How to increase sustainable production in the food sector?Mapping industrial and business strategies and providing future research agenda

How to increase sustainable development in the food sector? Mapping industry and business strategies for sustainable future

Abstract

Food waste is a tremendous systemic challenge, mainly at all stages of consumption and the supply chain process. In recent years, the global food supply challenge has called for new methods to decrease food waste or recover them to more valuable materials. Indeed, understanding the techniques for reducing and recovering food waste provides insights into exploring the impact of waste food recovery on the environment. This paper aims to review the literature on food waste in production processes. Hence, we employ a bibliometric and thematic analysis to explore a total number of 163 scientific articles published between 2000 and 2021. The present research uses the theoretical model of circular economy to analyse the literature on the topic both thematically and with cluster analysis. The results provide significant implications for academics and practitioners, drawing attention to a closer relationship between people and food waste, increasing the culture of the value of waste in all processes from agricultural production to distribution and consumption. Finally, it reiterates the need to emphasise the pollution caused by food production.

Keywords: food waste; recovery; production processes; systematic literature review; bibliometric; thematic analysis; circular economy

1. Introduction

In recent years, the demand for different food production has increased globally, whereas the food industry suffers from a lack of efficiency (Garcia-Garcia et al., 2017). Galanakis (2020) highlights that the global food waste produced by human consumption has crossed 1.3 billion tons per year. Food wastes can be generated at different stages of the food supply chain such as the initial agricultural phase, manufacturing processes, retailing, and household consumption (Bhattacharya et al., 2021; Garcia-Garcia et al., 2017; Yukesh Kannah et al., 2020). It has been argued that food could be wasted during this life cycle because of economic, societal, or technological reasons (Cui et al., 2022; de Moraes et al., 2020). The European Council stresses that waste management should prioritise food waste practices such as its reusability and recycling and preferably recovering valuable materials (Huang et al., 2021). In this vein, the recovered food waste can be applied for human consumption, creating energy, producing bio-based substances, and extracting valuable compounds such as proteins and fats (Magnacca et al., 2020, 2020; Rajeh et al., 2021; Sadraei, 2020). On the other hand, food waste management has also been considered an important sustainability objective by the United Nations 2030 Agenda (Pizzi et al., 2020; Santagata et al., 2021). Through the implementation of the Sustainable Development Goals (SDGs), food waste has been considered as related to specific goals such as goal number 2 named zero hungry (Goggins, 2018; Karki et al., 2021), number 12 on responsible consumption and production or number 17 on public-private partnerships (de Visser-Amundson, 2020). Specifically, sub-goal 12.3 aims to have global per capita food waste at the retail and consumer level and reduce food losses during production and supply chains, including post-harvest losses (Kumar et al., 2020; Lemaire & Limbourg, 2019; Rajic et al., 2022). Depending on the application of food waste recovery, different industries have applied various practices to address this ever-increasing challenge (Agrawal et al., 2022).

Literature has identified several methods to recover waste food (Nazzaro et al., 2018; Santagata et al., 2021). Scholars highlight that industrialisation is a challenge to apply such innovative recovery methods and theories (Frondel et al., 2007; Santagata et al., 2021). Esposito et al. (2020) argue that industrialisation involves comprehensive laboratory research, transferring to pilot plants and full-scale production, novel application development, and problem commercialisation. Additionally, Usmani et al. (2021) stress applying nonthermal technologies with green solvent to improve the purity and efficiency of the final products. Therefore, it is essential to ensure the sustainability of the process, its economic benefit, and the perpetual

establishment of the extracted products in the market (Dhir et al., 2021; Redlingshöfer et al., 2020).

In terms of theory, food waste and production processes are primarily studied through the circular economy concept with a prominent business model view (Garcia-Garcia et al., 2019; Moggi & Dameri, 2021). Additionally, the circular economy seems to be the correct tool to join theoretical and practitioners' studies with technological advancements for processing the food waste and re-using it as input (Somlai, 2022; Zucchella & Previtali, 2019). For instance, several Small and Medium-sized Enterprises (SMEs) have tried to start recovering food waste on a small scale. Still, the application on a big scale remains a challenge to be addressed (Batista et al., 2019; Khanra et al., 2022).

Despite the need to systematically review the latest research on food waste, few studies systematise the findings to explore the underlying theoretical assumptions and variables of this stream of research. For instance, Provin et al. (2021) outline the academic situation of circular economy applied in the fashion industry. Specifically, using an integrative review approach of academics and practitioners' sources, the authors demonstrate the use of bacterial cellulose from probiotic drinks to produce bioxetiles for the fashion industry. Then, Aschemann-Witzel & Stangherlin (2021) perform a systematic literature review on recycled by-products in agri-food systems focusing on consumers and the social and economic implications, in which they demonstrate experiences of waste valorisation in food and beverages for human consumption. Furthermore, some authors introduce the concept of agri-food supply chains' digital transformation (Amaral & Orsato, 2022). Several scholars present blockchain, artificial intelligence, big data, internet-of-things (IoT), robotics, and Radio Frequency Identification (RFID) as disruptive tools to enhance sustainability in agri-food (Dadi et al., 2021; Ersoy et al., 2022). Another interesting stream of research focuses on the hospitality sector. Notably, Dhir et al. (2020) and Filimonau & De Coteau (2019) provide two systematic literature reviews (SLR) critically analysing the phenomenon of food waste in the tourist accommodation industry, focusing on general issues as well as hospitality managers. The authors demonstrate the need for training and direct investments to translate into medium to long-term cost savings. Finally, Chen et al. (2017) illustrate the state of the art in food waste. The authors introduce new research topics such as waste valorisation and treatment and management innovation and provide variables such as authors and key countries in this research stream.

Considering all these published reviews, this investigation aims to extend the results by offering a structured literature review with a bibliometric and coding analysis of food waste in

production processes. In this vein, as suggested by Massaro et al. (2016) and Paul & Criado (2020), academics might be interested in providing a state-of-the-art of publications and constructivist critiques of what has been analysed. Additionally, according to Zupic & Čater (2015), The inclusion of bibliometric methodologies offers different perspectives on the research fields under study. This is possible thanks to objective analysis and the opportunity to find interpretative and critical models in the literature. Therefore, our first research question (RQ) is:

RQ1. What are the bibliometric variables concerning waste in the food industry?

However, researchers should not mistake not constructively criticising the research carried out by investigating the numerous selected documents by qualitative means (de Bem Machado et al., 2021; Dumay & Cai, 2014; Massaro et al., 2016). Therefore, the second research question (RQ) is:

RQ2. What critical elements of the circular economy emerge from the thematic study related to food waste in production processes?

For various reasons, the approach differs from past systematic literature assessments. First, this paper contributes to the ongoing discussion in this area of research by identifying qualitative and quantitative bibliometric variables such as the research trend regarding the source of growth, scientific field, relevant journals, authors and keywords, countries, and countries' collaboration. Second, we want to go beyond providing a static state of the art by providing interpretations and criticism such as dedicated analysis of authors' backgrounds and selected methodologies (Uluyol et al., 2021). Third, the research aims to guide practitioners by identifying useful variables to check to limit food waste during production processes. Fourth, the value of the analysis is the broad lens we will adopt by not only focusing on the fashion or hospitality sector but also looking at any sector that involves the production and processing of food raw materials.

To address these research questions and aims, the paper explores 163 scientific articles between 2000 and 2021. We conduct thematic synthesis to identify new research clusters by using the R software (biblliometrix package).

The present research provides several contributions to theory and practice. On the theoretical side, the applied methodology allows understanding and extending the state-of-the-art food waste theme in the industrial field by revealing useful variables for quantitative and qualitative studies. Furthermore, it highlights the need for innovative approaches to waste management that can hybridize academics and practitioners to further the achievement of the SDGs

(Michalec et al., 2018; Sakaguchi et al., 2018). Indeed, sustainability goals cannot be achieved without a joint effort from both spheres of knowledge. Therefore, the present study is instrumental in moving toward research for a cleaner production system that promotes the circular economy. In this perspective, CE emerges as a successful business model for transforming the production process into a sustainable key by highlighting factors of transformation, distribution, use, and recovery for the food sector.

Moreover, it is revealed that a closer relationship between people and food needs to be established to effectively limit food waste by changing the food culture of the population. Culture is also a factor for companies to consider the environmental impact and communicative transparency of their food production process. Hence, introducing a circular business model can be a condition for mitigating waste while pandering to consumers. The research shows consumers' critical role in choosing sustainable businesses and demanding anti-waste measures from the food industry.

Finally, the remaining paper is structured as follows. The following section explores the theoretical underpinning of food waste management. It is followed by identifying the method and tools used for this research. Subsequently, the bibliometric and thematic analysis results have been presented. Finally, we discuss and conclude the investigation by indicating the theoretical and practical implications, limitations, and future avenues of research.

2. Theoretical background

The circular economy (CE) concept was introduced to minimise the waste of resources and extend the product life (European Commission, 2014; Murray et al., 2017). According to Kirchherr et al. (2017), CE strives to create an economic system that can replace the concept of 'end-of-life' with alternative reuse or recovery of materials in production/distribution and consumption processes. The application of CE cannot be itself a guarantor of economic prosperity and social equity but is designed to be restorative and regenerative (Ghisellini et al., 2016; Puntillo et al., 2021). The central idea promoted by this paradigm is based on the willingness of industries and consumers to close material cycles, reduce inputs, and reuse or recycle products and waste to achieve a higher quality of life through greater resource efficiency (Perey et al., 2018; Peters et al., 2007). According to Liu et al. (2018), modelling the circular economy requires efforts on three dimensions. At the micro level, practices implemented by an individual firm to achieve cleaner production and increased recycling or reuse of resources are understood. The second dimension is meso which is defined through the development of eco-industrial parks, described as communities of firms with the ambition to

synergistically achieve economic and environmental benefits by using resources effectively and efficiently. Finally, resource and material flow on a regional or national scale are defined at the macro level.

The extant research has extensively explored food waste and CE. According to Slorach et al. (2019), one-third of food is wasted globally, which calls for a significant need for processing and re-use. As a result, this waste should ideally be avoided and, if not possible, treated to recover resources. From an interdisciplinary perspective, scholars have distinguished the topic of excess food from functional recycling materials to reflect future biorefineries of food waste in the circular bio-economy (Kumar et al., 2022; Teigiserova et al., 2020).

In this context, several studies have emphasised the role of the consumer (Young et al., 2018). According to Borrello et al. (2017), consumers can be crucial players in disposing of organic waste from food consumption. In addition, the impact of CE in people's everyday lives includes sensitivity-based moral complexity and partially contradictory ethical practices (Lehtokunnas et al., 2020).

Research on circular economy and food has mainly focused on engineering or production processes, manufacturing, and trade (de Jesus et al., 2016; Donner & de Vries, 2021). Recently, many studies have focused on the concept of CE as a paradigm. In particular, its relationship to sustainable development has been studied (Geissdoerfer et al., 2017; Hellemans et al., 2022) and the large number of concepts that define it (Kirchherr et al., 2017). For example, CE is defined as a closed-loop material flow throughout the economic system, taking into account the economic aspects by minimising the matter and without limiting economic growth (Lieder & Rashid, 2016; Tan et al., 2022). This provides researchers with economic model relevant to the study of waste in the food industry. Therefore, the present research is based on the concept of CE proposed by Prieto-Sandoval to map the elements of food waste in industry. Figure 1 shows that CE is configured as a five-part cycle. First, industries take resources from the environment and transform them into products and services (Park et al., 2010). Next, the outputs of this transformation are destined for the outlets and consumers (Prieto-Sandoval et al., 2018). The proposed cycle does not end with waste disposal but closes the loop through the recovery and enrichment of used materials (Stahel, 2016).

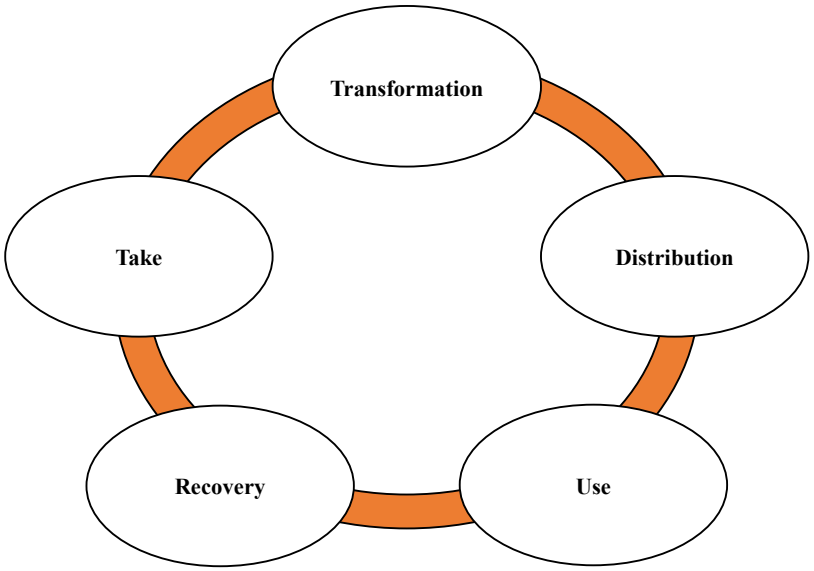

Figure 1. Elements under observation – Theoretical model

Source: Authors' elaboration via Prieto-Sandoval et al. (2018)

3. Methodology

This study aims to conduct a structured literature review (SLR) on food waste and industry (Massaro et al., 2016). The methodology fits the systematisation of literature streams that are only partially understood by international scholars (Biancone et al., 2020). Accordingly, the present study uses a hybrid approach to conduct an SLR with bibliometric analysis (Abarca et al., 2020). The present study adopts a workflow mapping methodology through five phases (Zupic & Čater, 2015): (i) study design, (ii) data collection, (iii) data analysis, (iv) data visualisation, and (v) interpretation.

3.1. Study design

The present study design aims to identify the research questions and theoretical model for observing the food waste in industry themes in the literature (Biancone et al., 2022). Indeed, although initially specific to the accounting industry, the proposed SLR methodology has been extended into the broader management field because of its reliable research protocol (de Bem Machado et al., 2021; Secinaro et al., 2020). Therefore, a jointly bibliometric and coding method can help researchers identify the essential variables of the research domain in a short period. The authors conducted an SLR through a deep and reliable knowledge review in the study domain and identified future research areas (Uluyol et al., 2021). It is possible to analyse multidisciplinary studies through metadata analysis (Secinaro, Brescia, et al., 2022). In particular, the present research aims to consider within the cluster not only papers closely

related to the business model concept but also those dealing with food industry production. In this sense, the research offers a holistic view of the state of the art of the topic and allows clustering of the literature on the topic by identifying appropriate sections to advance the research in the study by offering a research agenda (Secinaro, Calandra, et al., 2022; Ştefănescu et al., 2021).

In January 2022, the data collection process began using the Scopus database via the search key "*Food Wast**" AND "*Industry**". The multidisciplinary database is suitable for researchers in business and management (Okoli & Schabram, 2010).

3.2. Data collection

The primary results obtained were 2,918 documents. Subsequently, the time frame of reference was chosen, considering only 2,779 papers between 2000 and 2021 (Jalal et al., 2021). Despite the known interdisciplinary nature of the topic (Saber & Silka, 2020), it is consistent with the theoretical concept of reference to only consider papers related to the business and management field. Moreover, only articles from English-language peer-reviewed journals were considered (Brescia et al., 2021).

To ensure we did not miss any important data, we manually searched the references of all selected articles, employing backwards and forward snowballing (Christofi et al., 2021). This ensured that we did not miss some of the most relevant papers in the document selection process. After this phase, the researchers manually downloaded all pdfs of the articles to create the codes and the subsequent analysis of the search clusters (Dal Mas et al., 2019).

The data collection of the present research is consistent with the SPAR-4-SLR guidelines of (Paul et al., 2021), as shown in figure 2. According to Moher (2009), mapping a systematic review protocol is essential to overcome bias in paper selection.

Subsequently, 163 articles passed the restrictive criteria. The study used Bibliometrix, a statistical package in R-Studio (Aria & Cuccurullo, 2017). This allows analysis of bibliometric information, including authors, citations, sources, and keywords.

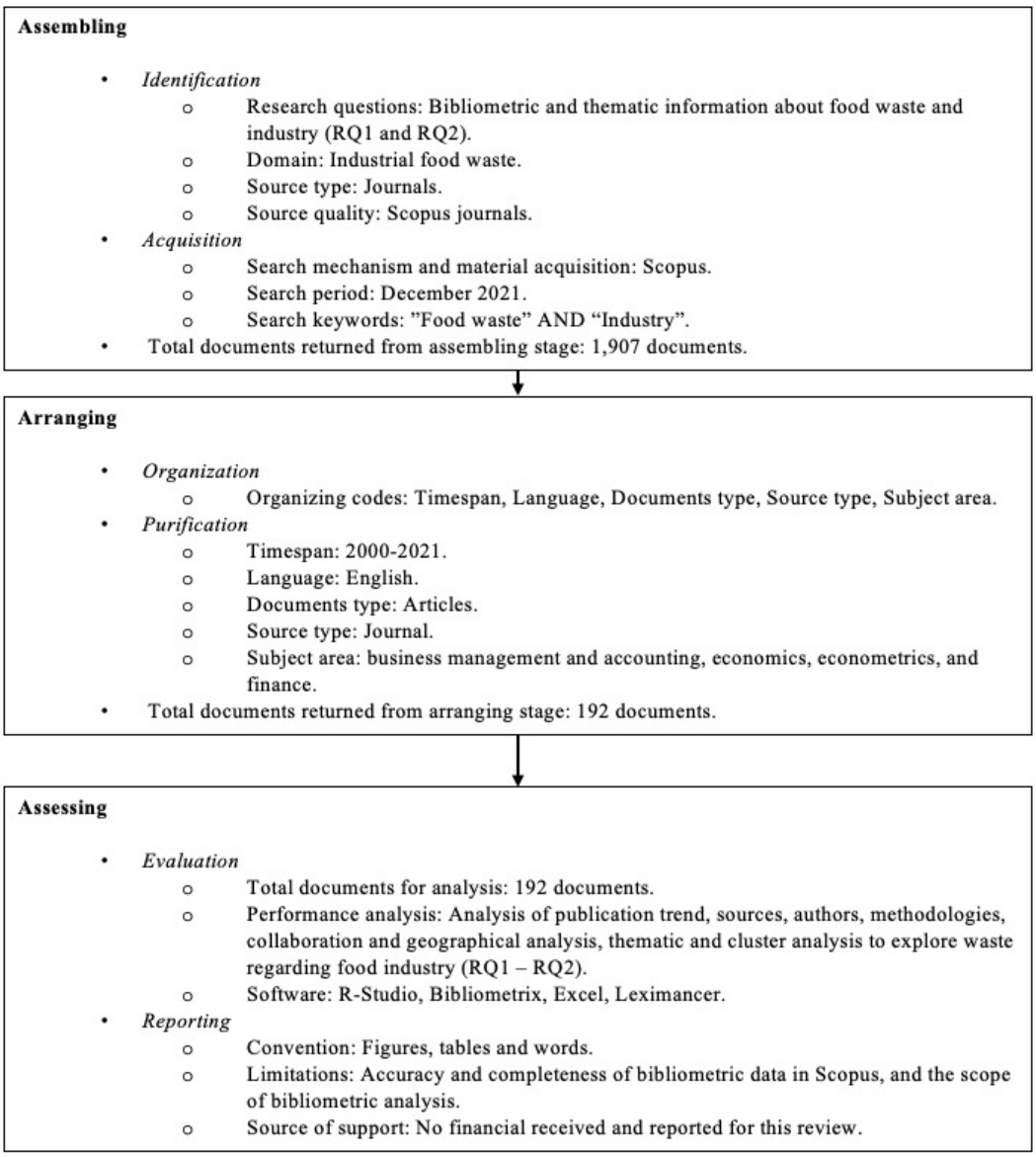

Figure 2. Procedure for reviewing food waste in the industry using the SPAR-4-SLR protocol

Source: Authors' elaboration

3.3. Data analysis

To answer the research questions and objectives of the study, multiple analysis tools have been applied. First, to answer RQ1, we used Bibliometrix R-Package and the biblioshiny app, which is increasingly used in the scientific literature to provide a state-of-the-art knowledge stream under study (Aria & Cuccurullo, 2017; Baima et al., 2020; Vaska et al., 2021). In addition, to answer RQ2 and inspire the constructive criticism, we used the Atlas.ti software in the cloud version to create specific codes to map the background and methods used by the authors. Indeed, the software is particularly suitable for managing inter-rater reliability (IRR) and

checking the level of consistency between codes and analysed documents (Hwang, 2008; Talanquer, 2014). Finally, to create the cluster map, we used the Leximancer software that enables the decoding and visualisation operations of the structure of complex textual data extracted from all document PDFs (Massaro et al., 2020; Smith & Humphreys, 2006).

The following sections give insights into data visualisation and interpretation. Finally, theoretical and practical implications linked to future lines of research can be found in the conclusion section.

4. Results

The bibliometric approach allows answering research questions and simultaneously understanding the main variables of a scientific field (Secinaro & Calandra, 2020). This paper exposes the selected sample's descriptive characteristics through the keywords, emphasising several aspects of scientific production and helping to answer the first research question. Subsequently, the survey of authors completes the answer. Secondly, the thematic analysis is proposed, which aims to answer the second research question by bringing out elements and main themes faced by the authors in dealing with food waste and industry. The cataloguing of literature through a thematic analysis opens new flourishing fields of scientific research.

4.1. Descriptive analysis

To understand the development of research in industrial methods for food waste recovery and to analyse the trends in this scientific field, 163 articles in business and management were obtained. Figure 3 shows the number of scientific publications on industrial methods for food waste recovery over the year, from the year 2010 to the year 2021. As can be seen, the number of articles published in this field has increased as the year has increased. Recent CE policies operated by the European Commission (EC) have increased attention.

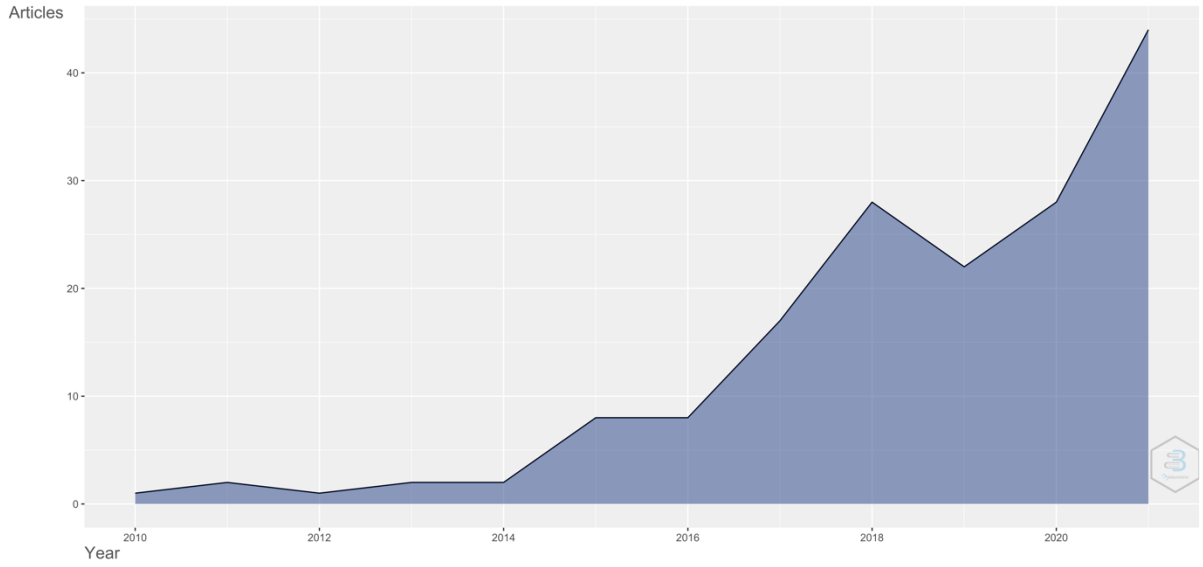

Figure 3. Topic development over the years

Source: Authors' elaboration through Bibliometrix

Table 1 shows the variables describing the sample considered. The 163 papers written by 583 authors are extracted from 49 Journals. The interdisciplinary nature leads to collaborative studies. Therefore, the articles under consideration were written by at least three authors on average. Only 11 research papers feature a single author out of 583.

Table 1. Descriptive information of the sample

Main information	**Explanation**	**Results**
Documents	Total number of documents	163
Sources	The frequency distribution of sources as journals	49
Author's Keywords	Total number of keywords	649
Keywords Plus (ID)	Total number of phrases that frequently appear in the title of an article's references	1.113
Period	Years of publication	2010-2021
Authors	Total number of authors	583
Author Appearances	The authors' frequency distribution	626
Authors of single-authored documents	The number of single authors per article	11
Authors of multi-authored documents	The number of authors of multi-authored articles	572
Average citations per document	The average number of citations in each article	25,54
Co-Authors per Documents	The average number of co-authors in each document	3,84
Authors per Document	The average number of authors in each document	3,58
Collaboration Index	-	3,76

Source: Author's elaboration through biblioshiny for bibliometrix

4.2. Source's analysis

This section aims to identify journals on which the ongoing topic is debated. As can be understood from Figure 4, the first journal among the most relevant sources is the Journal of Cleaner Production. The international journal is shaped as transdisciplinary and aims to publish on environmental and sustainability topics. Namely, "*Cleaner Production*" aims to prevent waste production by increasing energy, water, resources, and human capital efficiency. The journal appears central to reducing industrial waste through cleaner production and technical processes, including research on surplus waste (Messner et al., 2021), energy conservation (Xu & Szmerekovsky, 2017), green production models (Sel et al., 2017), and packaging reuse (Bishop et al., 2021). The second rank is the British Food Journal which appears to be more focused on food waste. The journal places several food-related issues such as consumer choices, preferences and concerns or sustainability, and food economics at the heart of the debate. The cluster produces examples in this regard. Therefore, it is possible to read about alternatives to the current industrial model to reduce food waste (Gadde & Amani, 2016) or about minimising food waste from a consumer point of view (Cozzio et al., 2021). With five papers published on the subject under study, we can find the International Journal of Hospitality Management. The journal studies economic linkages centred on tourism and hospitality, covering topics such as reducing food waste in commercial establishments (Filimonau et al., 2019).

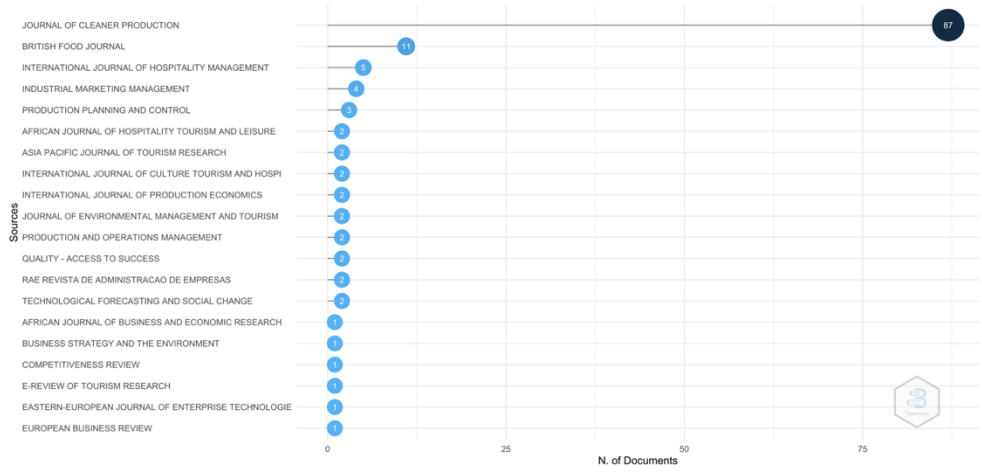

Figure 4. Ranking of journals by the number of publications

Source: Authors' elaboration through biblioshiny for bibliometrix

4.3. Author's analysis

Author analysis clarifies the primary references for the topic (Figure 5). The bibliometric elements place Professor Amicarelli and Professor Bux (Amicarelli, Aluculesei, et al., 2021; Amicarelli, Bux, et al., 2021; Amicarelli, Fiore, et al., 2021; Amicarelli, Lagioia, et al., 2021; Amicarelli, Rana, et al., 2021) at the top. These authors offer research on the relationships between resources, assets, and the environment. The focus is on the scarcity of natural resources and improving the use of waste during production. The two scholars are supervised by Prof Daniel C.W. Tsang (Lam et al., 2018; Y. Liu et al., 2021; Mak et al., 2018; Yang et al., 2020), whose research concerns the vital link between society's needs and real-life environmental challenges. His studies aim at the expected progress of efficient technologies to achieve sustainable development goals.

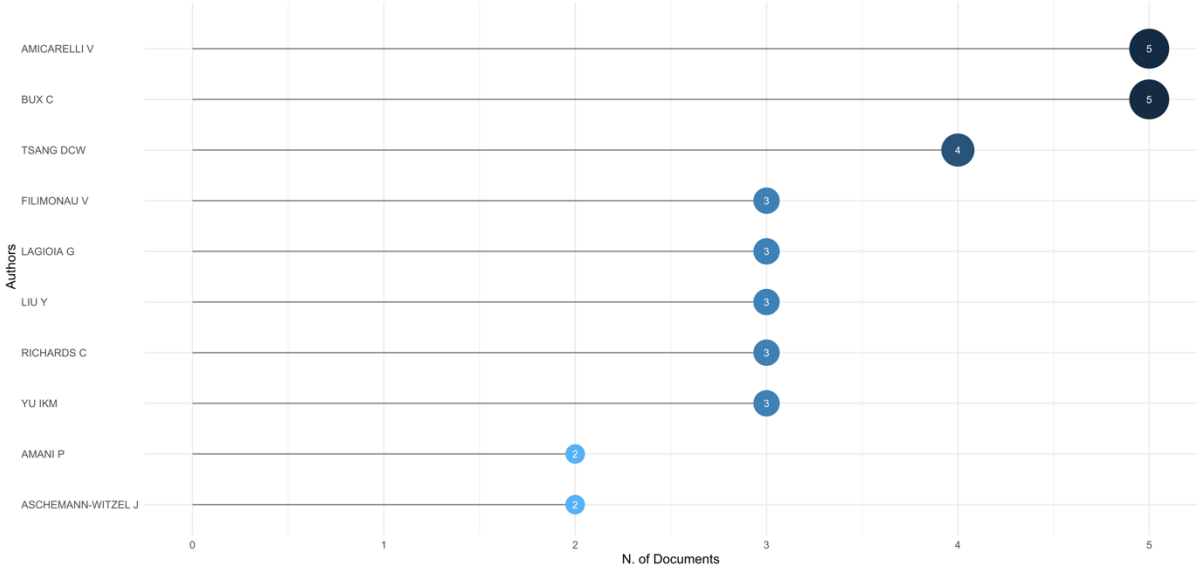

Figure 5. Ranking of authors by the number of papers

Source: Authors' elaboration through biblioshiny for bibliometrix

Furthermore, Table 2 shows the results of the authors' impact calculated by h-index, g-index and m-index in the study area. According to Egghe (2006), Saad (2006) and Schreiber (2008), such statistical indicators, mainly when studied in a specific research field, help ascertain the productivity and impact of an academic's citations (m-index) to investigate the distribution of citations received by an academic's publications (g-index) and to study the value of the h-index not only for ten years but year by year (m-index). The results obtained show that the ten most relevant authors have an h-index and g-index between 4 and 2. This can be interpreted by considering that in the social sciences, prominent scholars have an average value of 7.6. These

results, therefore, demonstrate a nascent research sector that is also made up of young researchers who are passionate about the subject (London School of Economics, 2010). However, Tsang DCW is the scholar with the highest indicators due to his recent entry into this field of research and his number of published papers.

Table 2. Top 10 authors

Author	h-index	g-index	m-index	Total citations	Total papers	Year start
Tsang DCW	4	4	0.800	76	4	2018
Liu Y	3	3	1.000	36	3	2020
Richards C	3	3	0.600	106	3	2018
Yu IKM	3	3	0.600	66	3	2018
Amani P	2	2	0.250	24	2	2015
Amicarelli V.	2	4	1.000	20	4	2021
Aschmann-Witzel J	2	2	0.500	20	2	2019
Bux C	2	4	1.000	20	4	2021
Caicedo L	2	2	0.333	30	2	2017
De Clercq D	2	2	0.333	30	2	2017

Source: Author's elaboration

Furthermore, we illustrate the results concerning the authors' background. Figure 6 shows that 506 authors have academic experience at various levels. In addition, 77 authors are professionals and have corporate affiliations. Finally, this research also finds that 19 authors have a mixed background, including both academic and corporate partnerships. Considering the high number of scholars in the other categories, it can be understood that the level of collaboration is very low. Thinking about the practicality of the research field under study, the low level of cooperation is unusual. Therefore, as Bartunek (2007) and Romme et al. (2015) suggested, common areas of knowledge should be found to facilitate dialogue using scientific ideas and practical business applications.

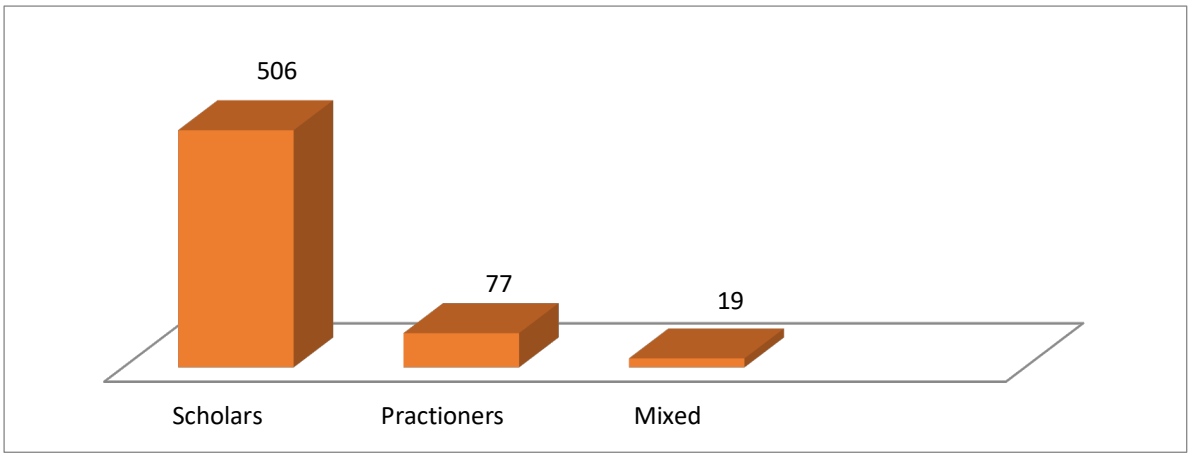

Figure 6. Authors' background

Source: Author's elaboration

4.4.Methodologies adopted

This section analyses the research methods used by the authors. The results visible in Figure 7 demonstrate an equal share between qualitative and quantitative methodologies. In particular, we show the wide use of the case study (34 - 21.25%), followed by methods adopting quantitative modelling (28 - 17.50%) and experiments (22 - 13.75%). The other methods used were primarily qualitative, including reviews (19 - 11.88), other qualitative studies (18, 11.25%), and mixed methodologies (14 - 8.75%).

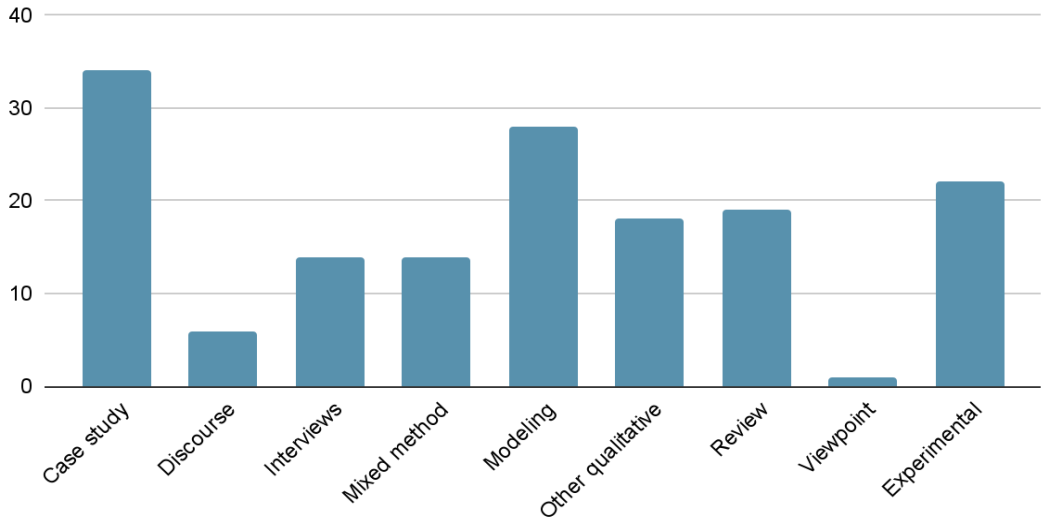

Figure 7. Research methodologies

Source: Author's elaboration

4.5.Geographical and collaboration analysis

As shown in Table 3, among the countries with the highest number of papers on food waste related to industries, Italy leads the ranking with 43 contributions. The commitment of the European Union to the transition towards the model of Circular Economy has led to growing attention to food by-products and waste valorisation practices. Italy has represented a flourishing ground for case studies (Comino et al., 2021) and experimentation (Alberti & Belfanti, 2019). Notably, the structure of multiple relationships among stakeholders involved in creating a new food waste management system has been observed, providing theoretical contributions found within the Italian context (Amicarelli, Bux, et al., 2021; Ghinoi et al., 2020). Moreover, the numerous cases of COVID-19 have made the region of interest in assessing changes in the agri-food industry in terms of food production, storage and distribution, and to asseverate changes concerning food access, food consumption and food waste behaviour (Amicarelli, Lagioia, et al., 2021; Su et al., 2022). Then, the 40 papers from academics with US affiliations considered several aspects. First, researchers considered how reducing food waste has many positive environmental and socioeconomic ramifications (Sakaguchi et al., 2018).

Additionally, the US has been considered because of its energy-intensive power in food production (Xu & Szmerekovsky, 2017) and testing of consumer-related theories (Hunt & Ortiz-Hunt, 2017). The UK is also prolific in research on the topic, bibliometric analysis notes 37 papers in the sample. Some studies have focused on energy approaches relative to food production (Cooper et al., 2017). Others have considered food waste disposal (Salemdeeb et al., 2017). Other countries with contributions of high numerical value are China (27), Brazil (20), and Australia (17).

Table 3. Country scientific production

Country	**Number of publication**
Italy	43
USA	40
UK	37
China	27
Brazil	20
Australia	19
Spain	17
Austria	11
Turkey	11
Malaysia	9

Source: Author's elaboration

Figure 8 shows the connection between authors by highlighting the significant collaborations worldwide. The European region links academia in the US and China, with Italy and the UK as intermediary channels. However, the United States also cultivates fertile collaborations with the East considering a direct channel. Smaller collaborations see the establishment of academic relations between South America and Europe. Specifically, there are fruitful collaborations between the academy of Brazil and the Iberian peninsula.

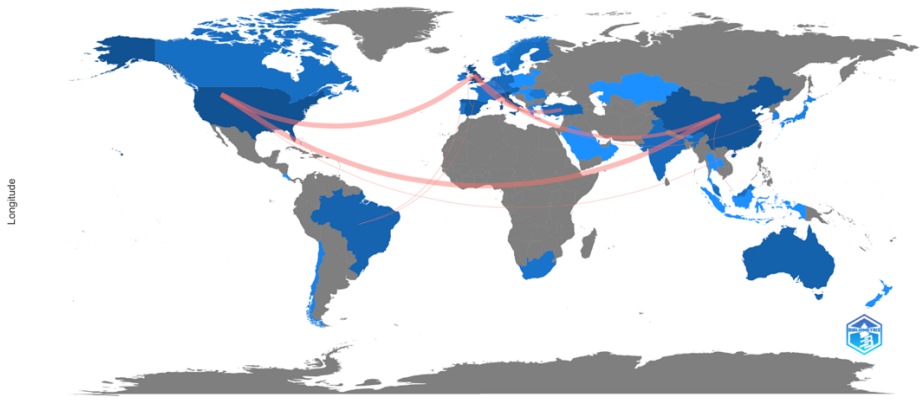

Figure 8. Country collaboration map

Source: Author's elaboration through biblioshiny for bibliometrix

4.6.Thematic analysis

The following section aims to identify items of interest in research related to food waste and industry. Figure 9 shows a dendrogram of topics reflecting the order of keywords created through hierarchical cataloguing and their connection. The authors conducted a multidimensional analysis of the authors' keywords to obtain research related to the topic and feed the debate through the critical elements of the circular economy. The results reveal six different categories.

The brown stream encloses the human and food industry. According to Zeng (2021), consumers are hindered from using renewable packaging by financial, physical, functional, temporal, and social factors in adopting eco-design packaging. The argument extends the theme towards CE in terms of actual consumption (use) of food and the use of reusable packaging (recovery). A second crucial role is a decision-maker. A growing number of studies are looking at transformation (Gadde & Amani, 2016) and the distribution of food (Turan & Ozturkoglu, 2021). The importance of the distribution phase can be seen in the vital transportation and storage phase. A mistake can pose a health risk, a massive food waste to the environment, and negatively impact food suppliers.

The second orange strand focuses on the environmental impact of production and the techniques applied. The food industry is energy-intensive (Notarnicola et al., 2017), and food waste can be used for bio-energy production (Sangeetha et al., 2019). According to Van Zanten et al. (2015), if food waste was used for composting, energy use and related greenhouse gas emissions could decrease. Instead, the link between eutrophication and Life Cycle Assessment (LCA) represents the techniques for processing, evaluating, and recovering food packaging (Bishop et al., 2021).

The purple strand focuses on agricultural food production. Traditional agriculture is being changed through ecological engineering, waste reduction, waste conversion and recycling techniques combined with end-of-pipe treatment techniques (Hai et al., 2016). Therefore, agriculture can be a cornerstone of the food transformation process. This is true if we consider that a critical component of waste materials, such as food waste and household-generated green waste, can produce a high-quality natural fertiliser (Zorpas et al., 2018).

The green stream is about waste treatment. The results highlight two primary directions: wastewater and irrigation water treatment and food waste management. The water scarcity problems have led to scholars' attention to new techniques leading to the reuse of freshwater (Hai et al., 2016). The second strand has focused on the treatment of food waste and the effective collection of waste that can be reused (Fei et al., 2021). Consequently, the management of waste as a resource appears to be a key element under the theoretical model of the CE to pursue the goals of use, recovery, take and transformation (Prieto-Sandoval et al., 2018). In this sense, waste management can be seen as an opportunity by entrepreneurs and managers to diversify their income and enable the sale of waste to stakeholders by diversifying the primary business (Garcia-Garcia et al., 2019)

The blue strand considers numerous aspects. The first is resource efficiency related to waste management in food industries. Recycling in the food industry, waste prevention in the retail industry, and scaling down in the food service industry are the main determinants of waste management (Fujii & Kondo, 2018). However, resource efficiency also appears to be a cornerstone in a CE vision. According to Karabulut et al. (2018), reducing the food production sector can synergise and foster production efficiency. In addition, this stream considers sustainable development. The 17 goals put in place by the United Nations 2030 Agenda have stimulated much research in the food field. These efforts have led researchers' attention to those dealing with hunger, food waste, and environmental destruction. In this sense, the strand presents studies related to the concerns arising from the reuse of food that is considered unsalvageable but still edible (Hlengwa & Sambo, 2019). The CE theme appears to be strongly

coupled with the supply chain (Cooper et al., 2017; Trento et al., 2021). However, it is essential to emphasise the role of the consumer in the food process (Lopes de Sousa Jabbour et al., 2021), which does not appear to emerge sufficiently from the sample under consideration. Finally, an interesting element of this strand is waste prevention, linked to the hospitality industry. From the point of view of a circular economy, the system's predisposition to recycling and waste prevention appears to be a fundamental dimension (Park et al., 2010). To extend the concept to the hospitality industry, consider how it generates significant quantities of food waste (Filimonau & De Coteau, 2019). In particular, financial incentives and careful design of business operations can lead to greater flexibility for retailers and consumers (Coşkun & Filimonau, 2021).

Finally, the red strand focuses on pollution from food production. The risks from composting deserve mention. According to Santos et al. (2018), there are potential environmental risks associated with composting, such as the emission of greenhouse gases. The production of harmful gases is not limited to the reuse phase but also the distribution phase (Stahel, 2016). Notably, food services actively participate in the production of greenhouse gases (Lund-Durlacher & Gössling, 2021).

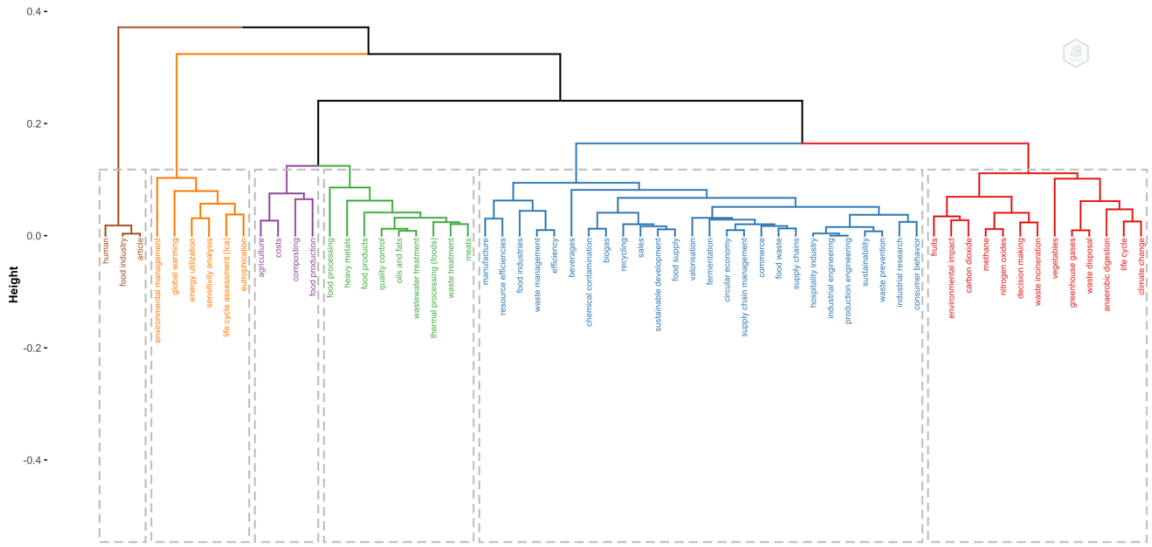

Figure 9. Topic dendrogram via multidimensional scaling

Source: Author's elaboration through biblioshiny for bibliometrix

4.7.Clusters' analysis

This paragraph explores all the connections coming from the research papers selected. In this sense, from Figure 10, some key clusters emerged: food, Waste, Supply, Production, Environmental, Hospitality, and Anaerobic.

Figure 10. Clusters' analysis

Source: Author's elaboration through Leximancer

Table 4 provides the number of occurrences and relevance of words within the papers under analysis. Occurrences are the total number of text context blocks within the data identified by each concept. The percentage of the relevance of the context blocks coded with that concept compared to the most frequent concept in the list. Instead, relevance is a percentage representation of the count value of each concept divided by the single highest count value. As a result, the food concept that is the most frequent has 100% relevance, regardless of whether it recurs in all the context blocks.

Table 4. Ranked theme and concepts

Theme	Occurrences	Relevance	Concepts
Food	15.840	100%	food, industry, sustainable, consumer, practices, social, change, business, retail, economy, literature, role, information, development, work
Waste	10.742	68%	waste, reduce, management, household, sector, amount, results, recycling, generation, method, number, food waste, scale, reported
Supply	1.925	12%	supply, products, consumption, packaging, quality, loss, time, demand, resources, market, meat
Production	1.588	10%	production, process, system, energy, material, technology, life, water, assessment, cycle, gas, conditions, temperature
Environmental	1.165	7%	environmental, impact, economic, value, cost, data, potential, model, activities, including global, online, support, green, design, strategy
Hospitality	556	4%	hospitality, service, hotel, effect, behaviour, restaurants, factors, knowledge, people, control, positive, action, groups
Anaerobic	427	3%	anaerobic, total, organic, emissions, treatment, solid, composting, biogas, carbon, content, acid

Source: Author's elaboration using Leximancer

The red sphere concerns the concept of food in a broad sense. The theme represents the central concept of this research as "waste", which encompasses the dynamics that determine food waste. Its impact is not only the direct one resulting from the excesses of production and food culture but also has effects on natural resources such as water, soil, land and energy (Richards et al., 2021).

The cluster related to dark green production was explored to investigate the current state of the concept. Sustainable operational processes for the management of industrial food waste appear to be the crucial tool for transforming society and human well-being (Alcorn et al., 2021). In this sense, the commitment of different actors in the design of industrial pathways goes towards transforming food waste into raw materials for production, which are combined with ordinary practices of food waste management (Belavina, 2021). The main technical application is maximising production through bioenergy and bio-fertilisers derived from organic waste (Li et al., 2020). On the other hand, attention to surplus and non-perishable foodstuffs close to expiry

is highlighted (Jere et al., 2021). Various strategies aim to counteract food waste and raise awareness of more ethical approaches to food that counteract negative environmental impacts (Richards et al., 2021). Raising awareness of the issue can facilitate industries handling and reusing organic waste. In particular, we highlight two moments in which users can support the reduction of food waste and the proper use of organic waste. On these assumptions, food initiatives can be established to push for the prevention of surplus creation (Rajendran et al., 2019) and the conversion of food waste through clean technology practices (Rodrigues et al., 2021). Technological growth appears to be decisive on the one hand for preserving and increasing food safety and, on the other hand, for the development of packaging with a low environmental impact (Hebrok & Heidenstrøm, 2019). According to Alcorn et al. (2021), industrial food production strives for more efficient energy, water and other natural resources consumed in growing, harvesting, processing and delivering food for consumption. However, not all food waste comes from edible food. Discarded food and separated inedible parts cannot become food waste but must be considered for primary production activities and food uses such as feed production (Redlingshöfer et al., 2017). The last aspect has emerged as one of the most discussed within the European community, in particular. The European Union has established a preferred hierarchy that sees the reduction of food waste in the first place followed by redistribution and recycling as animal feed which is currently not an accepted practice as it is currently illegal to use most food waste as feed in the EU (Salemdeeb et al., 2017). The hierarchy follows in compost creation, from energy recovery through anaerobic digestion and only if there is no alternative from landfilling (Salemdeeb et al., 2017).

Supply (light blue, Figure 10) and anaerobic (purple) concepts are closely related to the production phase. The concept of supply involves business processes, network structure and technology (Arlbjørn et al., 2011). In pursuing a paradigm shift leading to a reduction in waste, supply chain innovation that includes technological or business process changes to create new value for stakeholders appears significant (Jensen et al., 2013). In combating food waste, several elements of the supply chain are critical. At the transport stage, cooling equipment is critical. At the same time, at distributors, wholesalers and retailers, food waste results from operational factors including inadequate packaging, mishandling, poor ordering policies and expiry date (Kazancoglu et al., 2021). The treatment of recycled food waste sees two alternative directions: firstly, composting and secondly, anaerobic digestion for biogas production, a practice estimated to be carried out on 17.4% of organic waste to date (Ridoutt et al., 2010).

Anaerobic digestion appears to be a sustainable energy source capable of limiting waste generation by favouring energy and food waste recovery during treatment (Li et al., 2020).
Finally, the last cluster investigates the concept of "hospitality", understood as the sector that includes hotels, restaurants, bars, canteens and catering, and food services in facilities such as schools, universities, and health care (Dhir et al., 2020).

5. Discussion

Food waste management has been considered in several SDGs of the United Nations 2030 Agenda (Pizzi et al., 2020; Santagata et al., 2021). The treatment of food waste has been referred to as goal number 2, called zero hunger (Karki et al., 2021), goal number 12 on responsible consumption and production, goal number 17 on public-private partnerships (de Visser-Amundson, 2020) or some sub-goals of goal number 12 (Lemaire & Limbourg, 2019). However, the cluster analysis shows relevance with target 7.2 related to significantly increasing the share of renewable energy in the overall energy mix (Ridoutt et al., 2010; Salemdeeb et al., 2017). In addition, differences emerge between the theme of hospitality and objective 12.b, which aims to develop and implement tools to monitor sustainable development impacts for sustainable tourism, which creates jobs and promotes local culture and products (Dhir et al., 2020; Filimonau & De Coteau, 2019). Finally, objective 15 aimed at protecting, restoring and promoting the sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, halting and reversing land degradation and halting biodiversity loss (Karabulut et al., 2018; Richards et al., 2021) should be considered in the overall model.
The following section will be on CE approaches to reducing food waste, waste management and recovery and converting organic waste into raw materials for production (Belavina, 2021). The present study uses the CE concept as implemented by Prieto-Sandoval et al. (2018) to discuss the results from a circular economy perspective for dealing with food waste for industries. According to Lieder & Rashid (2016), CE is defined as a closed-loop material flow throughout the economic system that considers financial aspects while minimising matter and limiting economic growth.

5.1 Transformation

The transformation of food waste in the industrial context into resources focuses on production processes and trade (de Jesus et al., 2016). CE emerges as a paradigm capable of fostering sustainable development (Geissdoerfer et al., 2017). Transformation represents a solution to enable cycle closure by implementing specialised engineering for waste conversion and end-of-cycle treatment techniques (Hai et al., 2016). In addition, waste transformation must

consider the organic component and the effects on natural resources such as water, soil, land, and energy (Richards et al., 2021). Therefore, stakeholder solutions consider transforming food waste into raw materials for production (Belavina, 2021). The literature review highlighted numerous transformative techniques for the reintegration of food waste, which can be used as a high-quality natural fertiliser (Zorpas et al., 2018) or undergo chemical transformation processes such as anaerobic digestion to produce the production of biogas or biofuels (Li et al., 2020). Further reflection should involve all food waste that does not originate from edible food and needs to be reintegrated within the primary process or for secondary food uses (Redlingshöfer et al., 2017).

5.2 Distribution

CE is closely related to the supply chain concept involving business processes, network structure and technology (Arlbjørn et al., 2011; Cooper et al., 2017). Innovations related to the supply chain must include technological changes to ensure the equipment and cooling status necessary for safe food storage (Jensen et al., 2013; Messner et al., 2021). Furthermore, the production of harmful gases and greenhouse gases negatively affects the food supply chain (Lund-Durlacher & Gössling, 2021). Marketers' conditions determine the level of food waste through inadequate packaging, mishandling, poor ordering policies, and expiry dates (Kazancoglu et al., 2021).

5.3 Use

In a CE context, attention needs to be paid to the importance of surplus reduction and food expiry (Jere et al., 2021). Several strategies aim to combat food waste by raising awareness of more ethical approaches to food (Richards et al., 2021). The hospitality sector is affected by the dynamics between guest behaviour, employee behaviour and managerial protocols (Filimonau & De Coteau, 2019). A CE system observes the system's readiness for recycling, and waste prevention appears to be an essential dimension (Park et al., 2010). Greater alignment between retailers' and consumers' desires can facilitate CE aligned business operations (Coşkun & Filimonau, 2021).

In this context, consumer sentiment appears crucial in driving toward CE, as consumers can be critical actors in the disposal of organic waste from food consumption (Borrello et al., 2017). Consumer status appears contradictory as consumers may be hindered from using renewable packaging due to financial, physical, functional, temporal and social factors in adopting eco-design packaging (Zeng, 2021). Therefore, for effective fitting with the CE paradigm, it appears necessary to encourage a change in culture and value perception (Jensen et al., 2013).

5.4 Recovery

The recycling of raw materials appears to be an essential resource under the CE model to pursue the objectives of a closed-loop economic model (Prieto-Sandoval et al., 2018). Treated food waste can be efficiently collected for reuse (Fei et al., 2021). In this sense, waste recovery can be seen as an opportunity for entrepreneurs and managers to diversify their business by selling product waste that, if repurposed, finds a new purpose/value (Garcia-Garcia et al., 2019). The EU established the preferential hierarchy for food waste reduction wants recovery activity by composting or as the basis of chemical processes to be reused as secondary routes placing excess reduction and redistribution as preferred routes (Salemdeeb et al., 2017).

5.5 Take

The food industry is energy-intensive, and the solution of a CE model should meet the need through bio-energy produced through food waste take (Notarnicola et al., 2017; Sangeetha et al., 2019). Therefore, it is advocated to be used to maximise production through bioenergy and biofertilisers derived from organic waste (Li et al., 2020). However, the packaging is also a key element. Indeed, various techniques such as eutrophication and LCA represent solutions for the processing, evaluation and recovery of food packaging (Bishop et al., 2021). Technological developments lead to cleaner production practices to preserve and increase food safety and develop environmentally friendly packaging (Hebrok & Heidenstrøm, 2019).

6. Conclusion

Food waste has been considered a problem in the industrial sector from two perspectives. Firstly, the environmental impact of production on the planet (Notarnicola et al., 2017). Secondly, an imbalance between countries with a food surplus and a food deficit (Pollard & Booth, 2019). The aim of this study was to explore elements and variables that affect food waste in the production sector and guide industrial managers toward the best practices. Based on bibliometric and cluster analysis, we identified several drivers that influence the problem of food waste. The 163 scientific articles extracted between 2010 and 2021 demonstrate substantial growth in author productivity in several countries worldwide.

Additionally, the analysis reveals high-impact scholars such as Professor Amicarelli and Professor Bux in the field. On the other side, considering the h- and g-index, Professor Tsang DCW also appears prominent in this field. Furthermore, the thematic analysis of papers' keywords identifies six main topics (1) Humans and their relationship with the food industry,

(2) Environmental impact of production and applied techniques, (3) Agricultural food production, (4) Waste treatments, (5) Waste management and prevention, and (6) Food pollution. Finally, cluster analysis identifies the number of occurrences and relevance of words and highlights the terms "Food, Waste, Supply, Production, Environmental, Hospitality and Anaerobic".

6.1 Theoretical implications

Several theoretical implications emerged from the research (Table 5). First, the study of multidisciplinary topics through bibliometric methods that allow the definition of research strands and clusters was shown to be fitting. Consequently, state of art on the topic capable of mapping the research topic and extending it by providing variables for further qualitative and qualitative studies was obtained. This implication proves valuable for advancing studies in food waste management and meeting the sustainability goals emerging from Agenda 2030. Consistently, light has been shed on the need for cooperation between academics and practitioners in devising innovative food waste management systems (Michalec et al., 2018; Sakaguchi et al., 2018). As a result, the topic under analysis has proven to be a sure trend in the coming years, and the present contribution allows greater certainty for future researchers. Finally, the study shows how the circular business model fits waste management. In particular, the connection points represent problems common to academics and practitioners that can be analysed with the theoretical keys of transformation, distribution, use, and recovery.

Table 5. Key elements emerging

Main information	**Key elements**	**Authors**
Transformation	Circular business model	(Notarnicola et al., 2017)
	Energy-intensive	(Garcia-Garcia et al., 2019)
Distribution	Compostable packaging; Health Risks	(Turan & Ozturkoglu, 2021)
Use	Ethical consumption	(Zeng, 2021)
Recovery	Bio-energy production	(Sangeetha et al., 2019)
Take	Greenhouse gas emission	(Zorpas et al., 2018)

Source: Author's elaboration

6.2 Practical implications

The present findings include also some interesting practical implications. Specifically, we find that limiting food waste requires a closer relationship between people and food, looking into more culture-oriented studies that explore the impact of waste. Secondly, companies must consider the environmental impact and transparency of food production. Thirdly, attention to waste should start with agricultural production. Fourthly, companies should equip themselves with advanced production facilities to mitigate food waste by adapting their circular business models. Fifthly, consumers themselves should demand anti-waste measures from companies and agreements with organisations to transfer food to the disadvantaged. Sixthly, more evidence should be given to the pollution caused by food production.

6.3 Limitations

The study has been restricted by various limitations. Firstly, adopting the Scopus database alone may limit the sample of articles selected. Therefore, we cannot exclude non-favourable scientific contributions. Secondly, the thematic analysis performed, although conducted independently by the researchers, might include elements of the subjectivity of the investigation. Lastly, the use of keywords could limit the scope of the research conducted so far.

6.4 Future research implications

The present research makes it possible to propose further progress in the field from the limitations. Consequently, future studies could use other databases such as the Web of Science and multiple search streams. In addition, thematic analysis techniques could be refined by favoring the selected sample through specific research software that can delineate managers' feelings and variables on the issue of food waste. In addition, research initiatives based on single or multiple case studies could be conducted to explore virtuous initiatives. Finally, further studies could investigate consumers' perceptions of food waste by companies. This could activate knowledge exchange zones between consumers and business owners and derive additional variables that the food sector could use to mitigate the impact of food waste. Finally, the multidisciplinary nature of the topic allows the study to be extended to different fields of research. In particular, the research emphasizes the importance of collaboration between

different disciplinary fields in the hard sciences and the humanities to explore best practices that can be implemented to change the current production paradigm.

Conflict of Interest Statement

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