle/Circular economy/Feasibility	Food waste	Food waste generated from the University cafeteria	Case study	Value-added products (cascade procedure)	Malaysia	2020
12	Mozo	Food waste management/circular economy	Food waste	Household, retail, restaurant, manufacturing and supply chain level	LCA	Value-added products (cascade procedure)	Spain	2021

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