



# Household Food Waste Research: The Current State of the Art and a Guided Tour for Further Development

Judit Oláh<sup>1\*</sup>, Gyula Kasza<sup>2</sup>, Barbara Szabó-Bódi<sup>2</sup>, Dávid Szakos<sup>2</sup>, József Popp<sup>3\*</sup> and Zoltán Lakner<sup>4,5</sup>

<sup>1</sup>Faculty of Economics and Business, University of Debrecen, College of Business and Economics, University of Johannesburg, Johannesburg, South Africa, <sup>2</sup>Risk Management Directorate, National Food Chain Safety Office, Budapest, Hungary, <sup>3</sup>John von Neumann University, Hungarian National Bank—Research Center, College of Business and Economics, University of Johannesburg, Johannesburg, South Africa, <sup>4</sup>Department of Agricultural and Food Industrial Enterprise Management, Hungarian University of Agriculture and Life Science (MATE), Gödöllő, Hungary, <sup>5</sup>Kebbi State University of Science and Technology, Aliero, Nigeria

## OPEN ACCESS

### Edited by:

Irfan Ali,  
Aligarh Muslim University, India

### Reviewed by:

Umar Muhammad Modibbo,  
Modibbo Adama University of  
Technology, Nigeria  
Hammadikko Gaya Muazu,  
Modibbo Adama University, Nigeria  
Fariba Goodarziyan,  
Sevilla University, Spain

### \*Correspondence:

Judit Oláh  
olah.judit@econ.unideb.hu  
József Popp  
popp.jozsef@uni-neumann.hu

### Specialty section:

This article was submitted to  
Environmental Economics and  
Management,  
a section of the journal  
Frontiers in Environmental Science

**Received:** 09 April 2022

**Accepted:** 10 May 2022

**Published:** 27 May 2022

### Citation:

Oláh J, Kasza G, Szabó-Bódi B,  
Szakos D, Popp J and Lakner Z (2022)  
Household Food Waste Research: The  
Current State of the Art and a Guided  
Tour for Further Development.  
Front. Environ. Sci. 10:916601.  
doi: 10.3389/fenvs.2022.916601

Decreasing food waste is an important contribution to the practical achievement of Sustainable Development Goals of the United Nations. The last decades witnessed a dynamic expansion of food waste-related publications, parallel with this studies, systematic reviews and bibliometric analyses had been published on this topic. The novelty of the current publication is threefold: 1) it summarizes recent publications, and puts their results into development context; 2) applies the triangulation method by analyzing the food waste-based literature from the aspect of epistemological development, structural composition and scientometric mapping, 3) based on in-depth research of the literature and the determination of the most important ways of its development, the key steps of a modern waste research project as a function of research goals as well as available financial resources are outlined. The bibliometric research based on nearly three thousand resources has shown a considerable geographic disparity in food waste research: these topics are investigated mainly in developed and emerging countries. Bibliometric mapping highlights the importance of the application of qualitative methods for exploring motivational drivers and actual behaviour of households. A general workflow for food waste research is suggested by the authors based on a study carried out in developed countries. This method can be considered as a general, flexible framework, which could serve as a common platform for experts. The framework can be used independently from the of economic development level of the countries but it is especially useful for researchers in the global South because experiences gained by developed countries opens a favourable possibility to conceptualise, plan, realise and publish their food-waste related research.

**Keywords:** household food waste, sustainability, bibliometrics, big data, prevention, consumer science

## HIGHLIGHTS

The household food waste-related literature is increasing exponentially.

The topic is dominated by the authors from the most developed states.

The science mapping method helps to identify key research areas and their dynamics.

Nearing to end of questionnaire era: increasing of the importance of qualitative methods.

## 1 INTRODUCTION

In the recent decades increasing (household) food waste-related publications were published. The contribution of the present study for the available literature is threefold: 1) it summarises recent publications and puts the results into a development context; 2) the article applies the triangulation method by analysing the food waste-based literature from the aspect of epistemological development, structural composition and scientometric mapping, 3) based on in-depth research of the literature and the determination of the most important ways of its development the key steps of a modern waste research project are

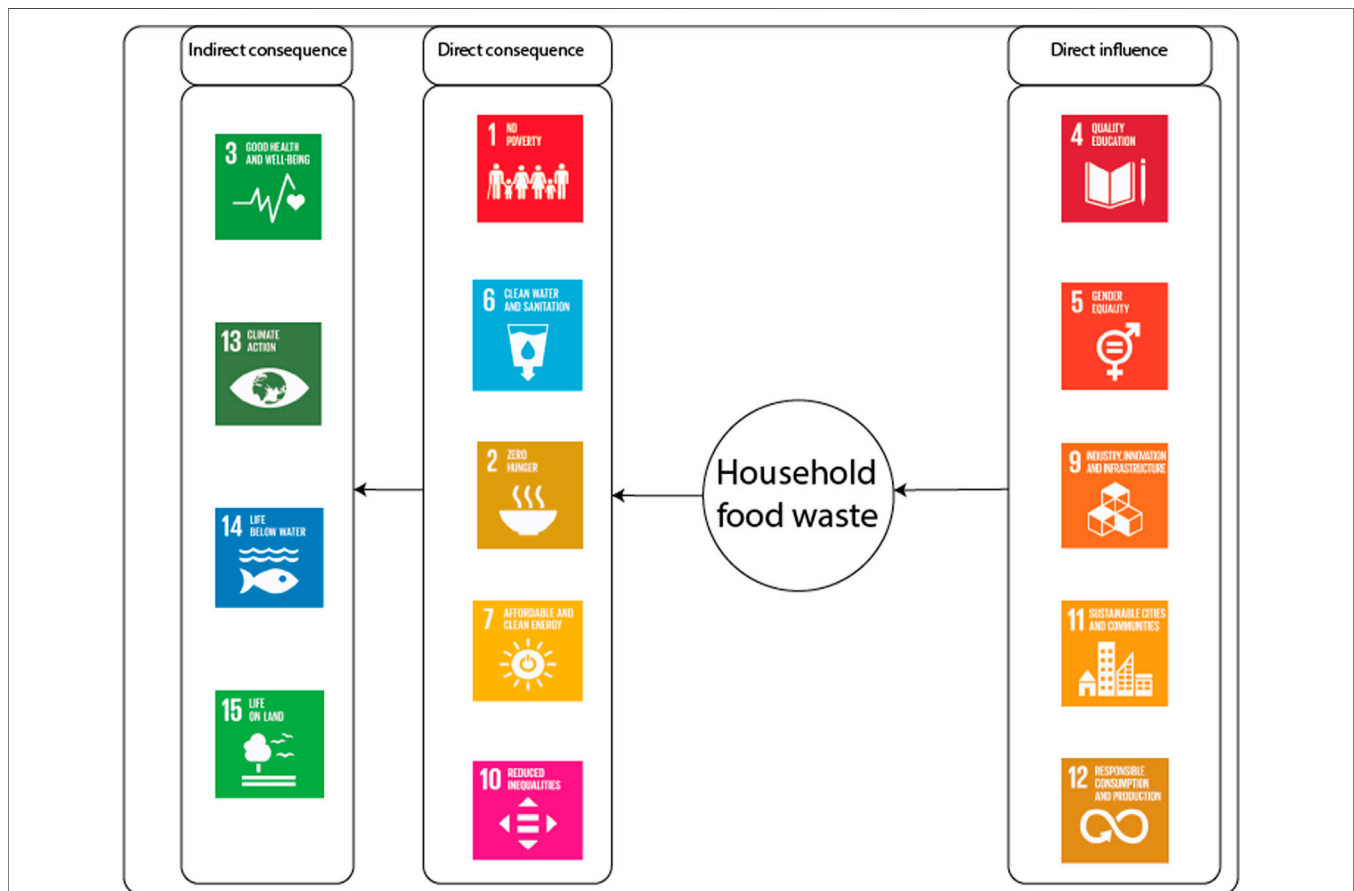
outlined as a function of research goals as well as available financial resources.

There is a close connection between food waste and the Sustainable Development Goals, declared by the United Nations (Grosso and Falasconi, 2018). The most important direct relationship between the Sustainable Development Goals and food waste demonstrates the direct and indirect effect of food waste on the long-range sustainability goals of the UN (Table 1; Figure 1).

UN SDG: Target 12—Sustainable Consumption and Production - requires not only the complete transformation of the use of natural resources, production technology, and consumer behaviour, but also the elimination of food waste at all stages of the food marketing chain (Bringye et al., 2021).

The problem of household food waste has been the subject of growing scientific interest. More and more publications are available on this topic, also including review articles (Cox et al., 2010; Lebersorger and Schneider, 2011; Bräutigam et al., 2014; Chen et al., 2017; Hebrok and Boks, 2017; Ingrao et al., 2018; Kibler et al., 2018; Schanes et al., 2018). The number of publications related to the factors influencing household food waste generation has also increased since 2000 (De Hooge et al., 2017).

According to the most recent estimate, a considerable proportion—approximately 53%—of global food waste is



**FIGURE 1** | Direct and indirect effects of food waste reduction on the achievement of the Sustainable Development Goals of the UN.

**TABLE 1** | Interactions between UN Sustainable Development Goals and food security.

| UN sustainable development goals    | Food security related aspects  |
|-------------------------------------|--|
| End poverty                         | Direct relation between reduction of food waste and alleviation of poverty Galli et al. (2019) |
| Zero hunger                         | Decreasing food waste contributes to the alleviation of hunger Arcuri (2019)                   |
| Improvement of quality of education | Food waste reduction should be an element in education Rennie (1995)                           |
| Access to energy                    | Decreasing food waste contributes to more rational energy consumption Melikoglu et al. (2013)  |

generated by households in the EU (FUSIONS, 2016). Based on the FAO's estimation, consumers are primarily responsible for food waste generation in economically developed regions (FAO, 2011). Thus, studies of consumer food waste were initially predominant in the highest income level countries, for example, in the United Kingdom and the United States (Schneider, 2013). Principato et al. (2015) have made an important contribution to a better understanding of the topics studied by the construction of a "Household Wasteful Behavioural Framework". Boulet et al. (2021), in their review, determined the factors influencing food waste in households. Household waste composition has been also analysed by several studies (Withanage et al., 2021).

There are significant differences between the results of studies using different methodologies. The estimated amount of household food waste was 76 kg per capita in Europe per year in the first years of the 21st century (BIOIS, 2011). The experts of the FUSIONS (Food Use for Social Innovation by Optimising Waste Prevention Strategies) project—as a follow-up of the BIOIS study, based on a slightly different methodology – reported 92 kg per capita household food waste in the EU-28 (FUSIONS, 2016). The calculated results published in this study are based on the EUROSTAT database of general animal and vegetable waste generation, officially reported by member states. In many cases, the authors of the above mentioned studies could also identify relevant national research reports, and used them to refine the statistically derived numbers. Nevertheless, due to the lack of research standards, the comparability and coherency of the national statistics are fairly limited (Bräutigam et al., 2014). However, it is certain that mathematical estimations based on officially reported "bio-waste" statistics could not give a detailed picture of household food waste by country. Consequently, research using primary methodology (surveys, waste logbooks, in-depth interviews, waste composition analyses, etc.) is the only way to gain accurate information about food waste at the household level.

The novelty of the study is that it investigates the issue of household food waste by bibliometric analyses based on the latest results, focussing on the determination of different research directions, in this way giving practical assistance to research policy decision makers and researchers in the

process of further investigations of this topic. On the basis of bibliometric analysis this study presents the major problems and stages of household-related food waste surveys in the form of a guided tour, review the most important, open-ended research questions, and key steps of research. The potential users of information, summarised in the current article can be (food waste) researchers and policy makers, especially in the developing world, who can set up their own research plans, adapting the experiences obtained in the developed states.

The structure of the current article is depicted in **Figure 2**.

## 2 METHODOLOGY

This study applies a combination of two leading academic literature databases: the Web of Science and Scopus. The mapping of the scientific literature was based on the Web of Science, because the coverage of this database is narrower compared to Scopus, allowing us to better focus on high-quality English publications (Aghaei Chadegani et al., 2013). On the other hand, we have used the Scopus database for the qualitative literature survey, due to the wider spectrum of publications covered by Scopus (Mongeon and Paul-Hus, 2016).

In the case of the bibliometric analysis the following search expression was applied:

$$TS = ((\text{"food waste*"})) \text{ AND } ((\text{"consum*"})) \text{ OR } (\text{"buyer*"})) \text{ OR } (\text{"household*"})) \text{ OR } (\text{"famil*"})) \text{ OR } (\text{"ménag*"}))$$

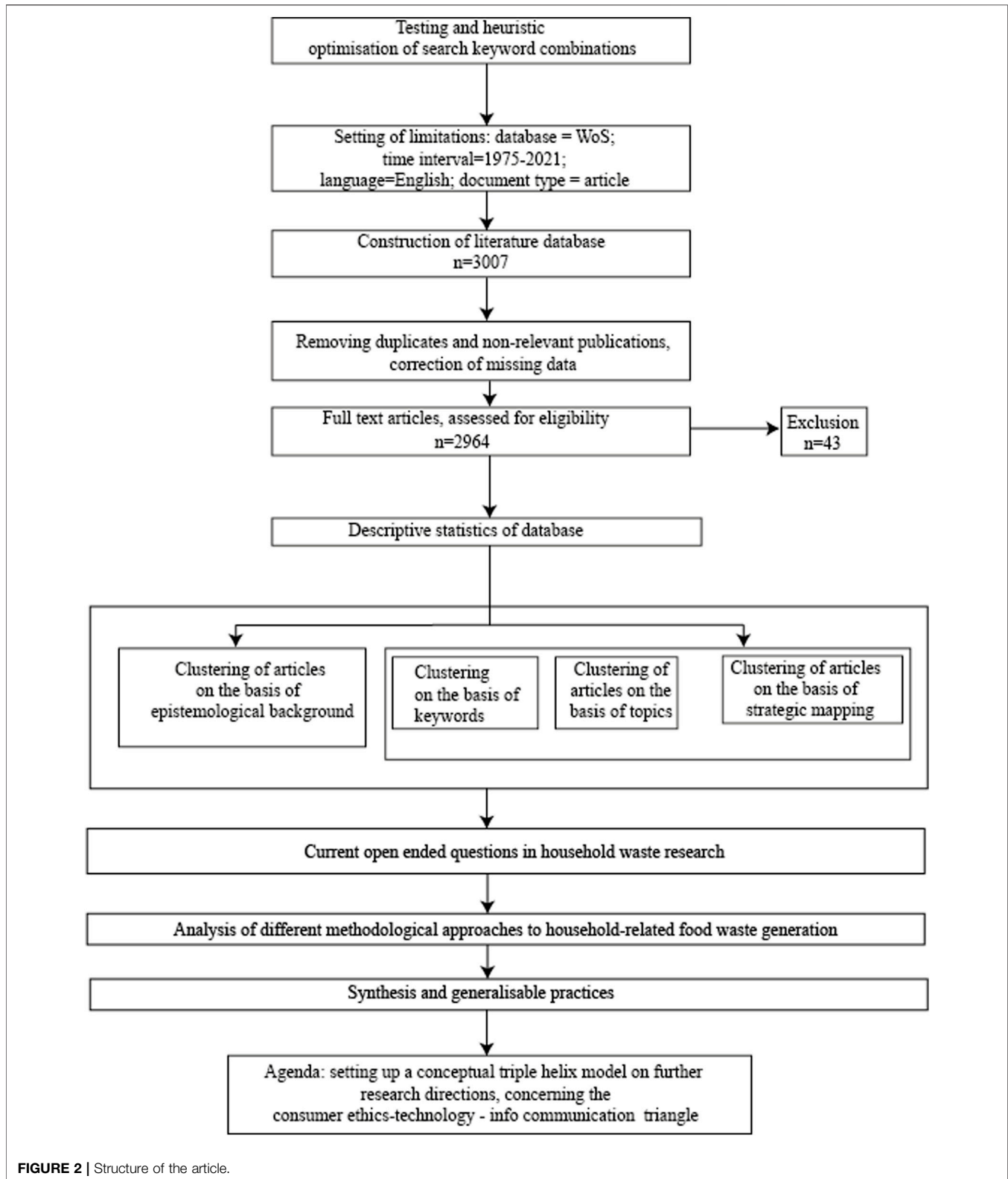
The time span of research was 1975–2012 (31.12), but the first publication appeared in the database in 1993.

Bibliometric analysis was conducted with the Bibliometrix R package (Derviş, 2019), following the general standards of bibliometric research (Guler et al., 2016).

The epistemological background of the problem has been analyzed by CitNetExplorer software, which was developed specially for these purposes (Van Eck and Waltman, 2014).

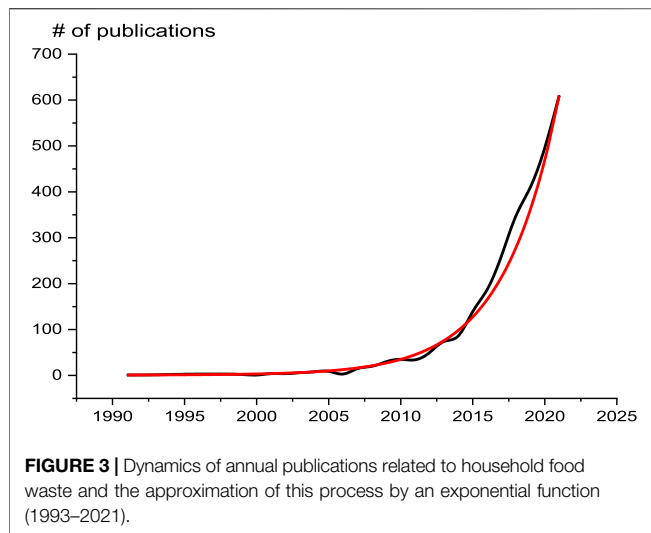
The clusters of different research concepts were analysed on the basis of the co-occurrence of words, by the VOS viewer tool (Arifin et al., 2021).

In the seminal paper by Cobo et al. (2011) the authors suggested a highly innovative approach to positioning different research topics, based on keyword clustering and then the positioning of clusters based on their intellectual space, determined by the centrality and density of different topics. Centrality characterizes the frequency of citations to a given topic, density the intensity of citations between different publications in the same topic cluster. According to the theory of Cobo et al. (2011), some topics are well developed and important. These can be characterised by a high degree of centrality and density. These are called motor themes. Some topics have intensive communication within the topics, but they are relatively poorly integrated into the larger research field. These topics are called specialised or peripheral topics, and can be characterised by high density



and low centrality. The emerging or disappearing topics have low centrality and density. Themes which are situated in the lower-right quadrant are highly cited, but the

intensity of communications within these topic clusters is relatively low. These themes are called general or basic themes.



We have applied this method to determine the most important themes of the research field. For a better understanding of the development of the topics, we have divided the set of publications into three parts, based on an algorithm for the determination of brake points in a time series, calculated by the generic algorithm of (Doerr et al., 2017). On this basis we have divided the time interval into three periods: 1993–2016, 2017–2018, 2019–2021.

## 3 RESULTS

### 3.1 General Characteristics of the Bibliometric Database

The set of results consisted of 2,964 resources. Analysing the dynamics of the increasing number of publications related to household-food waste, it is obvious that this topic has gained in importance rather rapidly (Figure 3). Between 1993 and 2016 only a few publications analysed this topic; later, the number increased sharply. The number of publications can be approximated by an exponential function. This highlights the increasing importance of this topic in academic research. At the same time, it underscores the rapidly growing public attention towards this problem. Although the food waste problem is quite serious in developing regions, the most important attention is paid to it in developed countries.

The number of authors is relatively high: more than 9,000 researchers analysed this problem in the time interval under investigation. The food waste problem demands a concentrated effort of different specialists. This fact explains why the number of single authored papers is relatively low: no more than 0.5% of the total relevant papers have been written by a sole author. The number of authors per document is on average 3.23. The structure of the journals, which can be considered the most relevant sources shows similar tendencies, which can be seen in another field of science and technology: the Journal of Cleaner Production and Waste Management, as well as Resources Conservation and Recycling have important positions, but there are numerous

new channels of food waste related communication: Sustainability, Foods and Energies.

The most important authors on food waste are those from developed countries. The number of publications on household food waste shows that this field is dominated by the United States and Western-European countries (Table 2). Among developing and emerging countries, only China is worth mentioning. The level of international collaboration is moderate, with some exceptions (China, United Kingdom).

If we measure the influence of different countries based on the number of citations, it can be seen that developed countries dominate this field, too (Table 3). The average number of article citations from the United Kingdom and Denmark, as well as Sweden, is extremely high. This fact highlights the level and trend-setting character of these publications.

## 3.2 Clustering of the Topics

### 3.2.1 Clustering Based on Epistemologic Development

The epistemological structure of household food waste research reveals its intellectual roots and the paths it has followed.

The total number of citation links in the corpus was 32,937. Based on their relationships, four groups could be identified. The first group is the largest. This group of publications consisted of 1777 publications. The second largest group had 970, the third 212, and the fourth 432 papers, respectively. The database included the non-matching cited references, and cited references with at least ten citations were included in the citation network. The publications were clustered on the basis of citation links. The resolution parameter was set to one, and the minimum cluster size to one hundred. In this way four clusters were identified. 434 publications did not belong to a cluster.

The first cluster consisted of publications focusing on general problems of food waste in the food chain and on consumer behaviour. The second cluster included studies on the utilization of food waste for energetic purposes. Minimizing food waste by changing consumer behaviour was the key topic of the third cluster. The fourth cluster consisted of publications focusing on non-energy related utilization of food waste.

In summary it can be concluded that the majority of publications analysed the general problems of food waste in households, a relatively smaller set of publications focused on specific aspects of consumer behaviour concerning waste, and two clusters analysed food waste from the perspective of by-product utilisation.

### 3.2.2 Clustering Based on Co-occurrences of Keywords

The analysis of the co-occurrence of different keywords shows that two clusters can be separated, one focussing on consumer behaviour and one on different, mainly technological questions (Figure 4). The former cluster incorporates two main branches: one deals with behaviours, the other with determinants, namely barriers and attitudes. The cluster focussing on behaviour has some specific aspects in the field of quantification of wastes and analysis of consumer behaviour. The second large cluster also has two parts. One well separable part deals with the utilisation of

**TABLE 2** | Key characteristic features of international publications on household food waste.

| Country          | Number of articles | Frequency | Intra-country collaboration index | Inter-country collaboration index | Intra-and inter country collaboration ratio |
|------------------|--------------------|-----------|-----------------------------------|-----------------------------------|---|
| 1 United States  | 371                | 0.12990   | 315                               | 56                                | 0.1509                                      |
| 2 China          | 297                | 0.10399   | 191                               | 106                               | 0.3569                                      |
| 3 Italy          | 252                | 0.08824   | 197                               | 55                                | 0.2183                                      |
| 4 United Kingdom | 246                | 0.08613   | 150                               | 96                                | 0.3902                                      |
| 5 Spain          | 115                | 0.04027   | 77                                | 38                                | 0.3304                                      |
| 6 Sweden         | 102                | 0.03571   | 71                                | 31                                | 0.3039                                      |
| 7 Australia      | 94                 | 0.03291   | 68                                | 26                                | 0.2766                                      |
| 8 Germany        | 91                 | 0.03186   | 61                                | 30                                | 0.3297                                      |
| 9 Canada         | 88                 | 0.03081   | 64                                | 24                                | 0.2727                                      |
| 10 Denmark       | 77                 | 0.02696   | 38                                | 39                                | 0.5065                                      |
| 11 Korea         | 73                 | 0.02556   | 47                                | 26                                | 0.3562                                      |
| 12 Netherlands   | 62                 | 0.02171   | 39                                | 23                                | 0.3710                                      |
| 13 France        | 60                 | 0.02101   | 43                                | 17                                | 0.2833                                      |
| 14 Brazil        | 59                 | 0.02066   | 44                                | 15                                | 0.2542                                      |
| 15 India         | 59                 | 0.02066   | 46                                | 13                                | 0.2203                                      |
| 16 Japan         | 49                 | 0.01716   | 25                                | 24                                | 0.4898                                      |
| 17 Greece        | 47                 | 0.01646   | 41                                | 6                                 | 0.1277                                      |
| 18 Malaysia      | 44                 | 0.01541   | 38                                | 6                                 | 0.1364                                      |
| 19 Poland        | 44                 | 0.01541   | 37                                | 7                                 | 0.1591                                      |
| 20 Norway        | 42                 | 0.01471   | 29                                | 13                                | 0.3095                                      |
| 21 Switzerland   | 35                 | 0.01225   | 25                                | 10                                | 0.2857                                      |
| 22 Portugal      | 34                 | 0.01190   | 22                                | 12                                | 0.3529                                      |
| 23 Turkey        | 34                 | 0.01190   | 30                                | 4                                 | 0.1176                                      |
| 24 Taiwan        | 31                 | 0.01085   | 23                                | 8                                 | 0.2581                                      |
| 25 Iran          | 28                 | 0.00980   | 17                                | 11                                | 0.3929                                      |
| 26 Austria       | 27                 | 0.00945   | 16                                | 11                                | 0.4074                                      |
| 27 Finland       | 27                 | 0.00945   | 19                                | 8                                 | 0.2963                                      |
| 28 New Zealand   | 21                 | 0.00735   | 13                                | 8                                 | 0.3810                                      |
| 29 Romania       | 21                 | 0.00735   | 15                                | 6                                 | 0.2857                                      |
| 30 Belgium       | 18                 | 0.00630   | 13                                | 5                                 | 0.2778                                      |

**TABLE 3** | Number of citations of articles from different countries.

| Country          | Total citations | Average article citations |
|------------------|-----------------|---------------------------|
| 1 United Kingdom | 8,664           | 35.22                     |
| 2 United States  | 8,251           | 22.24                     |
| 3 Italy          | 6,404           | 25.41                     |
| 4 China          | 6,268           | 21.10                     |
| 5 Denmark        | 3,535           | 45.91                     |
| 6 Sweden         | 3,483           | 34.15                     |
| 7 Germany        | 2,209           | 24.27                     |
| 8 Spain          | 1,997           | 17.37                     |
| 9 Canada         | 1,849           | 21.01                     |
| 10 Australia     | 1,819           | 19.35                     |

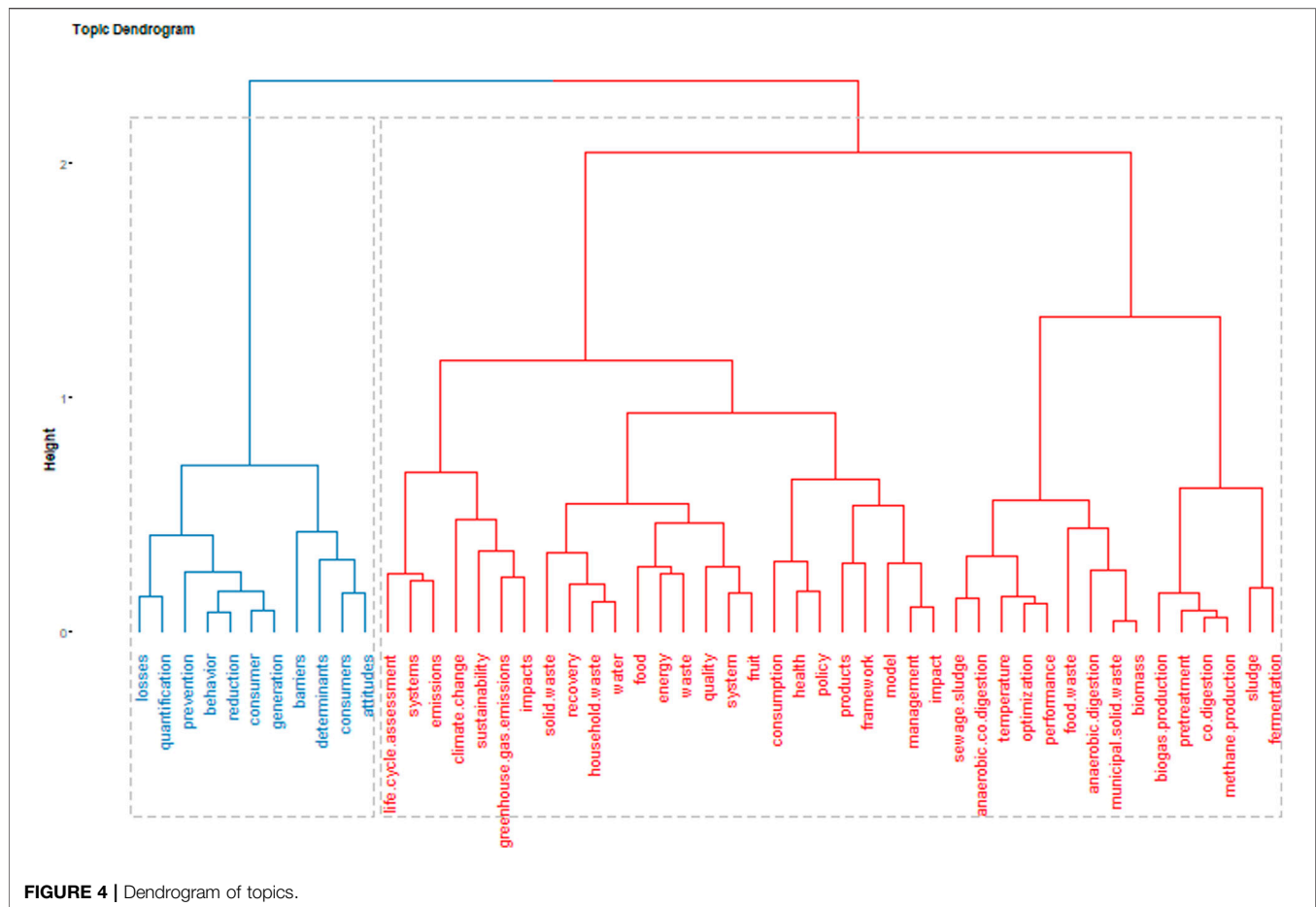
food waste as biomass, with one part of this sub-cluster focusing on biogas-production and the other on waste-water utilisation.

The second sub-cluster is a rather complex one and includes different branches. One important branch focuses on the effect of food waste based on life-cycle analysis, system dynamics and emission reduction. Another branch analyses this problem from the perspective of sustainability and climate change. The largest sub-cluster is a relatively heterogenous one. One part studies the food technological aspects of decreasing food waste, while the other investigates the environmental aspects of food waste.

The structure of different research directions was analysed by the clustering of the co-occurrence of keywords. Results of this analysis are summarised in **Figure 5**.

The first cluster is dominated by consumer related behaviour focussing on the attitudes to and management of household food logistics. The most important keywords are management, sustainability and behaviour. Specific attention is given to the prevention of food waste and barriers to food waste reduction. The second cluster focusses on the utilisation of food waste, mainly by biogas production. Consequently, the most important keywords in this cluster are anaerobic fermentation, sewage-sludge mixture and co-digestion. The third cluster put an emphasis on the realisation of a circular economy by the recovery and re-use of food waste.

Life-cycle analysis and municipal waste-logistics problems as well as emissions reduction are at the centre of the fourth cluster, which embraces the different aspects of questions related to food waste from the viewpoint of regional management and city logistics systems. The fifth cluster evaluates the problem of healthy eating and nutrition. In this cluster food waste problems appear in relation with leftover food and irrational, unhealthy food consumer behaviour, followed by obesity and interventions aiming at the education of future generations. The sixth cluster focusses on global problems related to food waste with regard to the energy-food-nutrition triangle.



### 3.2.3 Dynamics of Research Topics

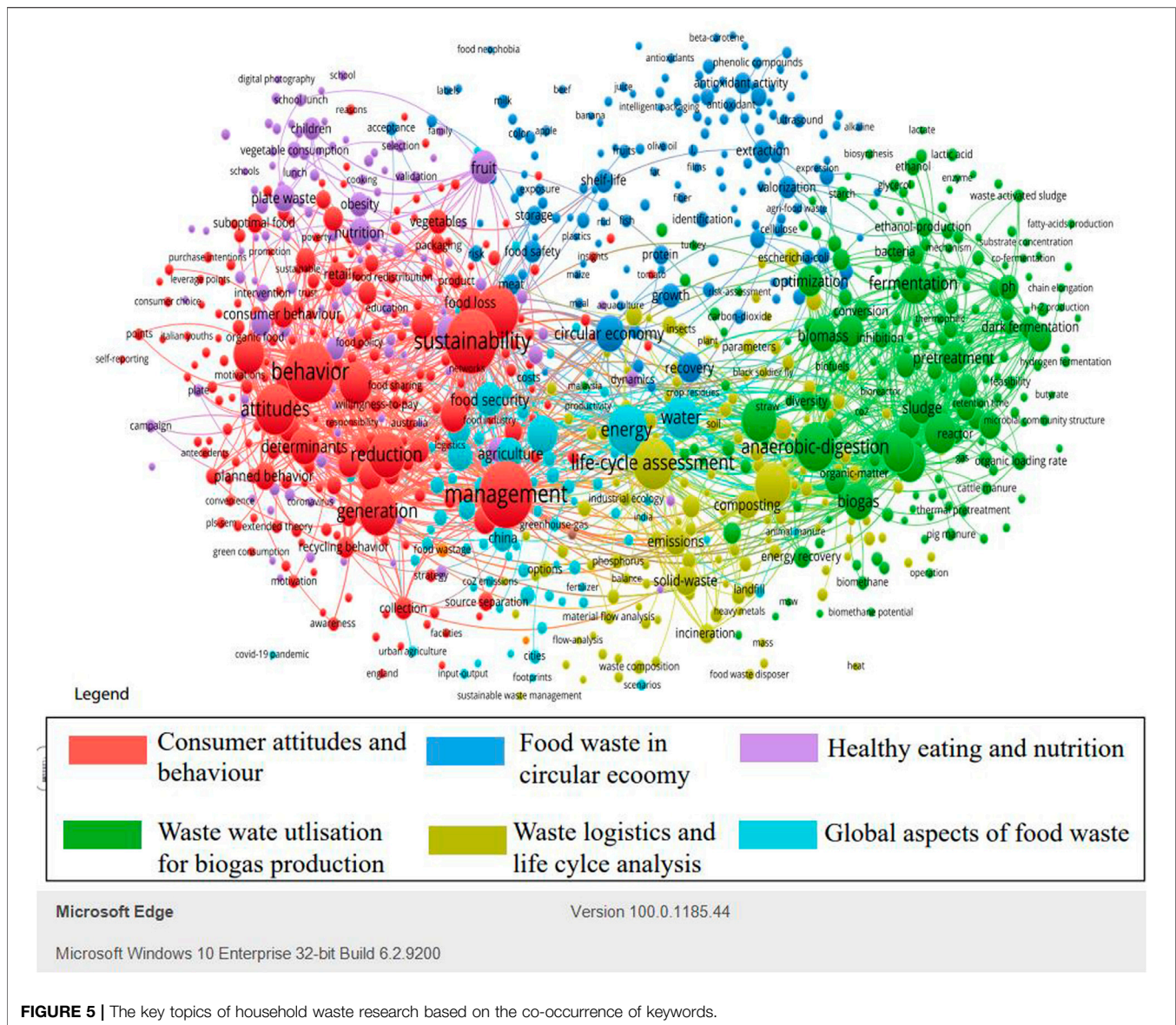
The relative position of different themes highlights the fact that in the first period (1993–2016) the most important topics with a high level of centrality and density were the global food shortage, the adverse consequences of food waste on the efficiency of the agro-food chain and the disposal of leftover food (**Figure 6**). In this period food shortages were a relatively new phenomenon, therefore the simple description of the problem gained considerable attention. Other topics are related to technological solutions for the disposal of leftovers or energy technology.

Surveys of household behavior or the system analysis of the energy-water-climate triangle were relatively new, emerging technologies at this time. Interestingly, in the early period of food waste research leftovers in catering systems, the human energy balance and the relationship between healthy eating and the irrational use of food were relatively peripheral topics. Several authors analysed these problems without integrating them into the available knowledge on food waste.

The second period can be characterized by considerable changes in the relevant topics (**Figure 7**). Food waste disposal, the place and role of municipalities and the different packaging systems were the basic topics, with a high level of citations. In the

late 2010s these fields of knowledge formed the foundations of food waste research. The increasing understanding of the role of suboptimal food purchase as a factor in environmental burden promoted the introduction of new methods into household food waste research (e.g. the wide ranging application of video systems and in-depth interviews, as opposed to the traditional methods of paper and pencil surveys). These new, highly innovative approaches are based on the application of modern methods of info-communication systems. At the same time, the conversion of food waste to bioenergy remained a central topic. In this period “outsider” researchers into food waste started to appear, which can be explained by the emergence of mathematical methods (e.g., operational research and new technologies for the re-use of food waste). As a consequence of the widening interest towards the problem of food waste, some more specialized groups of researchers formed. Some of them began to apply more sophisticated statistical methods (above all structural modelling equations), alongside research into the further development of food technology and the optimization of portion sizes. At this time these fields of science were relatively separated, with an island-like phenomenon.

In the last few years (**Figure 8**) there has been a considerable synthesizing work of the accumulated knowledge. Some techniques



become routine. The PLS-SEM models got an increasing importance. Of course, the Covid-19 pandemics caused a new situation in food consumption patterns, which is a new topics in waste-research, too.

### 3.3 Practical Problems of Food Waste Research—A Guided Tour

On base of the bibliometric analysis there is a possibility to outline the most important steps of preparation of a household food waste survey.

#### 3.3.1 Current Problems of the Research

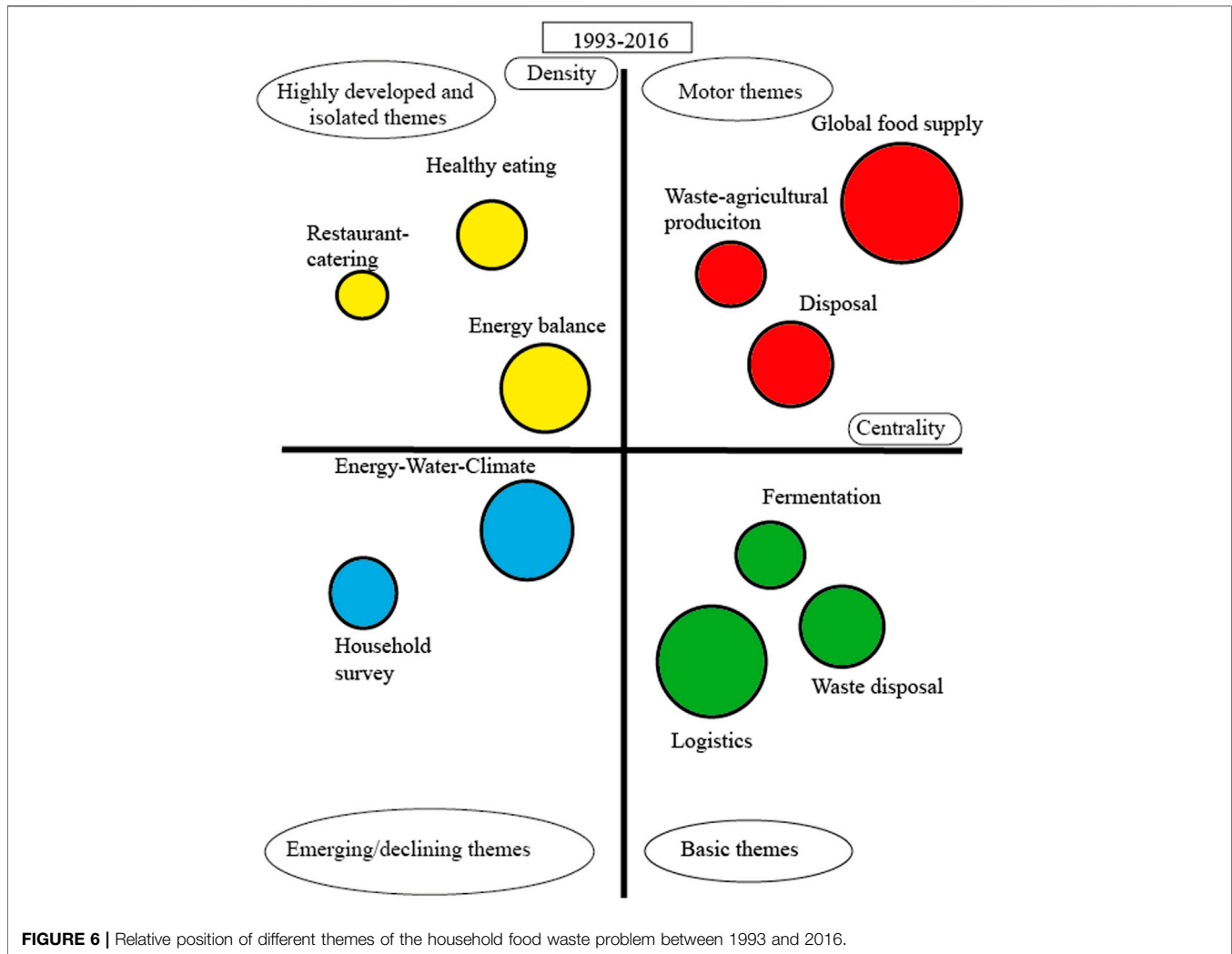
As we have seen, the generation of household food waste is a highly complex question. First of all it is useful to analyse its causes. On base of the literature, we have set up a general, conceptual model, depicted in **Figure 9**.

On base of this model in the next paragraphs we outline the most important known and unknown parts of the different components.

##### 3.3.1.1 Cognitive Components

Related to cognitive components, the observation made by researchers is that a significant proportion of consumers are unable to recognise the existence of the food waste-related problem itself (Graham-Rowe et al., 2014; Withanage et al., 2021). The explanation for this is the lack of immediate and direct personal benefit if consumers reduce their waste generation (Quested et al., 2013). Furthermore, they do not receive positive feedback from their residential environment i.e. the next door neighbour does not actually see their efforts to prevent food waste generation. Therefore, it is difficult to rationalize their food waste prevention behaviour.





According to Aschemann-Witzel et al. (2015), certain positive social norms, such as the appearance in restaurants of so-called doggy-bags to take left-over food home, support conscious consumers in their attempts to avoid generating food waste.

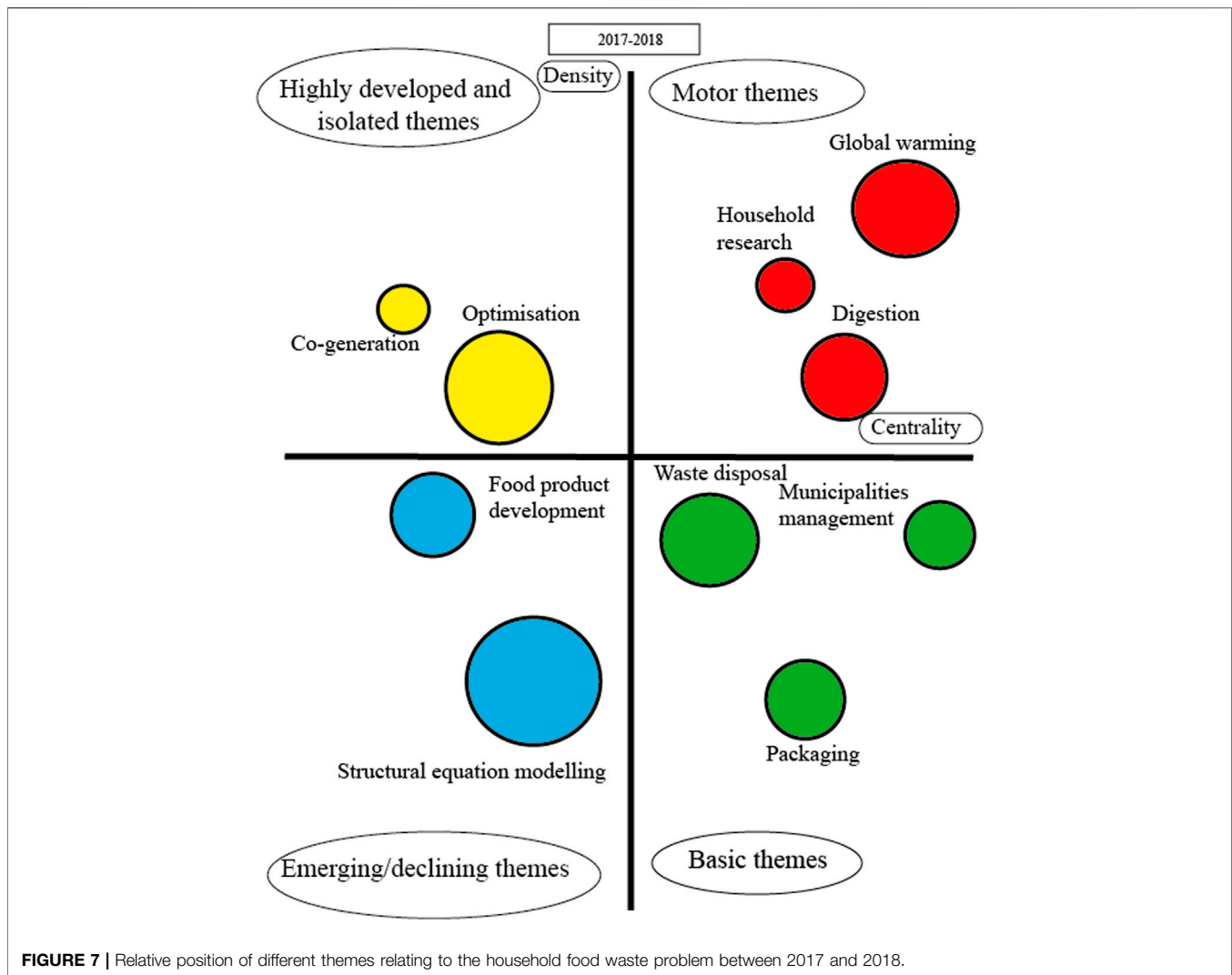
Another interesting cognitive component that relates to food waste is the overestimation of food safety risks resulting from long-term food storage. In most of the cases, this perception is due to consumers' lack of knowledge on food safety. The overestimation of risks is visible in their behaviour and practices, as well. Therefore, a lot of safe food is wasted for no conceivable reason. Research in this area goes back as far as the 1980's.

In the United States, Van Garde and Woodburn (1987) proved that participants' evaluation of food safety is incorrect, based on their experiment with 243 households. Lanfranchi et al. (2016) confirmed that concerns about food safety risks definitely also contribute to the production of food waste.

Similarly, the misinterpretation of the terms "Use-by date" and "Best before date" leads to food waste. The "Use-by date" is a food safety indicator, showing the last day a perishable product (e.g., a dairy product) is safe to consume, while the "Best before

date" is a quality indicator, reporting the date when a durable product (e.g., canned food) may lose some of its quality (DG SANTE, 2016). While foods cannot be legally sold after a "Best before" date, they can be consumed for a certain period as long as they are not damaged, although this 'safe period' is different for each item. Therefore, food experts face difficulties in producing a labelling system with relevant additional information for the different types of foodstuff (Whitehead et al., 2013). Field-related research points out that consumers are unable to distinguish between the "Use-by date" and the "Best before date." For them, both terms are related to food safety. This misinterpretation, rooted in a lack of knowledge, can lead to excessive waste generation (Silvennoinen et al., 2014; Melbye et al., 2017).

In the United Kingdom, the WRAP (Waste & Resources Action Programme) investigated the use of resealable packages to protect food products and maintain their freshness, and found that consumers ignore using this function as they are unaware of the benefits that packaging can offer, which again may be explained by their lack of knowledge of food waste prevention. Unsealed food loses its freshness, appetising looks and quality.



**FIGURE 7** | Relative position of different themes relating to the household food waste problem between 2017 and 2018.

Therefore, especially in single-person households, it contributes to food waste, as a packaging unit is not consumed as fast as in large households (WRAP, 2013).

### 3.3.1.2 Affective Components

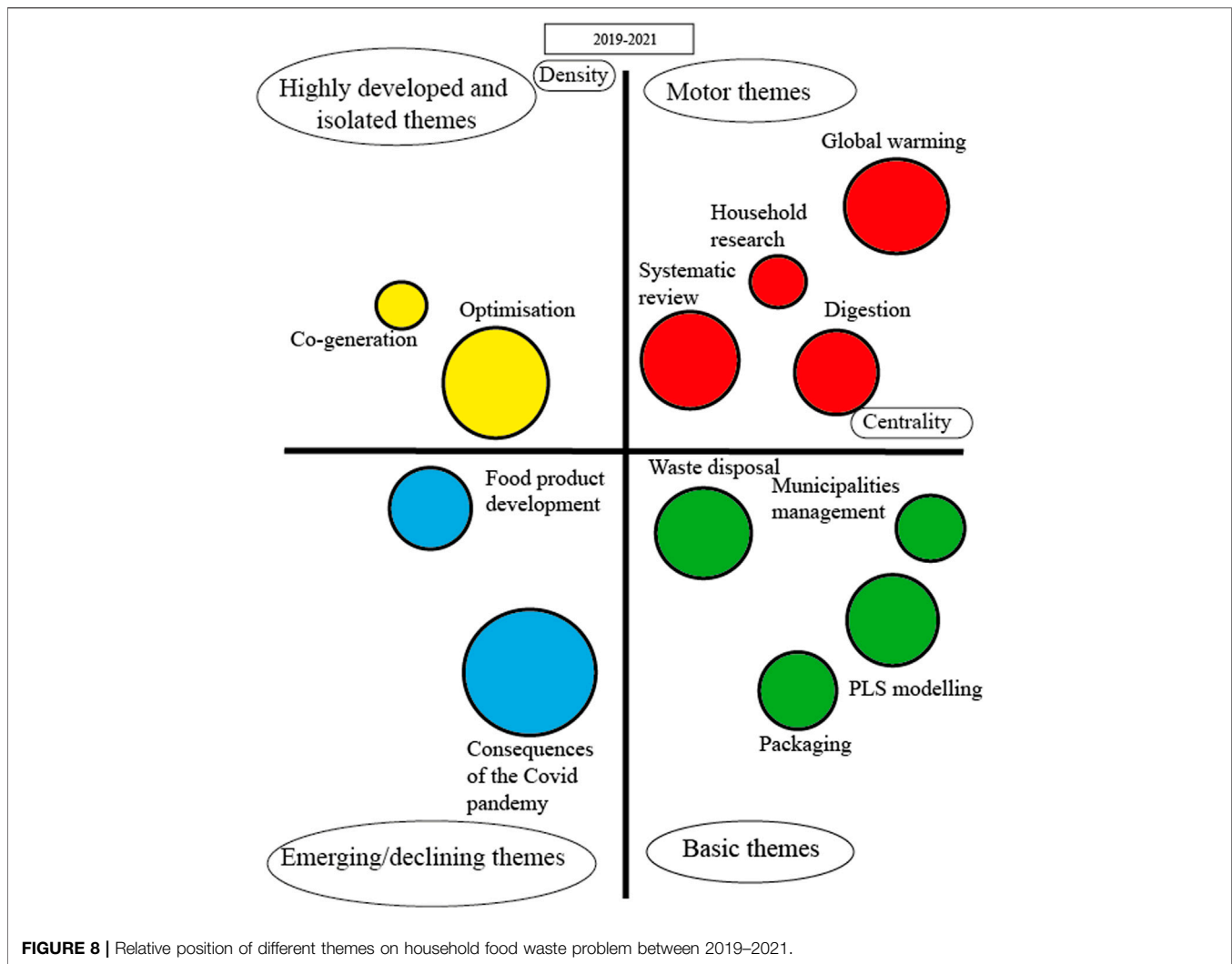
In their study, Graham-Rowe et al. (2014) focus on mapping the connection between the affective attitude components and actual food consumption habits (motivational vs. impeding factors in reducing food waste). Their results demonstrate that consumers are generally aware of the negative consequences of food waste generation, and they are worried because of this. Maintaining a personal comfort zone, i.e. having an extra food supply stored, is one of the most important problems.

A Greek survey, involving 231 respondents, confirms the positive attitude of consumers in preventing food waste generation, which, however, does not materialise in action, as the majority of respondents shop on impulse and, in addition, they are 'label ignorant' in many ways (Graham-Rowe et al., 2014). It is pointed out in a Belgian review study, that in our century people have no respect for food and consequently, they

do not value it (Beaufort, 2014). Several studies observed the lack of consumers' positive attitude in relation to food as a factor influencing food waste generation (Evans, 2012; Grandhi and Appaiah Singh, 2016; Stancu et al., 2016). This can be the primary cause of consumers' lack of a conscious handling of food. It was found in a Norwegian survey that people who are concerned about the environment also condemn food waste (Melbye et al., 2017; Ingraio et al., 2018).

### 3.3.1.3 Conative Components

Research has identified consumers' shopping habits, particularly their way of shopping, as a primary influencing factor. Evans (2012) and (Principato et al., 2015) proved that list-based, conscious shopping can reduce food waste. The role of "ad hoc" or impulse shopping in food waste generation was also confirmed by a Finnish research team in the same year in a detailed and comprehensive analysis of 380 households (Koivupuro et al., 2012). These results are consistent with some other quantitative consumer surveys (Stefan et al., 2013; Jörissen et al., 2015). According to the



**FIGURE 8** | Relative position of different themes on household food waste problem between 2019–2021.

research of Qi and Roe (2016), purchasing bulk products also contributes to food waste generation. The importance of making a shopping list is emphasised by a recent survey involving 233 students.

Presumably, shopping habits and perception are related to the packaging of certain types of food items and their ‘fresh look’. This phenomenon is especially manifested in the case of bread and roll products, based on the results of a Czech primary research study (Sulaiman et al., 2016).

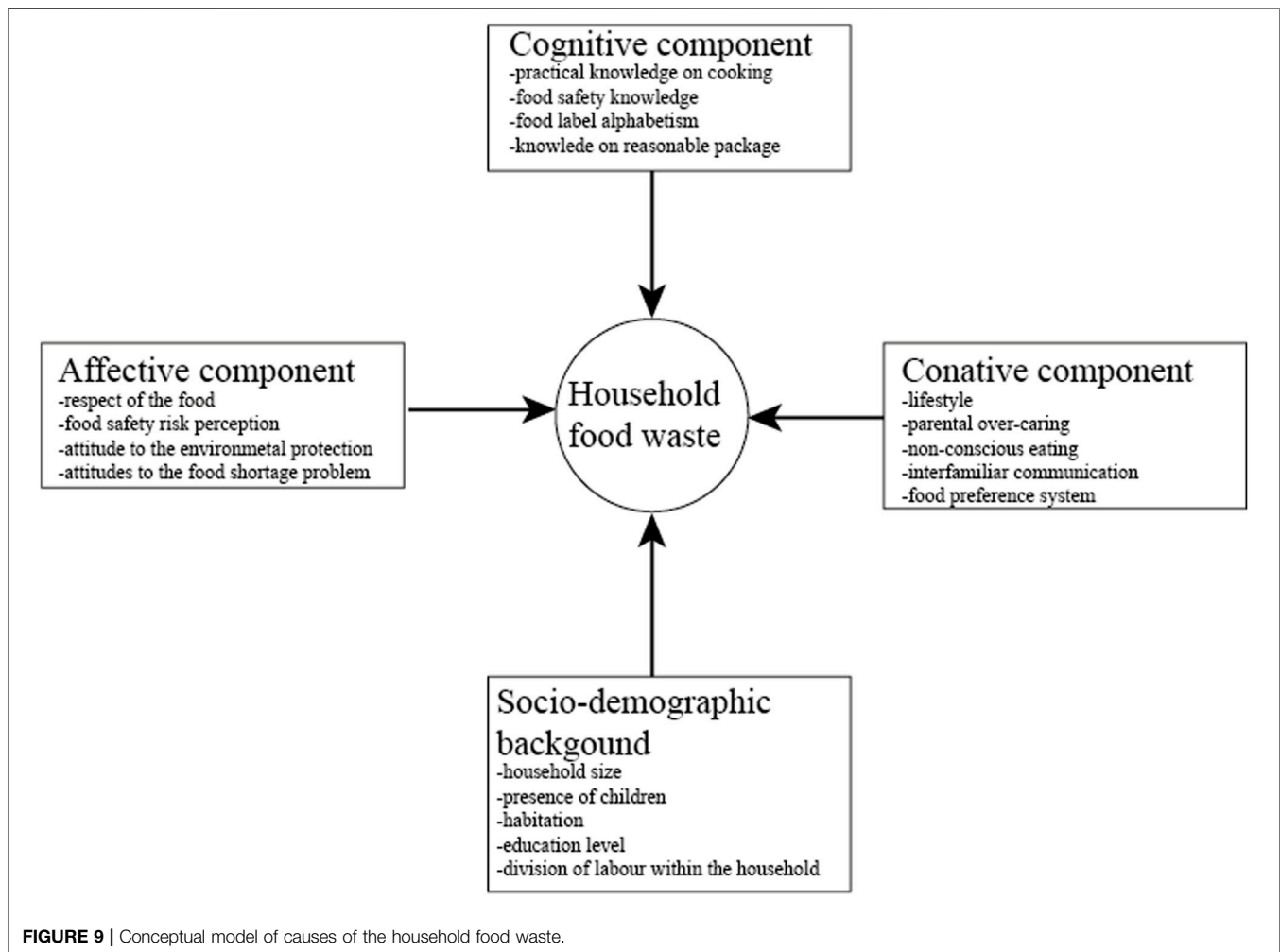
In a shopping situation, in addition to the aesthetics of food presentation, the psychological effect of price reduction is also important. Experts note that when seeing the vast array of products on sale, consumers tend to misjudge their need for their food supply, which in the case of perishable foods may lead to waste (Koivupuro et al., 2012; Aschemann-Witzel et al., 2015; Chan, 2022).

Another factor linked to shopping habits is packaging. A Swedish study points out that 20–25% of food waste can be related to packaging, particularly to the size and form of containers (Williams et al., 2012).

Shopping and domestic food storage habits are directly related. Some studies have shown that inappropriate food storage practices lead to the decay of both perishable and durable food (Chappell, 1954; Quedstedt et al., 2013; Masson et al., 2017). In the case of perishable food, it is the unpleasant smell that draws the consumer’s attention to the process of decay, while durable food is usually detected during ‘spring cleaning’.

A subsequent, field-related study reached the same conclusion (Jørisen et al., 2015). An Austrian-British study, based on in-depth (in-home-tour) interviews, revealed interesting consumer observations (Ganglbauer et al., 2013). In this study, one of the respondents reported a conscious arrangement of food while striving for ‘transparency’ in the storage area. He uses jars and glass containers at home to store muesli, rice or flour, which makes it possible for continuous checking of supplies.

Cooking is another factor that can lead to food waste generation. In his sociological study, Evans (2012) emphasises that the differences in cooking practices between nations, in terms of basic ingredients and methods used, can be observed in families belonging to the same nation, as well. Cooking



practices, as well as other beliefs and perceptions are transmitted from generation to generation. Therefore, the role of family traditions cannot be ignored because a “bad” practice acquired in childhood and “routinised” along the years can be changed with more difficulty than abandoning habits formed later at some stage in the individual’s life. On the contrary, in other cases, the problem itself is that the transmission of cooking practices does not take place within the family.

More important than recycling is the prevention of food waste through amount control. Graham-Rowe et al. (2014) used in-depth interviews (15 households) to identify the factors that impede food waste prevention. Their results reveal that the cause may be parents’ (most notably mothers’) endeavour to provide their families and visiting guests with good quality and plentiful food (preferring fresh food to canned food). With this attitude, parents would like to avoid unpleasant situations and possible family conflicts arising from shortage of supply. All this leads to surplus in cooking and eventually to food waste. This practice was confirmed by research on cooking habits conducted in the 2000’s (Ganglbauer et al., 2013; Stefan et al., 2013; Jörissen et al., 2015).

National eating traditions and the eating habits act as a different parameter in research on food waste. While it often roots in national culture, according to a comparative study on the Scandinavian states, the eating traditions of Nordic people are considerably influenced by global trends Gjerris and Gaiani (2013), and it is probably true for all developed countries. Besides the eating traditions, the eating habits are also important: Evans (2012) conducted an extensive investigation on the changing patterns of eating habits in families.

A question of practical nature relates to unconsumed food left after eating, known as “plate waste” in field-related research. In a study by Silvennoinen et al. (2014) based on factual assessment, irresponsible eating habits were also identified as a predictor of the quantity of food waste generation. These findings were equally confirmed by a primary study from the United Kingdom (Van Garde and Woodburn, 1987). An interesting approach to the question of plate waste is that Australian consumers sometimes produce plate waste to avoid extra kilograms (Hoek et al., 2017). According to some recent studies, practice of meal planning actually contributes to the minimization food wastage level in the households (Quested et al., 2013; Stefan et al., 2013; Mallinson et al., 2016).

Overall, the lifestyle of the members of a household has a considerable impact on food waste generation, especially the lifestyle of the person responsible for shopping and cooking and the amount of time they can afford to plan the family menu (Ghafoorifard et al., 2022). The fast pace of life as generator of food waste is present in many publications following the changes in lifestyle (Ganglbauer et al., 2013; Jørisen et al., 2015; Ferro et al., 2022).

According to experts Aschemann-Witzel et al. (2015), in case of urban dwellers, the connection between the suppliers of raw materials for food industry and consumers is practically non-existent (Lakner and Baker, 2014; Barma and Modibbo, 2022). Therefore, consumers find it difficult to visualise the amount of work required for food production. Aschemann-Witzel et al. (2015) stressed that if consumers had food-production knowledge, they would learn to appreciate the value of foodstuff. This is confirmed by earlier findings. For example, an Austrian consumer reports that they have learned to value foodstuff more since they produce it. It is also typical that households composting biodegradable waste regularly throw out less food compared to consumers who disregard this opportunity (Yepsen, 2009). In contrast, Tucker and Farrelly (2016) stated that the practice of composting usually reduces consumers' motivation for food waste prevention.

Consequently, it may seem that active participation in food production can strengthen consumers' food related perceptions and positive attitude.

### 3.3.1.4 Socio-Demographic Background

Researchers differ in their views on the impact of consumers' socio-demographical background on the amount of food waste generation. For many of them, it is self-evident that the income of the household influences the amount of waste. However, some studies could even prove statistically the positive correlation between the income of the households in question and the amount of food waste they produced (Schneider and Obersteiner, 2007).

According to Milanovic (2013), this phenomenon can be explained by the fact that 3 or 4 decades ago income inequality around the world was not as substantial as it is nowadays, therefore, the role of income as a differentiating factor was less significant. Still, there are examples for uncorrelation between income and waste production (Koivupuro et al., 2012; Williams et al., 2012). In addition, an interesting result in this field is that an Italian survey from 2016 examined this topic in depth and presented that mid-to-low income consumers waste more food than people with higher income in the case of products with lower price and quality (Setti et al., 2016). Thus, it can be said that the predictive role of income in the amount of food waste generation is not exactly clear.

Results concerning the size and composition of households are contradictory, as well. It was proven earlier that larger households with several members produce more waste in total, but in terms of waste per capita single-person households lead a more wasteful lifestyle. It has been also observed that children under the age of 16 produce a disproportionately high amount of waste (WRAP, 2014; Jørisen et al., 2015). The waste-avoidance attitude of the

older generation originates in the post-war period when they had to learn to economise relying on scarce resources. A study on food waste thus refers to consumers above 60 as "the post-war generation" (Schneider, 2008). However, Koivupuro et al. (2012) did not find any statistically provable correlation between the distribution of age in households and the amount of food waste they generated.

The gender of the person responsible for shopping can also influence the degree of wastage. It is claimed parents' (most notably mothers') excessive care to provide for their families often leads to overstocking supplies (Graham-Rowe et al., 2014). Wassermann and Schneider (2005) found that in case of jobs requiring high education, the burden of responsibility and the desire to meet the requirements of the position need a considerable amount of time, which is taken away from household management. Therefore, high education can indirectly lead to waste generation.

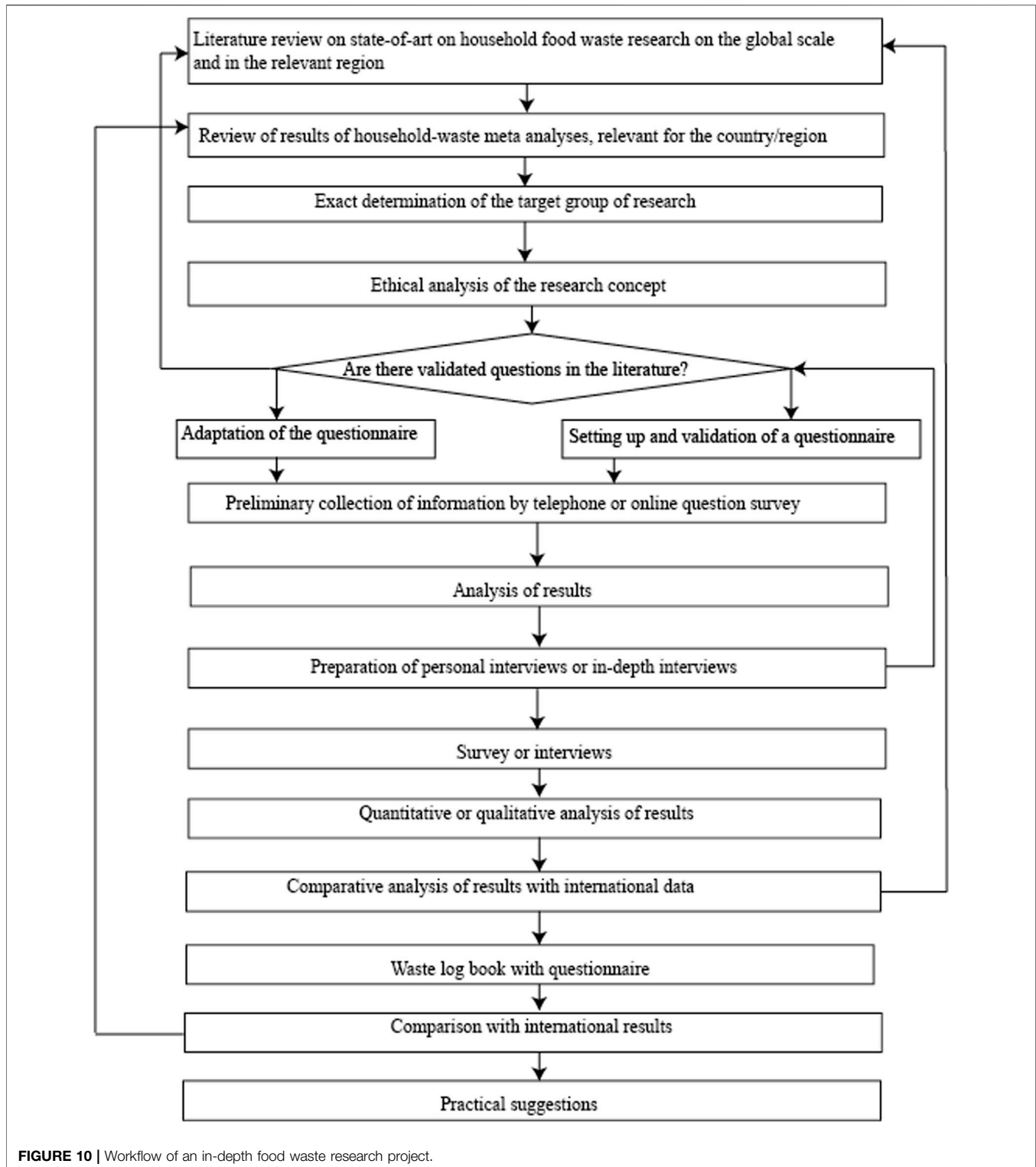
Lebersorger and Schneider (2011) found relevant difference between them. Norway experts also proved that food wastage level is higher in the urban region than in the rural area (Hanssen et al., 2016). In addition to the influence of urban or rural areas, (Koivupuro et al., 2012; Ganglbauer et al., 2013) surveyed the type of residence (e.g. detached house, flat on a housing estate), but did not find any significant correlation in this respect, either. According to Ganglbauer et al. (2013), residents in certain urban areas do shop more consciously and in the case of large households more food waste is generated due to the greater storage capacity at their disposal. This result may seem rational; however, it is qualitative in nature because it reflects the opinion of a reduced number of consumers only.

### 3.3.2 Practical Research Steps in Food Waste Research

The most important phases of the research workflow are outlined in **Figure 10**.

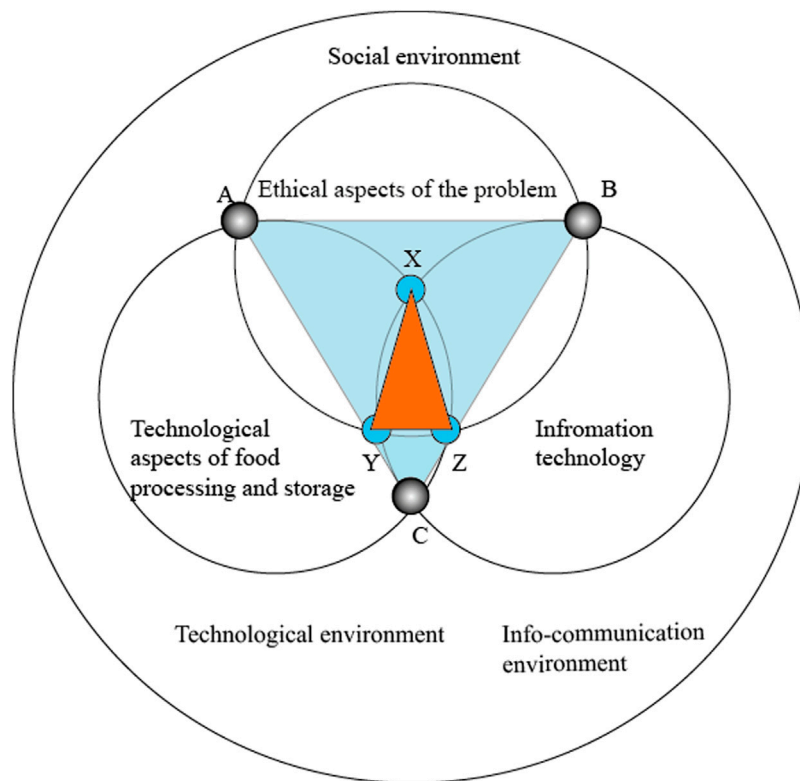
The most commonly used method is the quantitative consumer survey in the field of household food waste research. Within this category, a relatively new, but frequently used research tool in this field is the application of online questionnaires and telephone surveys (Jørisen et al., 2015; Qi and Roe, 2016). Classical quantitative consumer surveys provide an appropriate sample size, but respondents usually give general, socially accepted answers even in anonymous questionnaires. Therefore, conclusions will most likely be distorted in a positive direction (Beretta et al., 2013).

Different kinds of combined methods are also a common practice in this research field within the examined period (Hanssen et al., 2016). The methodology of using a waste logbook and qualitative interviews—which include in-depth, in-home-tour or focus group interviews—is less widespread (Ganglbauer et al., 2013; Silvennoinen et al., 2014). The application of the self-report method resulting in a possible underestimation may prevent the exact analysis of the effect of social factors on food wastage (Parizeau et al., 2015). In addition, in-depth interviews involving households are applied to explore the complexity of this context (Ganglbauer et al., 2013; Graham-Rowe et al., 2014).



The wide range of assessment tools make the validation of the potentially influencing factors difficult and limit the identification of differences between nations (Reynolds et al., 2014). Moreover, their reliability and comparability are very limited (Lebersorger

and Schneider, 2011). It is important to highlight that the World Resources Institute (WRI) and FUSIONS teams have already published reports on the harmonization of food waste measurements (Tostivint et al., 2016; WRI, 2016).



**FIGURE 11** | The triple helix structure of factors influencing the development of food waste related policies.

## 4 CONCLUSION AND FUTURE REMARKS

The food waste problem has become an important research topic, consequently a considerable increase in academic knowledge base in this field was observed. The rapidly augmenting number of tools of research and analysis, and the increasing multidisciplinary nature of this problem offers the possibility to better understand the causes and consequences of food waste. At the same time, there are considerable gaps in our knowledge in this field.

The majority of studies has been conducted in developed countries, but the food waste is a significant issue in developing countries, too. According to the opinion of Thi et al. (2015) the stochastic relationship between the level of economic development and the per capita food waste can be approximated by a parabolic function, that's why the food waste in developing countries is relatively low, the number of people, living in the developing world makes this problem as an accoutre one, influencing the global food balance.

The food waste in emerging countries is an acute problem due to the rapidly increasing consumption of the elite in these countries driven by diverse motives, such as identity affirmation, self-expression, family-pride and hedonism as a self-esteem factor can be important generators of food waste (Soma, 2018; Li and Wang, 2020). Researchers in developing regions, especially in the global South are able to identify these expanding tendencies in their own countries. Besides over-

consumption of the elite some other problems can be also highlighted in these regions, such as under-developed food preservation technologies, challenges of the cold-chain and inadequate food hygiene knowledge, and their importance is increasing as a result of global warming. By using the 'Workflow of an in-depth food waste research project' not just target groups, motives and behavioural elements can be identified but also levers to change consumption patterns. Timely research results might support decision making in order to introduce food waste mitigating actions before the consumption (and food wastage-) habits of the elite affects general social norms. Thus risk mitigating actions might include targeted interventions, such as awareness campaigns, school programmes and local programmes (ideally embracing local communities).

The definition of household food waste should be further developed. The current approach is based on the assumption that food which is consumed is not waste. At the same time it should be considered that the overconsumption of food does not have any justification, and is even harmful, leading to obesity and accompanying diseases. That is why a more constructive dialogue should be created between dietitians, specialists, those focussing on sustainable diet development and food waste researchers (Mortada et al., 2018; Tompa et al., 2020; Waitt and Rankin, 2022).

The food consumption of marginal communities in developed states is a rather specific problem. For example, we hardly know anything of the food consumption patterns of European Roma

communities (Dunajeva and Kostka (2022); however, this population, consisting of ca. ten million people, living mainly in Central and Eastern Europe is the “most vulnerable minority in Europe” (Gómez et al. (2019) and there are considerable anecdotal evidences, that in case of this ethnic minority there is a non-rational food consumption leading to waste of food and water (Halász, 2020).

The passing of time since the acknowledgement of importance of food waste problem and the introduction of the first educational programs offer an ever increasing possibility to measure these interventions on consumer behaviour and generation of food waste. On this base there is a possibility to choose the best practices and methods. It should be emphasized that the ‘Workflow of an in-depth food waste research project’ is more than just a help in the initial goal setting, but also provides a guided tour for the development path of a regional food waste prevention strategy when used as an iterative tool.

The Internet of things offers new possibilities for qualitative upgrading of consumer information (Wen et al., 2018). It would be extremely important to have a general picture on consumer attitude towards these technologies from point of view of food waster decreasing. Different logistical and technological systems of household food waste re-utilisation should be further developed, based on their complex evaluation, taking into consideration the different environmental consequences. In design and performance evaluation of these systems the wide-range application of lifecycle analysis is a key approach (Goodarzian et al., 2021; Hutchings et al., 2021).

The Covid-19 pandemics has accelerated considerably such changes, which could be observed soon before the lockdown and restrictions. It is especially important, and a relative lesser analysed, how these relatively new patterns of consumer behavior will change the food waste generated in households.

Minimizing food wastes by shortcutting the HORECA sector and the social care services offers a considerable possibility for the alleviation of the under-nutrition of socially segregated, often homeless people. The stakeholder attitude research towards these solutions could be an important step towards the understanding of the possibilities of and the barriers to a wide-range application of these seemingly simple methods.

The possibilities of development in different fields are determined by the A, B, C triangle (Figure 11).

## REFERENCES

- Aghaei Chadevani, A., Salehi, H., Yunus, M., Farhadi, H., Fooladi, M., Farhadi, M., et al. (2013). A Comparison between Two Main Academic Literature Collections: Web of Science and Scopus Databases. *Asian Soc. Sci.* 9 (5), 18–26. doi:10.5539/ass.v9n5p18
- Arcuri, S. (2019). Food Poverty, Food Waste and the Consensus Frame on Charitable Food Redistribution in Italy. *Agric. Hum. Values* 36 (2), 263–275. doi:10.1007/s10460-019-09918-1
- Arifin, M. Z., Jalal, F., and Makmuri (2021). Bibliometric Analysis and Visualization of Blended Learning Research Trends with PoP and VOS Viewer. *Turkish J. Comput. Math. Educ. (TURCOMAT)* 12 (11), 2010–2014. <https://www.turcomat.org/index.php/turkbilmal/article/view/6176/5127>.

The level of technology and its social acceptance (A), and info-communication technology and its acceptance, as well as the interaction of technology and info-communication will determine the theoretical sphere of action. In practice, the possibilities of integration and the effective co-working of technology and info-communication systems (X), the ethical limits of the acceptance of information technology (Y) and food science technology will determine the possibilities. This fact highlights the importance of a holistic attitude: e.g. info-communication technology offers considerable advantages for food planning and tracing, but there are considerable ethical concerns around the application of these technologies, related to the protection of personal data (Y). The technology offers new, functional products, but we do not have the necessary information on the actual health condition of consumers when planning systems (X), and the use of the data on consumers raises considerable ethical problems (Z).

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

## AUTHOR CONTRIBUTIONS

DS and BS-B conceived the study and were responsible for the design and development of the data analysis. ZL was responsible for data collection and analysis. GK was responsible for data interpretation. JO, JP, GK, and DS wrote the first draft of the article. JO and ZL supervised and edited the paper.

## FUNDING

The research was financed by the resources of the National Food Chain Safety Authority and has been supported by the Bolyai János Research Fellowship of the Hungarian Academy of Sciences and the Bolyai + Fellowship (ÚNKP-21–5) of the New National Excellence Program of the Ministry of Innovation and Technology.

- Aschemann-Witzel, J., De Hooge, I., Amani, P., Bech-Larsen, T., and Oostindjer, M. (2015). Consumer-related Food Waste: Causes and Potential for Action. *Sustainability* 7 (6), 6457–6477. doi:10.3390/su7066457
- Barma, M., and Modibbo, U. M. (2022). Multiobjective Mathematical Optimization Model for Municipal Solid Waste Management with Economic Analysis of Reuse/Recycling Recovered Waste Materials. *J. Comput. Cognit. Eng.* 1 (1), 1–6. doi:10.47852/bonviewJCE149145
- Beretta, C., Stoessel, F., Baier, U., and Hellweg, S. (2013). Quantifying Food Losses and the Potential for Reduction in Switzerland. *Waste Manag.* 33 (3), 764–773. doi:10.1016/j.wasman.2012.11.007
- BIOIS (2011). *Preparatory Study on Food Waste across EU 27*. Paris: Europa.
- Boulet, M., Hoek, A. C., and Raven, R. (2021). Towards a Multi-Level Framework of Household Food Waste and Consumer Behaviour: Untangling Spaghetti Soup. *Appetite* 156 (104856). doi:10.1016/j.appet.2020.104856



- Bräutigam, K.-R., Jörissen, J., and Priefer, C. (2014). The Extent of Food Waste Generation across EU-27: Different Calculation Methods and the Reliability of Their Results. *Waste Manag. Res.* 32 (3), 683–694. doi:10.1177/0734242X14545374
- Bringye, B., Fekete-Farkas, M., and Vinogradov, S. (2021). An Analysis of Mushroom Consumption in Hungary in the International Context. *Agriculture* 11 (7), 677. doi:10.3390/agriculture11070677
- Chan, R. B. Y. (2022). A Review of Packaging-related Studies in the Context of Household Food Waste: Drivers, Solutions and Avenues for Future Research. *Packag Technol. Sci.* 35 (1), 3–51. doi:10.1002/pts.2611
- Chappell, G. M. (1954). Food Waste and Loss of Weight in Cooking. *Br. J. Nutr.* 8 (4), 325–340. doi:10.1079/bjn19540050
- Chen, H., Jiang, W., Yang, Y., Yang, Y., and Man, X. (2017). State of the Art on Food Waste Research: a Bibliometrics Study from 1997 to 2014. *J. Clean. Prod.* 140, 840–846. doi:10.1016/j.jclepro.2015.11.085
- Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., and Herrera, F. (2011). Science Mapping Software Tools: Review, Analysis, and Cooperative Study Among Tools. *J. Am. Soc. Inf. Sci.* 62 (7), 1382–1402. doi:10.1002/asi.21525
- Cox, J., Giorgi, S., Sharp, V., Strange, K., Wilson, D. C., and Blakey, N. (2010). Household Waste Prevention - a Review of Evidence. *Waste Manag. Res.* 28 (3), 193–219. doi:10.1177/0734242X10361506
- De Hooge, I. E., Oostindjer, M., Aschemann-Witzel, J., Normann, A., Loose, S. M., and Almlí, V. L. (2017). This Apple Is Too Ugly for Me! *Food Qual. Prefer.* 56, 80–92. doi:10.1016/j.foodqual.2016.09.012
- Derviş, H. (2019). Bibliometric Analysis Using Bibliometrix an R Package. *Jscires* 8 (3), 156–160. doi:10.5530/jscires.8.3.32
- DG SANTE (2016). *SANTE/2016/E1/024 - Market Study on Date Marking and Other Information provided on Food Labels and Food Waste Prevention*. Brussels: Europa.
- Doerr, B., Fischer, P., Hilbert, A., and Witt, C. (2017). Detecting Structural Breaks in Time Series via Genetic Algorithms. *Soft Comput.* 21 (16), 4707–4720. doi:10.1007/s00500-016-2079-0
- Dunajeva, J., and Kostka, J. (2022). Racialized Politics of Garbage: Waste Management in Urban Roma Settlements in Eastern Europe. *Ethn. Racial Stud.* 45 (1), 90–112. doi:10.1080/01419870.2020.1863442
- Evans, D. (2012). Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste. *Sociology* 46 (1), 41–56. doi:10.1177/0038038511416150
- FAO (2011). *Global Food Losses and Food Waste*. Düsseldorf: FAO.
- Ferro, C., Ares, G., Aschemann-Witzel, J., Curutchet, M. R., and Giménez, A. (2022). "I Don't Throw Away Food, unless I See that It's Not Fit for Consumption": An In-Depth Exploration of Household Food Waste in Uruguay. *Food Res. Int.* 151, 110861. doi:10.1016/j.foodres.2021.110861
- FUSIONS (2016). *Estimates of European Food Waste Levels*. Stockholm: Eu-fusions.
- Galli, F., Cavicchi, A., and Brunori, G. (2019). Food Waste Reduction and Food Poverty Alleviation: a System Dynamics Conceptual Model. *Agric. Hum. Values* 36 (2), 289–300. doi:10.1007/s10460-019-09919-0
- Ganglbauer, E., Fitzpatrick, G., and Comber, R. (2013). Negotiating Food Waste. *ACM Trans. Comput.-Hum. Interact.* 20 (2), 1–25. doi:10.1145/2463579.2463582
- Ghafoorifard, N., Mesler, R. M., and Basil, M. (2022). Economic Hardship, Ontological Insecurity, and Household Food Waste. *Food Qual. Prefer.* 97, 104402. doi:10.1016/j.foodqual.2021.104402
- Gjerris, M., and Gaiani, S. (2013). Household Food Waste in Nordic Countries: Estimations and Ethical Implications. *Etikk Praksis - Nord. J. Appl. Ethics* 7, 6–23. doi:10.5324/eip.v7i1.1786
- Gómez, A., Padrós, M., Ríos, O., Mara, L.-C., and Pukepuka, T. (2019). Reaching Social Impact through Communicative Methodology. Researching with rather Than on Vulnerable Populations: the Roma Case. *Front. Educ. Front.* 4–9. doi:10.3389/educ.2019.00009
- Goodarzi, F., Kumar, V., and Abraham, A. (2021). Hybrid Meta-Heuristic Algorithms for a Supply Chain Network Considering Different Carbon Emission Regulations Using Big Data Characteristics. *Soft Comput.* 25 (11), 7527–7557. doi:10.1007/s00500-021-05711-7
- Graham-Rowe, E., Jessop, D. C., and Sparks, P. (2014). Identifying Motivations and Barriers to Minimising Household Food Waste. *Resour. Conserv. Recycl.* 84, 15–23. doi:10.1016/j.resconrec.2013.12.005
- Grandhi, B., and Appaiah Singh, J. (2016). What a Waste! A Study of Food Wastage Behavior in Singapore. *J. Food Prod. Mark.* 22 (4), 471–485. doi:10.1080/10454446.2014.885863
- Grosso, M., and Falasconi, L. (2018). Addressing Food Wastage in the Framework of the UN Sustainable Development Goals. *Waste Manag. Res.*, 36, 97–98. London, England: SAGE Publications Sage. doi:10.1177/0734242X17751968
- Guler, A. T., Waaijer, C. J. F., and Palmblad, M. (2016). Scientific Workflows for Bibliometrics. *Scientometrics* 107 (2), 385–398. doi:10.1007/s11192-016-1885-6
- Halász, L. (2020). Térbeli-Társadalmi Átalakulás, Szociális Válság És Válságkezelés Miskolc És Ózd Gettósodó Városrészeiben= Social-Spatial Transformation, Social Crisis and Crisis Management in Northern Hungarian Urban Ghettos-The Cases of Miskolc and Ózd. *Földr. Közlemények* 144 (4), 345–362. doi:10.32643/fk.144.4.1
- Hanssen, O. J., Syversen, F., and Stø, E. (2016). Edible Food Waste from Norwegian Households-Detailed Food Waste Composition Analysis Among Households in Two Different Regions in Norway. *Resour. Conserv. Recycl.* 109, 146–154. doi:10.1016/j.resconrec.2016.03.010
- Hebrok, M., and Boks, C. (2017). Household Food Waste: Drivers and Potential Intervention Points for Design - an Extensive Review. *J. Clean. Prod.* 151, 380–392. doi:10.1016/j.jclepro.2017.03.069
- Hoek, A. C., Pearson, D., James, S. W., Lawrence, M. A., and Friel, S. (2017). Shrinking the Food-Print: A Qualitative Study into Consumer Perceptions, Experiences and Attitudes towards Healthy and Environmentally Friendly Food Behaviours. *Appetite* 108, 117–131. doi:10.1016/j.appet.2016.09.030
- Hutchings, N., Smyth, B., Cunningham, E., Yousif, M., and Mangwandi, C. (2021). Comparative Life Cycle Analysis of a Biodegradable Multilayer Film and a Conventional Multilayer Film for Fresh Meat Modified Atmosphere Packaging - and Effectively Accounting for Shelf-Life. *J. Clean. Prod.* 327 (129423), 129423–129510. doi:10.1016/j.jclepro.2021.129423
- Ingrao, C., Facilongo, N., Di Gioia, L., and Messineo, A. (2018). Food Waste Recovery into Energy in a Circular Economy Perspective: A Comprehensive Review of Aspects Related to Plant Operation and Environmental Assessment. *J. Clean. Prod.* 184, 869–892. doi:10.1016/j.jclepro.2018.02.267
- Jörissen, J., Priefer, C., and Bräutigam, K.-R. (2015). Food Waste Generation at Household Level: Results of a Survey Among Employees of Two European Research Centers in Italy and Germany. *Sustainability* 7 (3), 2695–2715. doi:10.3390/su7032695
- Kibler, K. M., Reinhart, D., Hawkins, C., Motlagh, A. M., and Wright, J. (2018). Food Waste and the Food-Energy-Water Nexus: a Review of Food Waste Management Alternatives. *Waste Manag.* 74, 52–62. doi:10.1016/j.wasman.2018.01.014
- Koivupuro, H.-K., Hartikainen, H., Silvennoinen, K., Katajajuuri, J.-M., Heikintalo, N., Reinikainen, A., et al. (2012). Influence of Socio-Demographical, Behavioural and Attitudinal Factors on the Amount of Avoidable Food Waste Generated in Finnish Households. *Int. J. Consum. Stud.* 36 (2), 183–191. doi:10.1111/j.1470-6431.2011.01080.x
- Lakner, Z., and Baker, G. A. (2014). Struggling with Uncertainty: the State of Global Agri-Food Sector in 2030. *Int. Food Agribus. Manag. Rev.* 17, 141–176. doi:10.22004/agecon.188713
- Lanfranchi, M., Calabrò, G., De Pascale, A., Fazio, A., and Giannetto, C. (2016). Household Food Waste and Eating Behavior: Empirical Survey. *British Food J.* 118 (12), 3059–3072. doi:10.1108/BFJ-01-2016-0001
- Lebersorger, S., and Schneider, F. (2011). Discussion on the Methodology for Determining Food Waste in Household Waste Composition Studies. *Waste Manag.* 31 (9–10), 1924–1933. doi:10.1016/j.wasman.2011.05.023
- Li, N., and Wang, J. (2020). Food Waste of Chinese Cruise Passengers. *J. Sustain. Tour.* 28 (11), 1825–1840. doi:10.1080/09669582.2020.1762621
- Mallinson, L. J., Russell, J. M., and Barker, M. E. (2016). Attitudes and Behaviour towards Convenience Food and Food Waste in the United Kingdom. *Appetite* 103, 17–28. doi:10.1016/j.appet.2016.03.017
- Masson, M., Delarue, J., and Blumenthal, D. (2017). An Observational Study of Refrigerator Food Storage by Consumers in Controlled Conditions. *Food Qual. Prefer.* 56, 294–300. doi:10.1016/j.foodqual.2016.06.010
- Melbye, E. L., Onozaka, Y., and Hansen, H. (2017). Throwing it All Away: Exploring Affluent Consumers' Attitudes toward Wasting Edible Food. *J. Food Prod. Mark.* 23 (4), 416–429. doi:10.1080/10454446.2015.1048017
- Melikoglu, M., Lin, C., and Webb, C. (2013). Analysing Global Food Waste Problem: Pinpointing the Facts and Estimating the Energy Content. *Cent. Eur. J. Eng.* 3 (2), 157–164. doi:10.2478/s13531-012-0058-5

- Milanovic, B. (2013). Global Income Inequality in Numbers: In History and Now. *Glob. Policy* 4 (2), 198–208. doi:10.1111/1758-5899.12032
- Mongeon, P., and Paul-Hus, A. (2016). The Journal Coverage of Web of Science and Scopus: a Comparative Analysis. *Scientometrics* 106 (1), 213–228. doi:10.1007/s11192-015-1765-5
- Mortada, S., Abou Najm, M., Yassine, A., El Fadel, M., and Alamiddine, I. (2018). Towards Sustainable Water-Food Nexus: an Optimization Approach. *J. Clean. Prod.* 178, 408–418. doi:10.1016/j.jclepro.2018.01.020
- Parizeau, K., von Massow, M., and Martin, R. (2015). Household-Level Dynamics of Food Waste Production and Related Beliefs, Attitudes, and Behaviours in Guelph, Ontario. *Waste Manag.* 35, 207–217. doi:10.1016/j.wasman.2014.09.019
- Principato, L., Secondi, L., and Pratesi, C. A. (2015). Reducing Food Waste: an Investigation on the Behaviour of Italian Youths. *Br. Food J.* 117 (2), 731–748. doi:10.1108/BFJ-10-2013-0314
- Qi, D., and Roe, B. E. (2016). Household Food Waste: Multivariate Regression and Principal Components Analyses of Awareness and Attitudes Among U.S. Consumers. *PLoS one* 11 (7), e0159250. doi:10.1371/journal.pone.0159250
- Quested, T. E., Marsh, E., Stunell, D., and Parry, A. D. (2013). Spaghetti Soup: The Complex World of Food Waste Behaviours. *Resour. Conserv. Recycl.* 79, 43–51. doi:10.1016/j.resconrec.2013.04.011
- Rennie, D. M. (1995). Health Education Models and Food Hygiene Education. *J. R. Soc. Health* 115 (2), 75–79. doi:10.1177/146642409511500203
- Reynolds, C. J., Mavrakis, V., Davison, S., Hoj, S. B., Vlaholias, E., Sharp, A., et al. (2014). Estimating Informal Household Food Waste in Developed Countries: The Case of Australia. *Waste Manag. Res.* 32 (12), 1254–1258. doi:10.1177/0734242X14549797
- Schanes, K., Dobernig, K., and Gözet, B. (2018). Food Waste Matters - A Systematic Review of Household Food Waste Practices and Their Policy Implications. *J. Clean. Prod.* 182, 978–991. doi:10.1016/j.jclepro.2018.02.030
- Schneider, F., and Obersteiner, G. (2007). "Food Waste in Residual Waste of Households—Regional and Socioeconomic Differences," in Proceedings of the Eleventh International Waste Management and Landfill Symposium (S. Margherita di Pula: de Cleantech Community), 469–470.
- Schneider, F. (2008). *Wasting Food—An Insistent Behaviour*. Edmonton, Alberta, Canada: Research Gate.
- Schneider, F. (2013). The Evolution of Food Donation with Respect to Waste Prevention. *Waste Manag.* 33 (3), 755–763. doi:10.1016/j.wasman.2012.10.025
- Setti, M., Falasconi, L., Segrè, A., Cusano, I., and Vittuari, M. (2016). Italian Consumers' Income and Food Waste Behavior. *Br. Food J.* 118 (7), 1731–1746. doi:10.1108/BFJ-11-2015-0427
- Silvennoinen, K., Katajajuuri, J.-M., Hartikainen, H., Heikkilä, L., and Reinikainen, A. (2014). Food Waste Volume and Composition in Finnish Households. *Br. Food J.* 116 (6), 1058–1068. doi:10.1108/BFJ-12-2012-0311
- Soma, T. (2018). Re) Framing the Food Waste Narrative: Infrastructures of Urban Food Consumption and Waste in Indonesia. *Indonesia* 105 (1), 173–190. doi:10.1353/ind.2018.0007
- Stancu, V., Haugaard, P., and Lähteenmäki, L. (2016). Determinants of Consumer Food Waste Behaviour: Two Routes to Food Waste. *Appetite* 96, 7–17. doi:10.1016/j.appet.2015.08.025
- Stefan, V., van Herpen, E., Tudoran, A. A., and Lähteenmäki, L. (2013). Avoiding Food Waste by Romanian Consumers: The Importance of Planning and Shopping Routines. *Food Qual. Prefer.* 28 (1), 375–381. doi:10.1016/j.foodqual.2012.11.001
- Sulaiman, H., Ratering, T., and Banout, J. (2016). "Spatial and Temporal Arbitrage by Citrus Farmers Depending on Market Information System in Lattakia Region, RA Syria," in Proceedings of the International Scientific Conference (Latvia University of Agriculture), 284–290.
- Thi, N. B. D., Kumar, G., and Lin, C.-Y. (2015). An Overview of Food Waste Management in Developing Countries: Current Status and Future Perspective. *J. Environ. Manag.* 157, 220–229. doi:10.1016/j.jenvman.2015.04.022
- Tompa, O., Lakner, Z., Oláh, J., Popp, J., and Kiss, A. (2020). Is the Sustainable Choice a Healthy Choice?—Water Footprint Consequence of Changing Dietary Patterns. *Nutrients* 12 (9), 2578. doi:10.3390/nu12092578
- Tostivint, C., Östergren, K., Quested, T., Soethoudt, J., Stenmarck, A. s., Svanes, E., et al. (2016). *Food Waste Quantification Manual to Monitor Food Waste Amounts and Progression*. Neuilly-sur-Seine: BIO by Deloitte.
- Tucker, C. A., and Farrelly, T. (2016). Household Food Waste: the Implications of Consumer Choice in Food from Purchase to Disposal. *Local Environ.* 21 (6), 682–706. doi:10.1080/13549839.2015.1015972
- Van Eck, N. J., and Waltman, L. (2014). CitNetExplorer: A New Software Tool for Analyzing and Visualizing Citation Networks. *J. Inf.* 8 (4), 802–823. doi:10.1016/j.joi.2014.07.006
- Van Garde, S. J., and Woodburn, M. J. (1987). Food Discard Practices of Householders. *J. Am. Dietetic Assoc.* 87 (3), 322–329. doi:10.1016/s0002-8223(21)03115-1
- Waitt, G., and Rankin, K. (2022). Towards Household Sustainability? Experimenting with Composting Food Waste. *Geoforum* 129, 98–106. doi:10.1016/j.geoforum.2022.01.006
- Wassermann, G., and Schneider, F. (2005). "Edibles in Household Waste," in Proceedings of the Tenth International Waste Management and Landfill Symposium. Editors C. Raffaello and S. Rainer, 913–914.
- Wen, Z., Hu, S., De Clercq, D., Beck, M. B., Zhang, H., Zhang, H., et al. (2018). Design, Implementation, and Evaluation of an Internet of Things (IoT) Network System for Restaurant Food Waste Management. *Waste Manag.* 73, 26–38. doi:10.1016/j.wasman.2017.11.054
- Whitehead, P., Parfitt, J., Bojczuk, K., and James, K. (2013). *Estimates of Waste in the Food and Drink Supply Chain*. Banbury: Waste and Resources Action Programme, Albion Environmental.
- Williams, H., Wikström, F., Otterbring, T., Löfgren, M., and Gustafsson, A. (2012). Reasons for Household Food Waste with Special Attention to Packaging. *J. Clean. Prod.* 24, 141–148. doi:10.1016/j.jclepro.2011.11.044
- Withanage, S. V., Dias, G. M., and Habib, K. (2021). Review of Household Food Waste Quantification Methods: Focus on Composition Analysis. *J. Clean. Prod.* 279, 123722. doi:10.1016/j.jclepro.2020.123722
- WRAP (2013). *Consumer Attitudes to Food Waste and Food Packaging*. Banbury: Wrap.
- WRAP (2014). *Domestic Food Waste. Insights Report*. Banbury: WRAP and Shift.
- WRI (2016). *Food Loss and Waste Accounting and Reporting Standard*. Washington, DC: wbcscd.
- Yepsen, R. (2009). US Residential Food Waste Collection and Composting. *BioCycle* 50 (12), 35–41. <https://www.biocycle.net/u-s-residential-food-waste-collection-and-composting/>.

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Publisher's Note:** All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Copyright © 2022 Oláh, Kasza, Szabó-Bódi, Szakos, Popp and Lakner. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.