

# Mapping the intersections of sustainability, circular economy, and consumer behavior: a bibliometric review on food waste

Miray Baybars<sup>\*1</sup>, Fatma Demircan Keskin<sup>1</sup>, İpek Kazançoğlu<sup>1</sup>, and Yiğit Kazançoğlu<sup>2</sup>

<sup>1</sup> Ege University, Department of Business Administration, 35040, İzmir, Turkey

<sup>2</sup> Yaşar University, Department of Logistics Management, 35040, İzmir, Turkey

**Abstract.** The topic of food waste, which is considered to be an important focus within the framework of the Sustainable Development Goals of the United Nations (UN), has created a wide academic research area as well as guiding the policies implemented on this issue. Many researchers closely interested in the topic have produced academic studies that address food waste from various perspectives. Food waste at the consumer level is an important issue in terms of protecting the natural environment and using resources efficiently, considering future generations. This study aims to evaluate academic studies in this field and figure out the recent trends. The method utilized for this aim is selected to be bibliometric analysis. The results of the study, clarifying the trend topics, relevant authors, countries, sources, motor, niche and emerging themes regarding the field are expected to be useful for policymakers, practitioners, and consumers.

## 1 Introduction

Sustainability is a concept that can be considered in the context of looking after resources for the future without reducing the ability to respond to present needs. By definition, the concept emphasizes the wiser and more efficient use of today's natural resources, considering future generations' needs. As of the period we are in, it is possible to meet the requirements using various sources. However, people have become aware of resource efficiency and effective resource use with the increase in their awareness within the scope of sustainability, and in this direction, both academic and practical studies have gained importance.

Since it would be insufficient to define sustainability only as the continuity of natural resources, this concept is at the intersection of concepts such as economy, social justice, and the natural environment. The definition of sustainability, which points to the interaction of the concepts of protection of the natural environment, economic development, and social equality and focuses on a long-term existence, needs a detailed analysis due to its multifaceted nature. For this reason, academic interest in the subject has increased in recent years, and this increase has led to a proliferation of publications that examine many sub-titles within the scope of sustainability.

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\* Corresponding author: [miray.baybars@ege.edu.tr](mailto:miray.baybars@ege.edu.tr)

Circular economy, which is considered one of the sub-topics of sustainability, can be expressed as an approach that focuses on minimizing waste while using resources in the most efficient way possible within the economic system. In this respect, the circular economy approach, which can be considered a solution proposal to reduce existing environmental problems, is an important part of sustainable development that also considers social equality and economic growth.

According to the Sustainable Development Goals Report published by the UN in 2022, food loss along the production chain is 13%, and the level of food waste by consumers is 17%. The same report reveals that nearly one-third of the world does not have access to adequate nutrition, and one in ten people suffers from hunger [1].

Examining the issue of food waste is extremely important on the way to the wiser use of natural resources and, at the same time, for removing barriers to equal access to food for all. Considering that consumers are important actors causing food waste, and in line with the UN's goal of halving waste and losses, understanding their reasons related to consumer-induced waste should be a top priority in determining the steps to be taken to prevent it.

In this study, a bibliometric analysis is designed to reveal the current knowledge in the literature on the intersection of sustainability, circular economy, and food waste at the consumer level. In order to identify the studies that are relevant to the research area, a series of search terms are created and searched in the title, abstract, or keyword fields of the studies in the Web of Science (WoS) database. With the descriptive analysis of the data set, annual based scientific production, top sources, authors, countries, keywords, and trend topics are determined in the research area. Furthermore, co-occurrence and thematic map analyses are performed to examine the research area's conceptual structure.

## 2 Background

Food waste is associated with an inefficient use of edible food at the consumer level, while food loss refers to inefficiency arising from factors such as production processes, logistics, etc., within the food supply chain. In line with the UN's Sustainable Development Goals, reducing food loss and waste will contribute to economic and social sustainability. However, considering the food reaching the consumer is superior to other products in terms of added value, it calls for more attention to prevent the waste of resources used for production [2].

Food waste is an issue that involves many factors, including the psychology of the individual, the society in which he/she lives, and economic conditions, and it requires examination. For this reason, the issue of food waste, which involves many disciplines, requires a multidisciplinary approach to be examined. Similar to food consumption, food waste, which should be understood from a sociological, cultural, and economic perspective and not only from individual decisions [3], is too intricate to be eliminated entirely even if it is reduced by efforts such as information, awareness raising, and attitude change, which have been focused on an individual level many times so far (4; 3). Nevertheless, policymakers need to emphasize this issue, develop measures to understand and control food waste and ensure that existing measures are valid and reliable to tackle avoidable food waste [5].

For example, when the busy pace of business life and time constraints are considered as a factor that increases food waste today, it can be stated that social practices, as well as individual measures, can be beneficial to prevent food waste. Nevertheless, it is clear that individual initiative is extremely important in preventing food waste and that individuals have the potential to take important steps to prevent food waste as a result of efforts such as awareness raising and education. Indeed, dos Santos et al. [4], in a systematic literature analysis of consumer-induced factors, found that lack of planning, overbuying, and not

using leftover food are the leading causes of preventable consumer-induced waste of food. Despite individuals' tendency to avoid food waste [6,7] at the individual level, the inevitable occurrence of food waste necessitates the study of its structural causes of it.

Factors such as the culture in which consumers live and the socio-economic structure of the geography in which they live affect the practices of individuals regarding food waste. In some cases, it has been revealed that the food waste behavior of people living in the same country can even differ regionally [8]. For this reason, preparing policies and regulations to be developed to reduce food waste on a local scale rather than a global scale will help increase their effectiveness and contribute to achieving more positive results in the fight against food waste [9]. On the other hand, since context-dependent factors such as individual differences, family type, and special times of the year like holidays, occasions, etc., have been shown to have a significant relationship with food waste [2, 10], it is necessary to underline the importance of context-based studies in this field. It has been revealed that people's understanding of food categories impacts their wasteful behavior. It is stated that consumers waste more when throwing away foods that can be characterized as "unhealthy" because they do not think that this is waste; on the other hand, they act more sensitively when throwing away such foods because they associate waste with "healthy food" [11].

Recent studies discussing the role of different demographic groups in food waste show that young people and high-income families are associated with higher food waste compared to low-income groups, who make more rational and limited purchases due to economic constraints [12]. Education level has been found to have a negative relationship with food waste [8]. Findings on demographic groups indicate that awareness-raising campaigns to reduce food waste will be more effective on families with many children, young individuals, and men [13]. In light of this information, it can be said that it is important to tailor marketing communication to prevent food waste according to the segment of consumers [14].

Since food waste is a multi-layered issue involving planning, purchasing, preparation, storage, storage, consumption, consumption, and utilization of leftover food, possible errors or omissions at all steps in the process lead to waste. However, the lack of awareness of the environmental impact of food waste leads to food waste being associated more with economic losses [3]. Preventing food waste has also been reported to be part of the moves associated with reducing individual-level expenditures to reduce waste, especially in economically distressed societies [6]. While food waste occurs mainly at the household level in developed economies, food losses are mostly encountered at the stages of production processes in developing economies [15]. On the other hand, changes in the household food waste profile may occur due to processes such as the Covid-19 pandemic; for example, an increase in positive attitudes and behaviors towards stockpiling extra food due to unpredictability may lead to an increase in food waste [4]. Increased demand for food during periods such as festivals and New Year celebrations may also lead to a periodic increase in food waste [10]. Besides, individuals consider the environmental damage of packaging waste and wastage to be more important than the issue of food waste [16].

Many studies on food waste are not organized in an orderly and coherent manner due to their highly divergent methodological approaches and measurement methods and focus on different steps of the process leading to food waste, etc. [15]. For this reason, although the number of studies conducted within the scope of food waste is not small, it is thought that it will take time to structure all studies in a way that speaks the same language and thus contribute to the field synergistically. Therefore, this study can help to understand the complex structure of this field and can be evaluated as a meaningful effort to organize the current content related to the area.

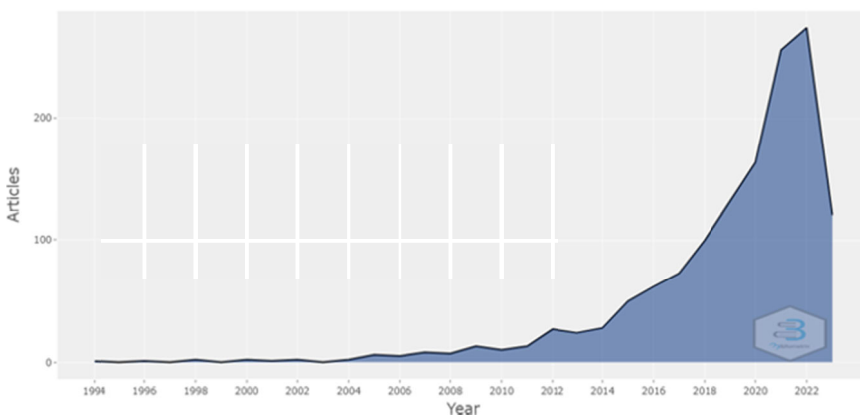
### 3 Research approach

This study examines scientific studies addressing sustainability, circular economy, and food waste at the consumer level in the literature. It aims to reveal the change in scientific production in this field over the years, leading authors, sources, countries, trending topics, and conceptual structure of the field. Bibliometric analysis has been conducted in the R bibliometric tool for these purposes. Three search sets in Table 1 were prepared to find the relevant studies in the research field. Studies containing at least one term from each set in the title, abstract, or keyword fields were exported from the WoS database.

**Table 1.** Search sets.

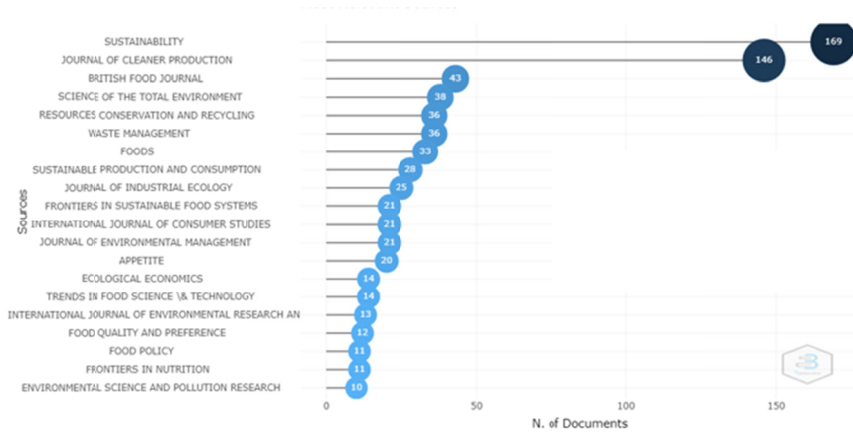
Sets	Search Terms
Circular economy and sustainability	"Circular econom*" OR "Circular business model*" OR "Circular supply chain*" OR "Circular design*" OR "Closed-loop system*" OR "Resource efficien*" OR "Waste manag*" OR "Sustainable product*" OR "Industrial ecolog*" OR "Resource recover*" OR "Extended producer responsibilit*" OR "Remanufactur*" OR "Sustainable consumpt*" OR "Ecological footprint*" OR "Green procurement*"
Food waste	"Food wast*" OR "Food loss*" OR "Food dispos*" OR "Food recov*" OR "Food supply*" OR "Food consump*" OR "Food recycl*" OR "Food redistribut*" OR "Sustainable food*" OR "Food packaging wast*"
Consumer	"consum*"

Articles, book chapters, and proceedings were included in the analysis. A total of 1384 documents published and accepted for publication between 1994-2023 were reached. Sustainability, circular economy, and food waste at the consumer level were studied first in 1994, and especially in recent years, the research field has been gaining increasing attention in the literature. Figure 1 depicts the annual scientific production in this research field.



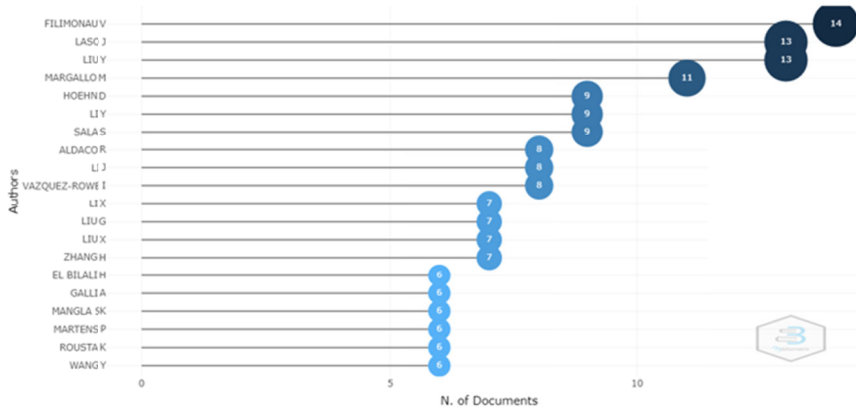
**Fig. 1.** Annual Scientific Production.

In this field, where academic studies are published in many sources, the "Sustainability" and "Journal of Cleaner Production" journals are far ahead of all other journals regarding the number of documents published. The "British Food Journal", "Science of the Total Environment", "Resources Conservation and Recycling" and "Waste Management" follows these journals.



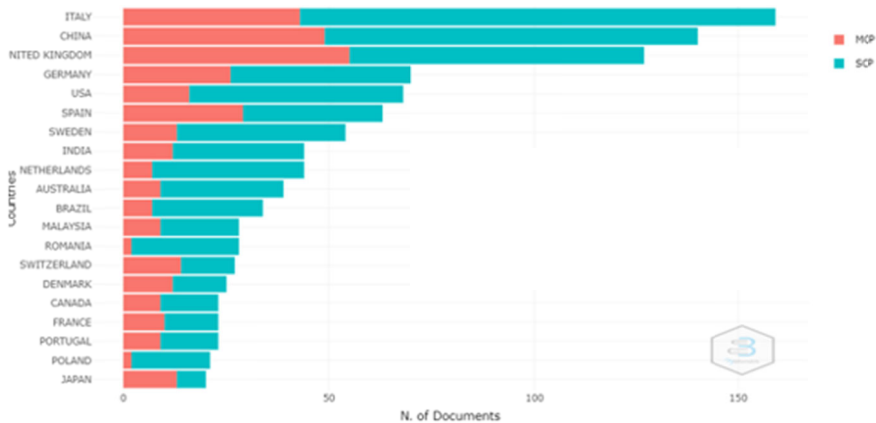
**Fig. 2.** Most Relevant Sources.

Figure 3 shows the top 20 authors with the most studies in the field.



**Fig. 3.** Most Relevant Authors.

Italy, China, and the United Kingdom are in the top three, far ahead of other countries, in the ranking of the countries of the corresponding authors of the studies in the research field. The top 20 countries in the ranking are shown in Figure 4.



**Fig. 4.** Corresponding Author's Country.

Fig. 4 has two indices: intra-country (SCP) and inter-country (MCP). SCP states that the study is done with the authors' contribution of the same country, while MCP identifies that it is developed with international cooperation [17]. In the list of most cited countries presented in Figure 5, Italy, the United Kingdom, China, Belgium, the Netherlands, and the United States lead as those with the highest citations.

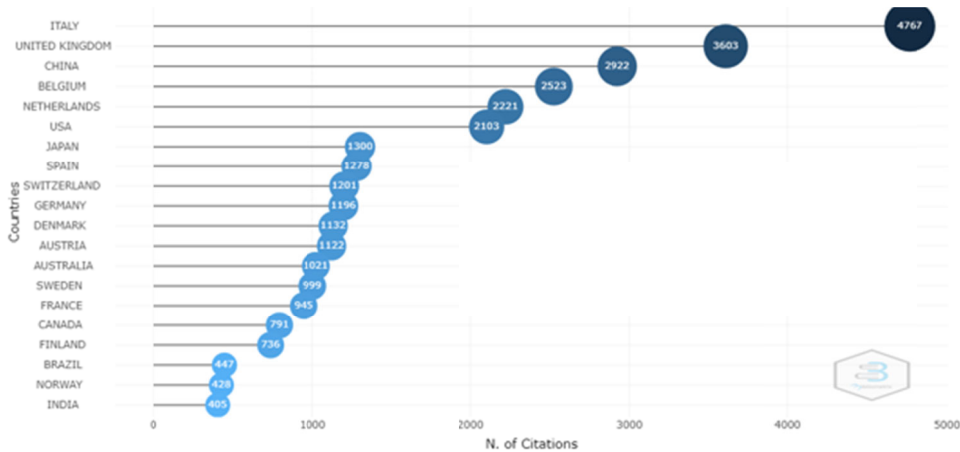


Fig. 5. Most Cited Countries.

The first most frequently used 50 words in the data set are depicted as a word cloud in Fig.6. The five terms with the highest frequency are “food waste”, “sustainability”, “sustainable consumption”, “circular economy”, and “food”, also included in the search sets. Besides the terms within the search sets, “life cycle assessment”, “ecological footprint”, “environment”, “food security”, and “organic food” have also been among the words used significantly.

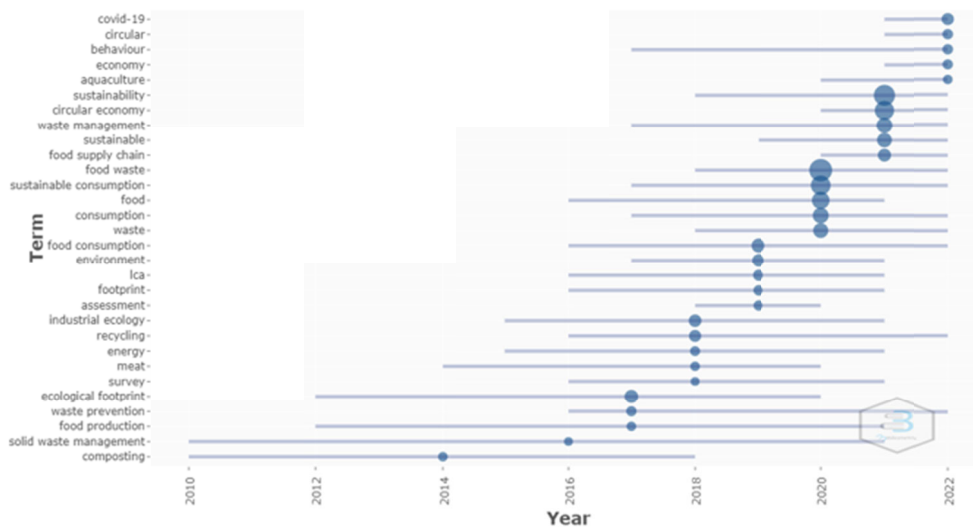


Fig. 6. Word Cloud.

Figure 7 presents the results of trend topic analysis applied to the research field between 1994-2023. This analysis based on the frequency of use of the terms, keeping the minimum word frequency value of 10. Although the studies in the research area started in 1994, meaningful results have been achieved in the last ten years when the number of studies accelerated. Moreover, in the studies conducted so far in 2023, no trending topic with a minimum frequency of 10 has emerged. According to this analysis, the most discussed topic in 2016 was "solid waste management", and in 2017, "ecological footprint", "waste prevention", and "food production".

"industrial ecology", "recycling", "energy", "meat", and "survey" were the most frequently discussed topics in research conducted in 2018. On the other hand, "food consumption", "environment", "lca (life cycle assessment)", "footprint", and "assessment" were the most discussed topics in the literature in this field in 2019.

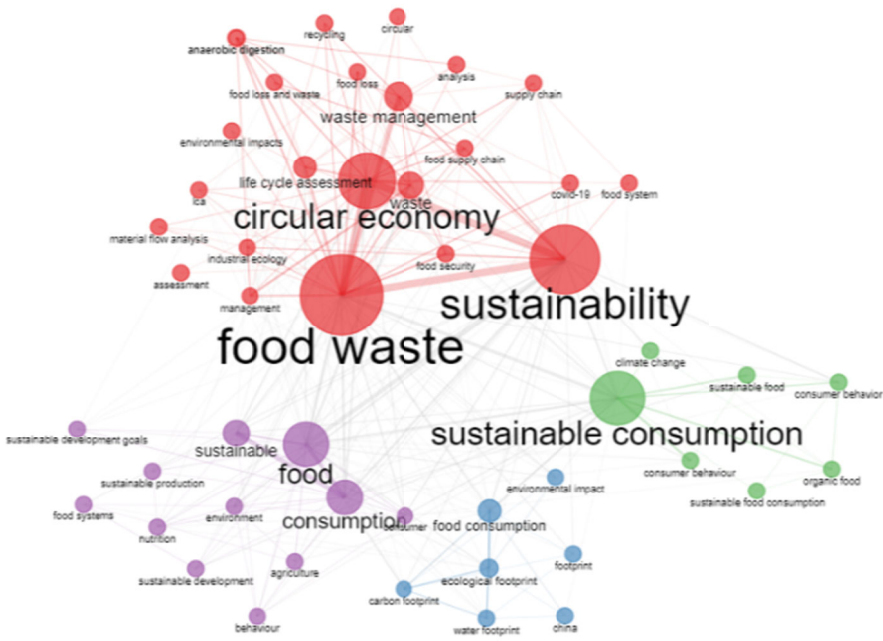
The field's most popular topic of 2020 was "food waste", followed by "sustainable consumption", "food", "consumption", and "waste". In 2021, "sustainability", "circular economy", "waste management", and "food supply chain" were the most frequently discussed topics. In 2022, the most frequently used terms in the field of research were "covid-19", "circular", "behaviour", "economy", and "aquaculture".



**Fig. 7.** Trend Topics.

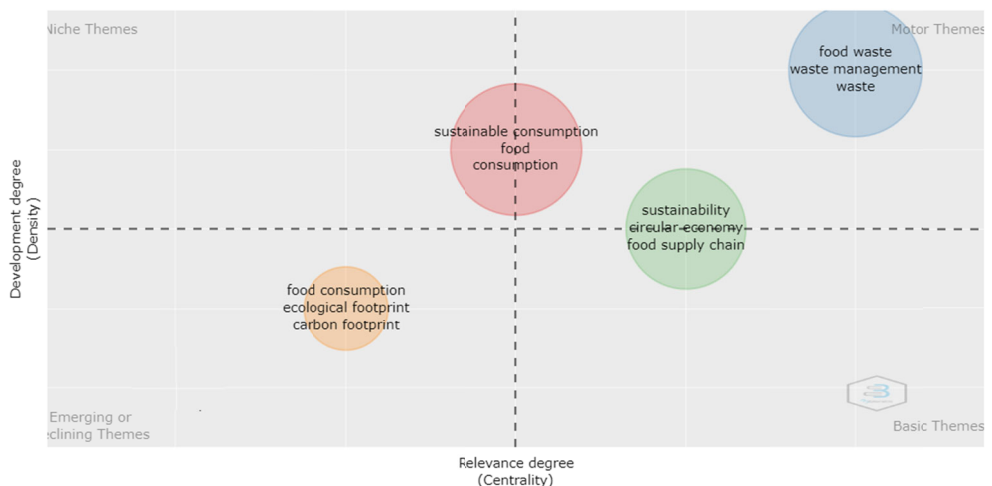
In the R bibliometrix tool, a co-occurrence network is created by considering how many times the words in certain parts of the data set are used and how many times there are co-occurrences with other words [18]. This study created a co-occurrence network using the Authors' Keywords part of the studies.

The co-occurrence network depicted in Fig.8 includes 4 clusters colored red, green, purple, and blue. The largest cluster is the red cluster, with 23 words focusing on food waste, sustainability, and circular economy. The green cluster is at the center of sustainable consumption, the purple cluster is focused on food, and the blue cluster is where words are gathered around food consumption.



**Fig. 8.** Co-occurrence Network.

Thematic map is a diagram in which the themes are positioned in a two-dimensional, four-quadrant space regarding their density and centrality rank. According to the findings of the thematic maps, suggestions for future research topics are included. While X-axis shows the centrality or importance of the studied subject, Y-axis represents the density of a theme's connection with other themes, expressing how important a theme is in the research field's development. Density is a measure that shows the strength of a theme's relationship with the keywords within that theme [20, 21].



**Fig. 9.** Thematic Map.



With thematic map analysis, four themes have resulted in the research field, as seen in Figure 9. Motor themes are both highly developed and have a high relationship with other themes. Topics in this quadrant are considered important and well-developed for the research field. These themes are “food waste”, “waste management” and “waste”. Generally, many studies have been done on food waste and waste management.

Niche themes are highly developed, but isolated from others because they focus on specific areas [22]. “Sustainable consumption” “food” and “consumption” topics are between the niche and the motor themes quadrants. While the densities of these themes are sufficient to enter the motor themes quadrant, their centrality degree is insufficient. Their positions may imply that the internal strength levels of the themes are high, but the level of interaction with other themes is not high enough.

Emerging/declining themes, on the other hand, are the theme category with a low level of development and low level of interaction with other themes [20]. It indicates that the development of the topic in this quadrant is limited. Topics in this cluster include “food consumption”, “ecological footprint” and “carbon footprint”. These topics have become the topic of particular interest and emerging research topics in research on food consumption. However, on the other hand, the fact that the bubble of these themes is not far from the center point of the diagram indicates that these themes can evolve by strengthening their relations with internal and other themes if they are studied more in the future.

Basic themes are frequently studied but not concentrated, generally studied themes with a high relationship level with other themes [23]. “Sustainability”, “circular economy” and “food supply chain” themes are located in the middle of the basic and motor themes quadrants. The position of these themes might be interpreted as their densities are not high enough because they are used in a wide range, although they are frequently used in the research field.

## 4 Conclusions

In recent years, the issue of food waste has been recognized as one of the sustainability issues that should be addressed at both academic and social levels. When the studies are examined over the years, the research that started in 2015 continues to increase gradually in 2022. Following the UN’s announcement of the Sustainable Development Goals within the scope of 17 purposes in 2015, there has been an increase in studies involving these words, showing researchers’ increased interest and motivation in favor of the area.

Many different methodological approaches and measurement methods have been employed to describe and understand the topic of food waste from the consumer perspective and with a specific interest in sustainability and circular economy, which shows the importance of interdisciplinary understanding and a vital requirement for interconnectedness for understanding. In this respect, current research evaluates the topic of food waste with a specific interest in consumer behavior and from the aspects of sustainability and circular economy.

The most influential authors were determined according to the number of publications and citations in the field of research. At the same time, Italy, China, and the UK are far ahead of other countries in terms of number of studies and citations. The studies in this field can be evaluated as outcomes of international cooperation among different countries. In other words, the area is having the global attention of researchers. Depending on the major findings of bibliometric analysis, the first five words most frequently used in the data set between 1994-2023 are “food waste”, “sustainability”, “sustainable consumption”, “circular economy” and “food”. In addition to these keywords of the current study, “life cycle assessment”, “ecological footprint”, “environment”, “food safety” and “organic food” are also words that are used significantly in the literature within this time frame.

While frequent terms in the literature were found to be “solid waste management” in 2016, “ecological footprint”, “waste prevention” and “food production” were trend topics for the year 2017. In 2018, the keywords of “recycling”, “energy”, “meat” were among the highly discussed topics. This can be related to the high energy requirement for meat production and its indirect potential to be an important reason for food waste. Moreover, the most discussed topics in this field during 2019 are “food consumption”, “environment”, “lca”, “footprint”, whereas these topics can be listed as “food waste”, “sustainable consumption” in 2020; “sustainability”, “circular economy”, and “food supply chain” in 2021. The term “covid-19” has been added to most frequently used terms in the predetermined research framework in 2022. Therefore, it can be said that the effect of the pandemic on research priorities can clearly be seen for that year.

The thematic map analysis has indicated that “food waste” and “waste management” are the leading and most developed themes in the research area. On the other hand, “sustainability”, “circular economy,” and “food supply chain” stand out as themes that are widely known and studied in the field of research but have not reached the level of impact as widely as the motor themes. Another interesting finding is that “sustainable consumption” has emerged as a theme combining niche ideas in consumption and sustainability with widespread adoption. “Food consumption”, “ecological footprint” and “carbon footprint”, which are categorized as emerging or declining themes, are themes that have the potential to be studied in the field of research. Among the journals publishing in food waste, sustainability, circular economy, and consumer behavior, “Sustainability” and the “Journal of Cleaner Production” are listed as the journals the researchers mostly prefer. Researchers showing interest in these issues can monitor these journals for opportunities for collaboration and the exchange of ideas with researchers of similar interests. Understanding the area of food waste from the perspective of consumers with a specific interest in sustainability can help policymakers and companies develop strategies and initiatives to align with consumers' needs and sustainable goals for society in general. With the help of understanding the issue of food waste from the perspective of consumers, the negative environmental impact, economic efficiency, and social equality related to food waste can be addressed by developing more effective strategies by countries, organizations, and other stakeholders.

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