Received 25 January 2022
Revised 17 May 2022
15 June 2022
11 July 2022
Accepted 12 July 2022

Towards circular economy practices in food waste management: a retrospective overview and a research agenda

Sara Alonso-Muñoz, Fernando E. García-Muiña,
María-Sonia Medina-Salgado and Rocío González-Sánchez
Department of Business Administration (ADO), Applied Economics II and Fundaments of Economic Analysis, Rey Juan Carlos University, Madrid, Spain

Abstract

Purpose – This study aims to offer a research overview of circular food waste management, covering key themes and trends. It analyses state-of-the-art research in this field and proposes an agenda to guide future research.

Design/methodology/approach – This study outlines bibliometric analysis from a sample of 349 articles with VOSviewer and SciMat software to identify research trend topics.

Findings – The findings reveal a substantial amount of interest in this field. The main research topics relate to the recovery processes and valorisation of food waste and its conversion into renewable and cleaner materials or energy sources, towards circularity. However, these processes require consideration of social aspects that facilitate their implementation, which are currently under-researched.

Practical implications – Companies can target their circular food waste management by considering three key aspects. Firstly, the establishment of closer and more sustainable relationships with various stakeholders; Secondly, a regulatory framework and the support of institutions are both required for the correct implementation of circularity. Finally, what is not measured does not exist. It is therefore necessary to establish indicators to measure both the level of development of circularity in waste management and the fulfilment of the established objective.

Originality/value – This bibliometric analysis looks at the application of circularity principles in food waste management from a holistic perspective, considering different areas of knowledge.

Keywords Food waste, Waste management, Circular economy, Supply chain, Bibliometric analysis, Research agenda, Thematic analysis, Research hotspots

Paper type Research paper

1. Introduction and background

Achieving a more sustainable food system is relevant in terms of both economic efficiency and new ethical standards in our society. This interest has been intensified by the need to achieve the sustainable development goals (SDGs) that would enable improved food security and sustainability (Santeramo, 2021). Specifically, SDG 12.3 for the fulfilment of the 2030 Agenda, which highlights the importance of halving, per capita, food waste at retail and

Funding: The study is funded by REDiRECT: REDuce REuse Ceramic Tiles, V1093-80345, GRUPPO CERAMICHE GRESMALT S.P.A. 5th Plan for the Promotion of Research - Faculty of Law and Social Sciences, Rey Juan Carlos University.

British Food Journal
Vol. 124 No. 13, 2022
pp. 478-500
Emerald Publishing Limited
0007-070X
DOI 10.1108/BFJ-01-2022-0072

consumer levels and reducing food losses along production and supply chains (United Nations, 2015; Närvänen *et al.*, 2020). This requires a break with the current linear system of the food supply chain, based on value chains inspired by the expression "from field to fork" (Béné *et al.*, 2019). In these linear food systems, raw materials are extracted and transformed into final products. Final consumption or generation of food waste is disposed of with little reuse or recovery. A change that is already reflected in Ericksen's seminal work (2008, p. 2) and referred to as "feedback loops". New trends for a more sustainable food industry require further research. One such trend argues for an application of circularity principles to the food supply chain (Santeramo, 2021).

Food waste is a part of biodegradable waste, discharged by humans, which reflects environmental and health issues (Paritosh *et al.*, 2017). UNEP (2021) The Food Waste Index Report calculated that in 2019, around 931 million tons of food waste were generated: 61% from households, 26% from food services and 13% from retail. Food waste is particularly common in developed countries (Börühan and Ozbiltekin-Pala, 2022). In Europe, around 50% of the global municipal solid waste is food waste (Ananno *et al.*, 2021). Thus, new methods of food waste management are required in its treatment (Pattnaik and Reddy, 2010; Paritosh *et al.*, 2017).

The benefit of reducing food waste from a circular perspective has environmental, economic and social impacts. At the environmental level, food waste is considered a great contributor to climate change and greenhouse gas emissions and a large consumer of energy or materials (Krishnan *et al.*, 2020; Närvänen *et al.*, 2020). From an economic perspective, circular waste management reduces costs and results in lower food prices (Despoudi *et al.*, 2021). At the social level, reducing food waste through the utilisation of unwanted food is beneficial for alleviating hunger (Chauhan *et al.*, 2018).

Circular supply chain management involves all functions of a supply chain by exercising greater control over all stages or processes with increased efficiency, resulting in greater reductions to cost and higher levels of food quality and safety (Corrado and Sala, 2018; Krishnan *et al.*, 2020; Närvänen *et al.*, 2020). Closed-loop food supply chain implies a circular economy approach with the use of reverse logistics systems, by means of food waste recycling and reuse (Jabbour *et al.*, 2021).

In the food supply chain, waste and loss occur at different points in the food value chain (Schuster and Torero, 2016). Food loss occurs in the early stages, such as in production, while food waste takes place in the subsequent stages; mainly focused on food distribution and consumption (Parfitt *et al.*, 2010). Since application of the circular principles involves differing approaches, depending on the phase analysed, this study has focused on waste management as it affects more stages of the supply chain.

Indeed, recent studies highlight the need for further research on the implementation of circularity, considering aspects such as improved processes: collection, storage, the adoption of new technologies and the creation of new infrastructure and transport (Cicculllo *et al.*, 2021; Santeramo, 2021). Similarly, further knowledge related to new behaviours and the establishment of cooperative arrangements with other actors is needed. New routines and habits among consumers and retailers are required for the reduction of food waste from a circular and green economy perspective (Aschemann-Witzel *et al.*, 2017; Welch *et al.*, 2018; Santeramo, 2021).

Bibliometric studies on food waste management have been published, focusing on aspects such as: (1) the context in which it is produced–the urban context (Zhong *et al.*, 2021) or in the coffee sector (Kourmentza *et al.*, 2018), (2) the processes or technologies with which it is produced or related, - the food loss ,food waste and food safety nexus (Santeramo and Lamonaca, 2021), the food waste hierarchy (Teigiserova *et al.*, 2020) or digitisation in food supply chains (Rejeb *et al.*, 2022).

There are previous bibliometric articles associating waste management with the circular economy, yet in specific aspects, focusing mainly on processes such as recovery, waste-to-energy, bio-refinery, anaerobic digestion and pyrolysis (Germar *et al.*, 2021). Context has also been considered in the analysis of the reviewed works. For instance, municipal solid waste management (Tsai *et al.*, 2020) or the crisis state marked by Covid-19 and healthcare waste management (Ranjbari *et al.*, 2022a, b). Two of these papers focus on specific aspects of the food sector. Casallas-Ojeda *et al.* (2021) examined the cheese whey transformation into energy by means of anaerobic digestion. Ranjbari *et al.* (2021) analysed research topics related to circular food waste management highlighting the bio-plastic-based food packaging.

Our bibliometric analysis makes a new contribution to those already published by considering food waste management and the circular economy from a holistic perspective. Regarding the fragmentation of research on this topic and its markedly technical nature, it is necessary to reflect on state-of-the-art research and guide future research from a comprehensive and managerial standpoint. Research is at its most useful when it reaches practical application. Therefore, its development should facilitate the implementation of the concept under study. To provide a research overview on the application of circularity in food waste management and the main trends of research, this paper proposes the following research questions:

RQ1. What is the historical evolution of the literature on circular economy and food waste?

RQ2. Which are the most influential journals, authors, countries and institutions that have published content on this research topic?

RQ3. What is the conceptual structure in this research stream?

RQ4. What are the future research agendas and patterns related to circular economy and food waste?

This paper is structured as follows. Following the introduction and literature background, the methodology and bibliometric results are presented as: (1) the historical evolution of publications, (2) the most influential journals in the field of circular economy and food waste; authors, countries and institutions most cited and the research areas involved, (3) thematic organisation in the field, using the co-occurrence analysis by VOSviewer and SciMat to detect research trends. Subsequently, we established key points for the development of a research agenda: the discussion, and finally, the conclusions.

2. Methodology

This paper employs bibliometric analysis methodology combined with thematic analysis of the literature, considering articles that contain the most co-occurrent keywords. In this way, research hotspots are identified, to support the proposal of a research agenda. This analysis allows us to make theoretical and practical contributions of interest to researchers and practitioners.

To synthesise previous studies and findings, it is essential to study the relationship between knowledge elements, such as keywords in co-word analysis (Cobo *et al.*, 2011). Bibliometric methods follow a quantitative approach of visual representation that is widely used in fields such as management, entrepreneurship or innovation. These methods provide evidence to explore the connections of the intellectual structure of a field of study (Zupic and Cater, 2014; Donthu *et al.*, 2021). By interpreting bibliographic data, it is possible to identify the evolution and currents of research (van Eck and Waltman, 2010) and eventually characterise the state of development of a specific field (Boyack and Klavans, 2014; Powell *et al.*, 2016; Garousi and Mantyla, 2016). The citation analysis and co-occurrence analysis are the main methods that we used in the present paper.

Figure 1 shows the methodological process carried out in this article which is divided into four phases: (1) data collection, (2) bibliometric analysis, (3) research trend topics identification and (4) research agenda.

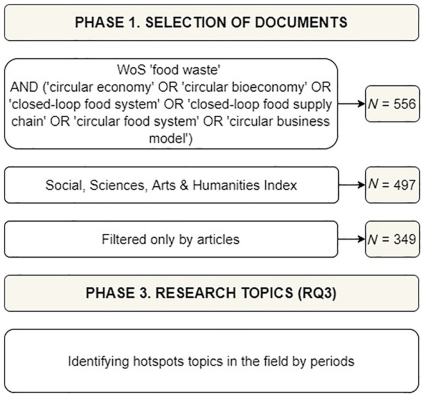


Figure 1.
Methodological process

For the data collection, documents were retrieved from the Web of Science Database, December 2021. The selection of documents was carried out combining the terms: "food waste" AND ("circular economy" OR "circular bioeconomy" OR "closed-loop food system" OR "closed-loop food supply chain" OR "circular food system" OR "circular business model"). The terms were filtered by topic, including title, abstract and author keywords, within the period 2015 to 2021, obtaining 556 results. Then, we sorted this by Social, Science Citation Index and Arts and Humanities Citation Index, retrieving 497 papers. Finally, we excluded Conference Proceedings Citation Index and Book Citation Index, filtered only by articles and obtaining a total sample of 349 documents.

In the second phase, we examined the historical evolution of publications, the most influential journals, authors, institutions, countries and research areas on the subject. Then, we conducted a co-occurrence analysis by VOSviewer and SciMat software to analyse the thematic organisation. Both are utilised to perform a co-word analysis (keyword co-occurrence). (1) VOSviewer tool is used to map the scientific research topics in the entire period under review (2015–2021) and to identify the research trend topics according to: the occurrences, the average publication year, the average citations and the link strength between keywords (phase 3). (2) SciMat provides a strategic diagram for period 2 (2020–2021), which serves to analyse, in detail, the research trend topics (phase 3). Finally, in the fourth phase, we proposed a research agenda for future opportunities and further development of the field.

3. Results

3.1 Historical evolution of publications

Figure 2 shows the evolution of publications in the field. Since 2015, there has been an increase in papers published, coinciding with two important milestones: The 2030 Agenda for Sustainable Development approved by The United Nations General Assembly; and the Circular Economy Package by The European Commission. Hence, this field is gaining momentum for research (Rizos *et al.*, 2015). The years 2020 and 2021 are the most representative, and for that reason, a section about trending topics in the field is covered in this work.

3.2 Most influential journals

Table 1 shows the most productive journals in the field. These sources represent 47.85% of the total sample, which means 167 articles from 349 documents, retrieved by WoS.

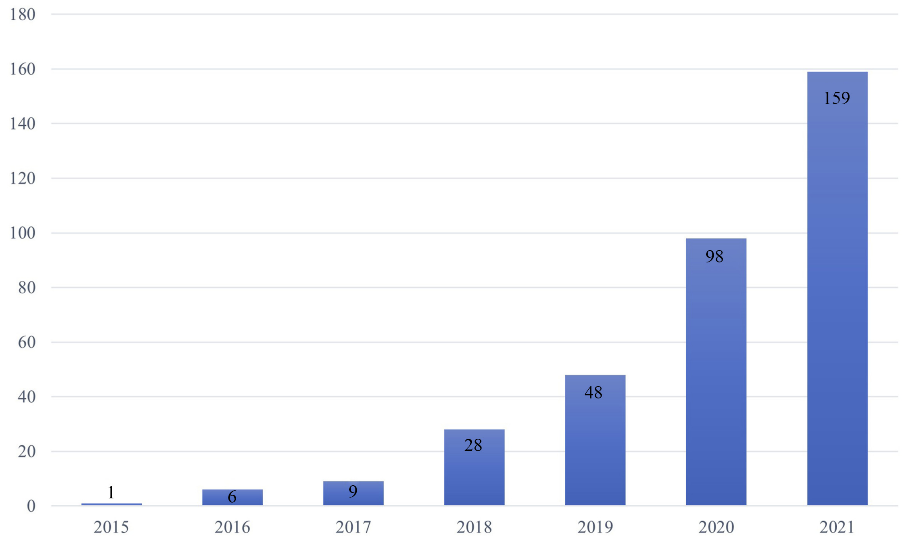


Figure 2.
Historical evolution of publications in the field

Journals	JCR (2021)	Quartiles	Category	*C*	*D*	%
Journal of cleaner production	11.072	Q1 (24/279)	Environmental sciences	1,032	41	11.75%
Waste management	8.816	Q1 (36/279)	Environmental sciences	607	23	6.59%
Science of the total environment	10.753	Q1 (26/279)	Environmental sciences	589	18	5.16%
Sustainability	3.889	Q2 (133/279)	Environmental sciences	378	29	8.31%
Bioresource technology	11.889	Q1 (13/119)	Energy and fuels	313	10	2.86%
Resources conservation and recycling	13.716	Q1 (12/279)	Environmental sciences	246	13	3.72%
Renewable and sustainable energy reviews	16.799	Q1 (8/119)	Energy and fuels	238	11	3.15%
Energies	3.252	Q3 (80/119)	Energy and fuels	138	13	3.72%
Environmental science and pollution research	5.190	Q2 (87/279)	Environmental sciences	120	9	2.58%

Note(s): Abbreviation: *D* = number of documents; % = from the sample of documents (*N* = 349) *C* = total number of citations

Table 1.
The most representative journals in the field

3.3 Authors, institutions, countries and research areas

Table 2 shows the most productive authors in the field, with more than 3 articles published. In addition, their influence is considered regarding total citations. Underscored, was the fact that most of them are working for The University of Manchester, in United Kingdom.

From 349 documents selected, 87.36 and 21.23% is represented and gathered, respectively, showing the 10 most influential countries and institutions. According to the different research areas, as can be seen in Table 3, there is a greater wealth of research related to environmental and technological sciences.

R	Author	Organization	Country	D	C
1	Sala, S	Joint Research Centre (JRC)	Brussels	3	248
2	Azapagic, A	The University of Manchester	United Kingdom	4	219
3	Cuellar-Franca, R	The University of Manchester	United Kingdom	3	186
4	Jeswani, H.K.	The University of Manchester	United Kingdom	3	186
5	Slorach, P.C.	The University of Manchester	United Kingdom	3	186
6	Zorpas, A.A.	Open University of Cyprus	Cyprus	4	149
7	Principato, L	Roma Tre University	Italy	3	140
8	Secondi, L	University of Tuscia	Italy	3	140
9	Mohan, S.V.	CSIR-Indian Institute of Chemical Technology	India	6	131
10	D'adamo, I	Sapienza University of Rome	Italy	4	129

Note(s): Abbreviations: *R* = rank; *D* = total of documents published; *C* = total number of citations

Table 2. Ten most cited authors in the field

R	Countries	D	%	Institutions	D	%	Research areas	D	%
1	Italy	79	22.63%	Sapieza University Rome	10	2.87%	Environmental sciences	180	51.57%
2	United Kingdom	43	12.32%	Council of Scientific Industrial Research CSIR India	9	2.58%	Engineering environmental	106	30.37%
3	Spain	43	12.32%	University of Milan	8	2.29%	Green sustainable science technology	101	28.94%
4	Peoples R. China	36	10.31%	Hong Kong Polytechnic University	7	2.01%	Energy fuels	56	16.05%
5	India	22	6.30%	National Research Institute for Agriculture, Food and the Environment (France)	7	2.01%	Environmental studies	38	10.89%
6	United States	19	5.44%	Parthenope University Naples	7	2.01%	Chemistry multidisciplinary	28	8.02%
7	Germany	17	4.87%	University of Cantabria	7	2.01%	Engineering chemical	28	8.02%
8	Brazil	16	4.58%	University of Naples Federico II	7	2.01%	Biotechnology applied microbiology	27	7.73%
9	France	16	4.58%	Indian Institute of Chemical Technology IICT	6	1.72%	Food science technology	26	7.45%
10	Sweden	14	4.01%	University of Ca Foscary Venezia	6	1.72%	Agricultural engineering	13	3.72%

Note(s): Abbreviations: *R* = rank; *D* = number of documents; % = from the sample of documents (*N* = 349)

Table 3. Distribution of articles by most influential countries, institutions and research areas

4. Thematic organisation of the field

4.1 Co-occurrence analysis by vosviewer software: discovering research hotspots

In a co-occurrence analysis, the links and frequency between keywords help to find the research topics they represent, contributing to comprehending the cognitive structure of a specific field (Börner *et al.*, 2003) and to locating the hot topics of a research stream (Schildt *et al.*, 2006).

The VOSviewer output (Figure 3) shows the co-word analysis in the field from 2015. There are 4 clusters grouped by keywords, represented in red, green, blue and yellow. According to the main research focus in the field and considering the strength of the links between the keywords, these clusters are created from a threshold based on the co-occurrence identified by the VOSviewer software. The total link strength measures the strength between the keyword relationship (van Eck and Waltman, 2010). For this case, out of the 349 articles selected, we obtained 2,161 words, with a minimum of 10 occurrences, 44 keywords met the threshold.

Table 4 has been elaborated to better understand the structure and content of the identified clusters, along with the research trend. It shows clustered keyword information on their occurrences, their average publication year -when the keyword appears- (Figure A1 Appendix), the average citations of the article that contains the keyword, the number of links -the number of keywords that a keyword co-appears with in a paper- and the total link strength which points the total strength of the keyword links. Additionally, the five most co-occurring keywords are presented.

4.1.1 Cluster 1: anaerobic digestion. The first cluster in red relates “food waste” to “anaerobic digestion”. Anaerobic digestion is a process of decomposing biodegradable material which releases gases used as energy. The “sewage-sludge” obtained within food waste produces volatile fatty acids that allow the production of bio-fuels (Battista *et al.*, 2020), eventually generating value from organic waste.

Most of the keywords in this cluster relate to the production of “biogas” by means of “municipal solid waste” in the anaerobic digestion and the “co-digestion” phase. This process is considered for the generation of “renewable energy” – the most recent keyword of this cluster-towards biofuels production such as the biomethane (Paul *et al.*, 2018) to achieve a reduction of “greenhouse-gas emissions” (Cecchi and Cavinato, 2019).

4.1.2 Cluster 2: circular food supply chain. The green cluster links new sustainable systems in food supply chains applying circular principles. It is fundamental to modify the linear and traditional supply chains models towards “sustainability” -the most common keyword of the analysis, and circular business systems to improve “performance” and “management”. This new framework suggests challenges in consumption patterns (Fogarassy *et al.*, 2020),

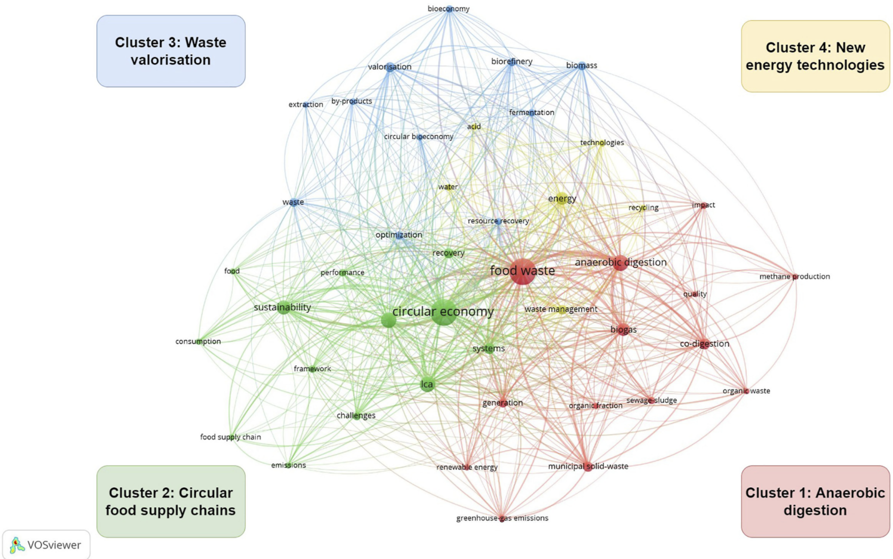


Figure 3.
Co-occurrence analysis by VOSviewer software

Keyword	Occurrences	APY	AC	Links	TLS	Most co-occurring keywords
Cluster 1: Anaerobic digestion						
Food waste	196	2020.02	17.20	43	685	Circular economy (117); anaerobic digestion (51); LCA (40); management (38); sustainability (36)
Anaerobic digestion	73	2019.86	20.04	39	322	Food waste (51); circular economy (37); biogas (26); energy (19); co-digestion (12)
Biogas	44	2019.74	21.80	35	221	Food waste (34); anaerobic digestion (26); circular economy (23); co-digestion (17); biogas (12)
Co-digestion	33	2019.91	20.39	31	153	Food waste (25); circular economy (18); biogas (17); anaerobic digestion (12); energy (9)
Municipal solid waste	29	2019.86	22.55	31	136	Food waste (18); circular economy (15); anaerobic digestion (14); LCA (12); systems (8)
Generation	21	2019.79	22.19	34	96	Circular economy (12); biogas (7); anaerobic digestion (3); municipal solid waste (3); energy (3)
Sewage-sludge	15	2020.07	15.80	27	69	Circular economy (12); food waste (11); co-digestion (8); biogas (4); management (3)
Impact	14	2020.14	14.07	21	57	Food waste (13); circular economy (8); anaerobic digestion (6); LCA (5); biogas (3)
Greenhouse-gas emissions	12	2019.50	21.42	21	59	Food waste (7); municipal solid waste (6); LCA (6); systems (5); anaerobic digestion (4)
Organic waste	11	2019.45	21.18	20	54	Circular economy (9); food waste (7); anaerobic digestion (7); circular economy (6); LCA (4)
Renewable energy	10	2020.20	15.00	22	52	Circular economy (7); food waste (6); Biogas (7); municipal solid waste (4); LCA (3)
Organic fraction	10	2020.11	15.60	19	42	Circular economy (6); LCA (4); municipal solid waste (4); co-digestion (4); food waste (3)
Methane production	10	2019.80	19.30	15	37	Food waste (7); anaerobic digestion (6); co-digestion (5); biogas (4); circular economy (2)
Quality	10	2019.60	21.50	16	31	Circular economy (6); food waste (5); organic waste (2); generation (2); municipal solid waste (2)
Cluster 2: Circular food supply chains						
Circular economy	197	2020.10	15.57	42	666	Food waste (117); management (48); LCA (42); sustainability (39); anaerobic digestion (37)
LCA	67	2019.87	19.58	40	305	Circular economy (42); food waste (40); anaerobic digestion (22); management (18); sustainability (14)
Management	67	2020.34	14.90	41	301	Circular economy (48); food waste (38); anaerobic digestion (20); LCA (18); recovery (8)

(*continued*)

Table 4.
The major research topics in the field

Keyword	Occurrences	APY	AC	Links	TLS	Most co-occurring keywords
Sustainability	55	2020.48	14.95	37	207	Circular economy (39); food waste (36); management (15); LCA (14); framework (7)
Systems	33	2019.23	16.36	39	157	circular economy (20); food waste (19); LCA (13); anaerobic digestion (10); municipal solid waste (7)
Recovery	27	2020.04	15.15	35	105	Circular economy (20); food waste (12); management (8); sustainability (5); systems (3)
Challenges	18	2020.12	22.78	28	83	Circular economy (14); food waste (11); management (8); sustainability (5); framework (4)
Performance	17	2020.31	17.41	30	80	Food waste (13); circular economy (12); sustainability (5); waste management (4); biogas (4)
Framework	16	2019.67	25.06	25	75	Circular economy (13); food waste (10); management (9); LCA (4); challenges (4)
Emissions	11	2019.64	24.73	20	44	LCA (6); circular economy (5); anaerobic digestion (4); sustainability (4); energy (3)
Consumption	11	2020.20	15.55	15	42	Circular economy (8); food waste (6); management (5); systems (4); sustainability (4)
Food supply chain	10	2020.20	20.00	13	38	Circular economy (7); management (3); emissions (3); challenges (3); LCA (3)
Food	10	2019.90	18.30	19	33	Circular economy (7); sustainability (4); food waste (3); recovery (2); systems (2)
Cluster 3: Waste valorisation						
Valorisation	29	2020.32	12.28	30	109	Circular economy (18); food waste (13); management (8); LCA (7); anaerobic digestion (6)
Biomass	23	2020.04	18.04	27	94	Food waste (13); circular economy (9); energy (8); anaerobic digestion (7); biorefinery (6)
Waste	20	2020.05	18.65	26	58	Circular economy (11); management (5); food waste (4); LCA (3); sustainability (3)
Biorefinery	18	2019.82	24.67	28	77	Food waste (12); circular economy (8); biomass (6); sustainability (4); anaerobic digestion (3)
Optimization	18	2019.89	17.00	30	73	Food waste (10); circular economy (8); management (5); LCA (5); biogas (4)
Bioeconomy	15	2020.43	17.60	22	71	Food waste (11); circular economy (8); valorisation (6); anaerobic digestion (6); management (5)
Fermentation	15	2020.40	17.33	24	50	Food waste (10); anaerobic digestion (5); circular economy (4); biomass (3); valorisation (3)
Resource recovery	14	2020.36	15.57	27	61	Circular economy (12); anaerobic digestion (4); biogas (4); sustainability (3); energy (2)

Table 4. (*continued*)

Keyword	Occurrences	APY	AC	Links	TLS	Most co-occurring keywords
By-products	14	2020.36	14.36	21	54	Circular economy (7); management (7); food waste (6); valorisation (4); extraction (3)
Circular bioeconomy	12	2019.92	21.08	17	33	Food waste (7); anaerobic digestion (3); optimization (3); resource recovery (2); fermentation (2)
Extraction	11	2020.45	9.82	15	26	Circular economy (5); food waste (3); by-products (3); valorisation (3); waste (2)
Cluster 4: New energy technologies						
Energy	45	2019.51	25.31	37	210	Food waste (32); circular economy (27); anaerobic digestion (19); LCA (14); biogas (13)
Waste management	26	2020.12	20.62	28	108	Food waste (19); circular economy (16); LCA (11); anaerobic digestion (8); energy (6)
Technologies	12	2020.27	26.42	27	52	Circular economy (8); food waste (7); management (5); anaerobic digestion (3); LCA (2)
Water	12	2020.08	14.75	19	39	Food waste (6); circular economy (5); management (3); sustainability (3); energy (3)
Acid	11	2019.82	9.27	17	27	Food waste (4); anaerobic digestion (3); circular economy (2); biogas (2); LCA (2)
Recycling	10	2019.20	26.80	17	32	Food waste (6); circular economy (5); energy (3); waste management (3); systems (2)

Note(s): Abbreviations: APY = average publication year; AC = average citation; TLS = total link strength

Table 4.

improving food "recovery" for preventing food surplus and achieving a closed-loop food supply chain (Teigiserova *et al.*, 2020).

In addition, this node pertains to "Life Cycle Assessment" (LCA), an analytical technique for assessing the environmental impacts associated with all stages of a product's life. Researchers have frequently used this methodology to measure the environmental impact of food supply chains (Krishnan *et al.*, 2020).

4.1.3 Cluster 3: waste valorisation. In the blue node, keywords focus on "waste valorisation" linked with the "optimisation" and a "resource recovery" from food waste. The "extraction" process, the most recent keyword of the cluster, is involved in food waste valorisation and biorefinery technology (Zuin *et al.*, 2020; Ebikade *et al.*, 2020). The "fermentation" process is linked to food raw materials in biogas production (Kumar *et al.*, 2021).

The "biorefinery" technology produces bio-based value products via organic waste recycling (Moretto *et al.*, 2020). This plays a key role towards "circular bioeconomy". Bioeconomy supports the replacement of fossil carbon with "biomass". Circularity practices in bioeconomy imply the integration of organic waste in processes to adopt stronger sustainable food waste management (Mak *et al.*, 2020).

4.1.4 Cluster 4: new energy technologies. In yellow, the "new energy technologies" cluster is linked to new "technologies" – the most recent keyword in this group-related to food processes, to obtain renewable sources of energies. The volatile fatty "acids" cultivated from anaerobic digestion to produce biogas in the methane formation enable renewable "energy" based on green chemicals (Tampio *et al.*, 2019).

Waste-to-energy technologies from municipal solid waste enhance a more effective “waste management” by means of “recycling” and waste separation (Istrate *et al.*, 2021). Other technologies are focused on wastewater valorisation treatments from waste (Chen *et al.*, 2020), the use of microalgae as a nutrient source (Sutherland and Ralph, 2021) and the implementation of Industry 4.0 to reduce waste generation towards circular economy business models (Jabbour *et al.*, 2021).

4.2 Co-occurrence analysis by SciMat software: 2020 and 2021 research trend topics

SciMat software (Cobo *et al.*, 2011) displays a strategic diagram of the terms which identifies keywords based on their development and internal cohesion (density) and the relationship with other research topics (centrality). In addition, this software allows one to divide the study into periods. This leads to the classification of the topics into (1) motor themes, (2) basic and transversal themes (3) more developed and isolated themes and (4) emerging or disappearing themes (Callon *et al.*, 1991). This provides an improved understanding of the evolution of the field. As this software also allows the study to be divided into periods, the diagram (Figure 4) was obtained for the last two years (2020–2021).

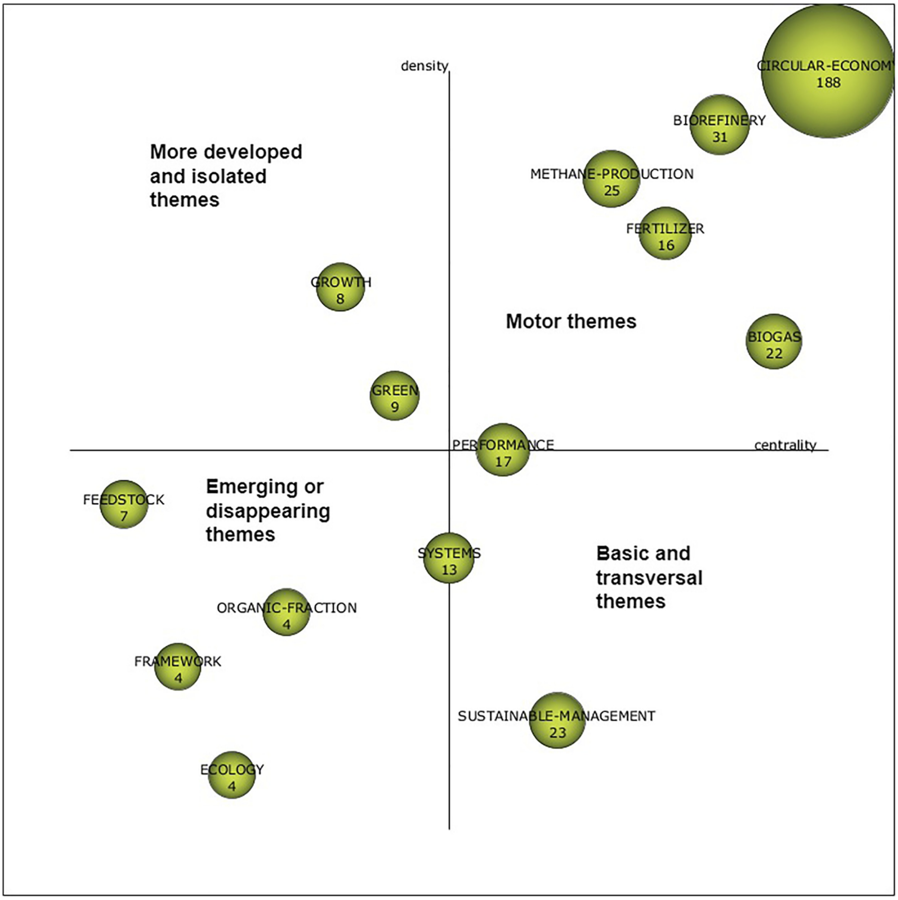


Figure 4.
Strategic diagram per number of documents by scimat software in period 2 (2020–2021)

The first motor theme is "circular economy" (Figure A2 Appendix). It appears with the terms "food waste", "anaerobic digestion" and "Life Cycle Assessment" which suggests it is one of the methodological tools most widely used (Krishnan *et al.*, 2020). The second theme is "biorefinery", which plays a key role in the transition towards circular "bioeconomy". Biorefineries uses "biomass" as a renewable energy resource. The third theme is "methane production", employed in the "anaerobic digestion" with "municipal solid waste" to produce "biomethane" (Martín-Pascual *et al.*, 2020). The fourth theme is "biogas", obtained from organic waste and widely used as a "renewable energy" in households towards improved waste management (Bedoic *et al.*, 2020). The fifth theme is "performance". This topic sits between a motor theme and basic or transversal theme. Its networks show that the implementation of food waste prevention "strategies" to improve "performance" and "management" is fundamental. Other terms are linked such as "recycling" and "supply chain", in relation to new circular business models (Borrello *et al.*, 2020). The sixth theme is "fertilizer", used in the "agriculture" sector. New techniques such as "composting", compost obtained from organic waste, can be implemented following more sustainable and circular practices (Haouas *et al.*, 2021).

"Sustainable management" appears as a basic and transversal theme (Figure A3 Appendix). This is linked to "consumer", "behavior" and "attitudes"; whilst "systems" is between a basic, transversal and emerging theme. Studying the subnets, we can observe the link between "urban waste" and "cities" and their relationship between "greenhouse-gas-emissions" and "carbon footprint".

Between the emerging themes (Figure A4 Appendix) we obtained the terms "feedstock", which it is highly linked to insects as a raw material. "Ecology" related to "SDGs" and "reduction", one of the 3 Rs principles, connected to circular economy. "Organic fraction" which is used in composting and associated with "volatile-fatty-acids" from food waste, and "framework" related to "surplus-food" and the required "transition" to a more sustainable and circular models.

"Growth" is an isolated theme related to "nitrogen" and "ph" involved in "organic-matter". "Green" is a more developed theme associated with "bioplastics" and "biodegradation" in the food industry, moving towards circular and sustainable business models (Figure A5 Appendix).

5. Discussion and research agenda

Following the co-occurrence analysis and clusterisation, this section presents a discussion to establish an interpretation of the results and sets out lines of development for a research agenda.

5.1 Discussion

The word "2030 Agenda" doesn't appear in any of the clusters analysed. This absence is remarkable considering the fact that the 2030 Agenda underscores food waste management as a key part of achieving several of its objectives. SDGs are mentioned, yet as an emerging issue. In light of this, Priyadarshini and Abhilash (2020) point out the lack of implentation in waste management. Is research taking place in isolation from the full achievement of the SDGs?

The analysis of the results demonstrates the absolute weight of the technical and process concepts in the research. It should not be forgotten that the operation of new procedures is conditioned by social and cultural aspects. Research in new technologies focuses on the different processes that allow renewable and sustainable energy to be obtained from organic matter within the food chain. Although this is undoubtedly a field of great application and usefulness for various sectors, technological development must cover new requirements, such as the need for deeper relationships with suppliers and customers and greater traceability. Is research accompanying realities in the sector such as the application of artificial intelligence and Blockchain in food waste management?

Sustainable management is related to consumer behaviour and attitudes. Consequently, stakeholder training and awareness-raising is essential (Leipold *et al.*, 2021; Börühan and Ozbiltekin-Pala, 2022) to coin the term "circular society" in the field of waste management. To encourage circular consumer behaviour, factors such as process and packaging design improve food recovery (Teigiserova *et al.*, 2020).

One of the topics attracting most attention from researchers is the circular bioeconomy in sustainable food waste management (Mak *et al.*, 2020). This new paradigm supports the substitution of fossil carbon with biomass for food, feed and energy supply. The incorporation of nutrients from food waste into animal and farm feed is a significant environmental improvement and generates wealth and employment opportunities.

5.2 Research agenda to achieve a circular management of food waste

The first proposal of the research agenda would be related to the *application of SDGs to the improvement of food waste management from social and educational angles*. With less than eight years to the deadline set by the 2030 Agenda, the related research should be further developed and more closely linked to the other circular economy (CE) principles and their social and economic aspects.

The second proposal is associated with the *need for more research into aspects beyond the environment and technical and technological development*. A better understanding of the new characteristics of circular relationships needs to be established with a wide range of stakeholders (Moggi and Dameri, 2021). Deeper and more frequent relationships are required, as they are key to the successful implementation of circular economy principles (Dora, 2020).

Awareness-raising, although a necessary condition, is no longer sufficient. Institutional and regulatory support is needed to implement circular waste management for both companies and consumers (Närvänen *et al.*, 2021). The third proposition is based on the *creation of a regulatory or normative framework supported by the institutions* and allowing for the encouragement or penalisation of certain actions. Taxation policies for example, could help to discourage food waste, which would contribute to improving individual food waste behaviour (Ang *et al.*, 2021). It should also contemplate new realities such as data processing or access to certain information. The use of tools within the framework of the Internet of things or the management of information through big data would facilitate the design of strategies and decision-making (Velvizhi *et al.*, 2020). This will require further research at the technological level, while considering regulatory adjustments to establish the rules of the game.

Thus, quantification with direct or indirect measurements could be carried out. The fourth line of a future research should consider *the need for waste measurement differentiating*. Researchers have frequently used LCA in measuring the environmental impact of food supply chains (Krishnan *et al.*, 2020). Further exploration of other measurement alternatives would allow for a more comprehensive measurement framework compared to direct measurements, which are more complex, yet at the same time more reliable. Indirect measurements require different quantification approaches with various actors to achieve greater precision (Corrado and Sala, 2018).

The fifth and last of the proposals on the research agenda relates to measurement constraints. Concepts must be *measured by considering both the context in which they are produced and the interrelationships between them*. The interpretation and measurement of these terms will be conditioned by the context in which they occur (D'Adamo *et al.*, 2021). There are interrelationships between the concepts studied that need to be considered.

Improved waste management would have a positive effect on solving other issues such as food loss (Kibler *et al.*, 2018).

6. Conclusions

To achieve food waste management in a more sustainable method, breaking with the inefficient linear model used up to now, numerous recent studies have analysed food waste management related to the circular economy. This study presents the cognitive structure of food waste management with the circular economy in a broader sense; providing information on the state of academic contributions and the links between the two topics.

Despite initial research on the topic in 2015, interest continues to rise, with more accelerated growth from 2018. The period 2018–2021 stands out, with research doubling compared to the previous year (RQ1). The results reveal that journals in environmental sciences are the most representative. No journal in the social sciences is among the most cited, although the most influential author, Serenella Sala, interestingly belongs to this area. Regarding institutions, The University of Manchester is the most influential (RQ2). The main research topics are related to the recovery processes of food waste towards the conversion into renewable and cleaner materials or energy sources (RQ3). To respond to RQ4, a discussion and a research agenda has been established that has important theoretical and practical implications.

6.1 Theoretical contributions

In terms of theoretical or academic implications, this study represents a new perspective on previous bibliometrics in the field of food waste management by bringing three contributions: (1) The incorporation of the circular economy from a holistic approach compared to previous papers, which focused on more specific aspects of this paradigm. (2) the use of two complementary software -VOSviewer and SciMat-to a better understanding of the research topics evolution. In this way, SciMat displays a strategic diagram based on its density and centrality. In addition, the results obtained in SciMat make it possible to validate the VOSviewer results. Hence, the clusterisation performed by VOSviewer as the most recent keywords, e.g. "sustainability", coincide with the topics considered as emerging in SciMat such as "sustainable management". (3) The scarcity of research coming from the social sciences means incorporating areas of knowledge such as management, law, psychology or anthropology is essential. The theoretical framework in future research should be enriched with different perspectives or areas of knowledge to achieve successful implementation of circular economy principles in food waste management.

6.2 Practical contributions

Linked to these aspects, it also offers practical implications. Companies must manage stakeholder expectations and evaluate their sustainability efforts (León Bravo *et al.,* 2021). Therefore, it also affects all supply chain actors and requires their involvement for the operation of circular procedures and techniques (Despoudi *et al.*, 2021). However, two additional aspects should be considered. On the one hand, the need to create a regulatory and support framework held by institutions at different levels (Närvänen *et al.*, 2021). On the other hand, firms need to establish indicators to measure both the level of circularity development in waste management and the compliance with the settled objectives (D'Adamo *et al.*, 2021).

6.3 Limitations and future research lines

This paper is not free of limitations. Relying solely on one database – WoS- implies the exclusion of papers that are useful for the study (Secinaro *et al.*, 2022). Articles written in

English only have been considered in this paper, meaning there is scope for greater insights in publications of other languages. In addition, the interpretation of the co-word analysis maps visualised by VOSviewer has a subjective component that cannot be ignored.

Future research lines can focus on monitoring the evolution of the topics to check whether the emerging topics are finally consolidated and whether new relationships are established between the terms. The creation of databases with relevant information for research on food waste would facilitate the development of new research and requires both public and private cooperation. Additionally, a replication of this study with a focus on food loss would allow a comparison with the present study. This would facilitate a better understanding of how to improve the application of circularisation principles throughout the food supply chain.

Finally, empirical works need to be extended to other food products (Krishnan *et al.*, 2020), other geographical areas (Battista *et al.*, 2020), other context (Hebrok and Heidenstrom, 2019) and comparisons between different companies (Kazancoglu *et al.*, 2021).

Food waste management is a complex phenomenon that can be facilitated by the application of circular economy principles. However, achieving circular food waste management requires complementing the extensive technical and technological knowledge already achieved, with knowledge from the social sciences.

References

Ananno, A.A., Masud, M.H., Chowdhury, S.A., Dabnichki, P., Ahmed, N. and Arefin, A.M.E. (2021), "Sustainable food waste management model for Bangladesh", *Sustainable Production and Consumption*, Vol. 27, pp. 35-51, doi: 10.1016/j.spc.2020.10.022.

Ang, W.-Z., Narayanan, S. and Hong, M. (2021), "Responsible consumption: addressing individual food waste behavior", *British Food Journal*, Vol. 123 No. 9, pp. 3245-3263, doi: 10.1108/BFJ-03-2021-0328.

Aschemann-Witzel, J., de Hooge, I.E., Rohm, H., Normann, A., Bossle, M.B., Grønhøj, A. and Oostindjer, M. (2017), "Key characteristics and success factors of supply chain initiatives tackling consumer-related food waste – a multiple case study", *Journal of Cleaner Production*, Vol. 155 No. 2, pp. 33-45, doi: 10.1016/j.jclepro.2016.11.173.

Battista, F., Frison, N., Pavan, P., Cavinato, C., Gottardo, M., Fatone, F., Eusebi, A.L., Majone, M., Zeppilli, M., Valentino, F., Fino, D., Tommasi, T. and Bolzonella, D. (2020), "Food wastes and sewage sludge as feedstock for an urban biorefinery producing biofuels and added-value bioproducts", *Journal of Chemical Technology and Biotechnology*, Vol. 95 No. 2, pp. 328-338, doi: 10.1002/jctb.6096.

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I.D., de Haan, St., Prager, St.D., Talsma, E.F. and Khoury, C.K. (2019), "When food systems meet sustainability - current narratives and implications for actions", *World Development*, Vol. 113, pp. 116-130, doi: 10.1016/j.worlddev.2018.08.011.

Bedoic, R., Spehar, A., Puljko, J., Cucek, L., Cosic, B., Puksec, T. and Duic, N. (2020), "Opportunities and challenges: experimental and kinetic analysis of anaerobic co-digestion of food waste and rendering industry streams for biogas production", *Renewable and Sustainable Energy Reviews*, Vol. 130, 109951, doi: 10.1016/j.rser.2020.109951.

Börühan, G. and Ozbiltekin-Pala, M. (2022), "Food waste management: an example from university refectory", *British Food Journal*, Vol. 124 No. 1, pp. 293-313, doi: 10.1108/BFJ-09-2020-0802.

Börner, K., Chen, C. and Boyack, K. (2003), "Visualizing knowledge domains", *Annual Review of Information Science and Technology*, Vol. 37 No. 1, pp. 179-255, doi: 10.1002/aris.1440370106/full.

Borrello, M., Pascucci, S., Caracciolo, F., Lombardi, A. and Cembalo, L. (2020), "Consumers are willing to participate in circular business models: a practice theory perspective to food provisioning", *Journal of Cleaner Production*, Vol. 259, 121013, doi: 10.1016/j.jclepro.2020.121013.

Boyack, K.W. and Klavans, R. (2014), "Creation of a highly detailed, dynamic, global model and map of science", *Journal of the American Society for Information Science*, Vol. 65 No. 4, pp. 670-685, doi: 10.1002/asi.22990.

Callon, M., Courtial, J.P. and Laville, F. (1991), "Co-word analysis as a tool for describing the network of interactions between basic and technological research: the case of polymer chemistry", *Scientometrics*, Vol. 22, pp. 155-205, doi: 10.1007/BF02019280.

Casallas-Ojeda, M., Torres-Guevara, L.E., Caicedo-Concha, D.M. and Gómez, M.F. (2021), "Opportunities for waste to energy in the milk production industry: perspectives for the circular economy", *Sustainability*, Vol. 13 No. 22, 12892, doi: 10.3390/su132212892.

Cecchi, F. and Cavinato, C. (2019), "Smart approaches to food waste final disposal", *International Journal of Environmental Research and Public Health*, Vol. 16 No. 16, p. 2860, doi: 10.3390/ijerph16162860.

Chauhan, A., Debnath, R.M. and Singh, S.P. (2018), "Modelling the drivers for sustainable agri-food waste management", *Benchmarking: An International Journal*, Vol. 25 No. 3, pp. 981-993, doi: 10.1108/BIJ-07-2017-0196.

Chen, W.H., Oldfield, T.L., Patsios, S.I. and Holden, N.M. (2020), "Hybrid life cycle assessment of agro-industrial wastewater valorisation", *Water Research*, Vol. 170, 115275, doi: 10.1016/j.watres.2019.115275.

Ciccullo, F., Cagliano, R., Bartezzaghi, G. and Perego, A. (2021), "Implementing the circular economy paradigm in the agri-food supply chain: the role of food waste prevention technologies", *Resources Conservation and Recycling*, Vol. 164, 105114, doi: 10.1016/j.resconrec.2020.105114.

Cobo, M.J., López-Herrera, A.G., Herrera-Viedma, E. and Herrera, F. (2011), "SciMAT: a new science mapping analysis software tool", *Journal of American Society for Information Science and Technology*, Vol. 62 No. 7, pp. 1382-1402, doi: 10.1002/asi.21525.

Corrado, S. and Sala, S. (2018), "Food waste accounting along global and European food supply chains: state of the art and outlook", *Waste Management*, Vol. 79, pp. 120-131, doi: 10.1016/j.wasman.2018.07.032.

D'Adamo, I., Falcone, P.M., Huisingh, D. and Morone, P. (2021), "A circular economy model based on biomethane: what are the opportunities for the municipality of Rome and beyond?", *Renewable Energy*, Vol. 163, doi: 10.1016/j.renene.2020.10.072.

Despoudi, S., Bucatariu, C., Otles, S. and Kartal, C. (2021), "Food waste management, valorization, and sustainability in the food industry", *Food Waste Recovery, Chapter 1*, pp. 3-19, doi: 10.1016/B978-0-12-820563-1.00008-1.

Donthu, N., Kumar, S., Pandey, N. and Lim, W.M. (2021), "Research constituents, intellectual structure, and collaboration patterns in journal of international marketing: an analytical retrospective", *Journal of International Marketing*, Vol. 29 No. 2, pp. 1-25, doi: 10.1177/1069031X211004234.

Dora, M. (2020), "Collaboration in a circular economy learning from the farmers to reduce food waste", *Journal of Enterprise Information Management*, Vol. 33 No. 4, pp. 769-798, doi: 10.1108/JEIM-02-2019-0062.

Ebikade, E., Athaley, A., Fisher, B., Yang, K., Wu, C.Q., Ierapetritou, M.G. and Vlachos, D.G. (2020), "The future is garbage: repurposing of food waste to an integrated biorefinery", *ACS Sustainable Chemistry and Engineering*, Vol. 8 No. 22, pp. 8124-8136, doi: 10.1021/acssuschemeng.9b07479.

Ericksen, P.J. (2008), "Conceptualizing food systems for global environmental change research", *Global Environmental Change*, Vol. 18, pp. 234-245, doi: 10.1016/j.gloenvcha.2007.09.002.

Fogarassy, C., Nagy-Percsi, K., Ajibade, S., Gyuricza, C. and Ymeri, P. (2020), "Relations between circular economic principles and organic food purchasing behavior in Hungary", *Agronomy*, Vol. 10 No. 5, p. 616, doi: 10.3390/agronomy10050616.

Garousi, V. and Mantyla, M.V. (2016), "Citations, research topics and active countries in software engineering", *Computer Science Review*, Vol. 19, pp. 56-77, doi: 10.1016/j.cosrev.2015.12.002.

Germar, G., Soler, I.P. and Sánchez-Teba, E.M. (2021), "Waste management; valorisation is the way", *Foods*, Vol. 10 No. 10, p. 2373, doi: 10.3390/foods10102373.

Haouas, A., El Modafar, C., Douira, A., Ibnsouda-Koraichi, S., Filali-Maltouf, A., Moukhli, A. and Amir, S. (2021), "Evaluation of the nutrients cycle, humification process, and agronomic efficiency of organic wastes composting enriched with phosphate sludge", *Journal of Cleaner Production*, Vol. 302, 127051, doi: 10.1016/j.jclepro.2021.127051.

Hebrok, M. and Heidenstrom, N. (2019), "Contextualising food waste prevention - decisive moments within everyday practices", *Journal of Cleaner Production*, Vol. 210, pp. 1435-1448, doi: 10.1016/j.jclepro.2018.11.141.

Istrate, I.R., Medina-Martos, E., Galvez-Martos, J.L. and Dufour, J. (2021), "Assessment of the energy recovery potential of municipal solid waste under future scenarios", *Applied Energy*, Vol. 293, 116915, doi: 10.1016/j.apenergy.2021.116915.

Jabbour, A.B.L.D., Frascareli, F.C.D., González, E.D.R.S. and Jabbour, C.J.C. (2021), "Are food supply chains taking advantage of the circular economy? A research agenda on tackling food waste based on Industry 4.0 technologies", *Production Planning and Control*. doi: 10.1080/09537287.2021.1980903.

Kazancoglu, Y., Ekinci, E., Mangla, S.K., Sezer, M.D. and Kayikci, Y. (2021), "Performance evaluation of reverse logistics in food supply chains in a circular economy using system dynamics", *Business Strategy and the Environment*, Vol. 30 No. 1, pp. 71-91, doi: 10.1002/bse.2610.

Kibler, K.M., Reinhart, D., Hawking, C., Motlagh, A. and Wright, J. (2018), "Food waste and the food-energy-water nexus: a review of food waste management alternatives", *Waste Management*, Vol. 74, pp. 52-62, doi: 10.1016/j.wasman.2018.01.014.

Kourmentza, C., Economou, C.H., Tsafrakidou, P. and Kornaros, M. (2018), "Spent coffee grounds make much more than waste: exploring recent advances and future exploitation strategies for the valorization of an emerging food waste stream", *Journal of Cleaner Production*, Vol. 172, pp. 980-992, doi: 10.1016/j.jclepro.2017.10.088.

Krishnan, R., Agarwal, R., Bajada, C. and Arshinder, K. (2020), "Redesigning a food supply chain for environmental sustainability - an analysis of resource use and recovery", *Journal of Cleaner Production*, Vol. 242, doi: 10.1016/j.jclepro.2019.118374.

Kumar, A.N., Sarkar, O., Chandrasekhar, K., Raj, T., Narisetty, V., Mohan, S.V., Pandey, A., Varjani, S., Kumar, S., Sharma, P., Jeon, B.-H., Jang, M. and Kim, S.-H. (2021), "Upgrading the value of anaerobic fermentation via renewable chemicals production: a sustainable integration for circular bioeconomy", *Science of the Total Environment*, Vol. 806 No. 1, 150312, doi: 10.1016/j.scitotenv.2021.150312.

Leipold, S., Weldner, K. and Hohl, M. (2021), "Do we need a 'circular society'? Competing narratives of the circular economy in the French food sector", *Ecological Economics*, Vol. 187, 107086, doi: 10.1016/j.ecolecon.2021.107086.

León Bravo, V., Moretto, A. and Caniato, F. (2021), "A roadmap for sustainability assessment in the food supply chain", *British Food Journal*, Vol. 123 No. 13, pp. 199-220, doi: 10.1108/BFJ-04-2020-0293.

Mak, T.M.W., Xiong, X., Tsang, D.C.W., Yu, I.K.M. and Poon, C.S. (2020), "Sustainable food waste management towards circular bioeconomy: policy review, limitations and opportunities", *Bioresource Technology*, Vol. 297, 122497, doi: 10.1016/j.biortech.2019.122497.

Martín-Pascual, J., Fernández-González, J.M., Ceccomarini, N., Ordonez, J. and Zamorano, M. (2020), "The study of economic and environmental viability of the treatment of organic fraction of municipal solid waste using Monte Carlo simulation", *Applied Sciences*, Vol. 10 No. 24, p. 9028, doi: 10.3390/app10249028.

Moggi, S. and Dameri, R.P. (2021), "Circular business model evolution: stakeholder matters for a self-sufficient ecosystem", *Business Strategy and the Environment*, Vol. 30 No. 6, pp. 2830-2842, doi: 10.1002/bse.2716.

Moretto, G., Russo, I., Bolzonella, D., Pavan, P., Majone, M. and Valentino, F. (2020), "An urban biorefinery for food waste and biological sludge conversion into polyhydroxyalkanoates and biogas", *Water Research*, Vol. 170, doi: 10.1016/j.watres.2019.115371.

Närvänen, E., Mesiranta, N., Mattila, M. and Heikkinen, A. (2020), *Food Waste Management: Solving the Wicked Problem*, Palgrave Macmillan, Cham.

Närvänen, E., Mattila, M. and Mesiranta, N. (2021), "Institutional work in food waste reduction: start-ups' role in moving towards a circular economy", *Industrial Marketing Management*, Vol. 93, pp. 605-616, doi: 10.1016/j.indmarman.2020.08.009.

Parfitt, J., Barthel, M. and Macnaughton, S. (2010), "Food waste within food supply chains: quantification and potential for change to 2050", *Philosophical Transactions of the Royal Society B*, Vol. 365 No. 1554, pp. 3065-3308, doi: 10.1098/rstb.2010.0126.

Paritosh, K., Kushwaha, S.K., Yadav, M., Pareek, N., Chawade, A. and Vivekanand, V. (2017), "Food waste to energy: an overview of sustainable approaches for food waste management and nutrient recycling", *BioMed Research International*, Vol. 2, pp. 1-19, doi: 10.1155/2017/2370927.

Pattnaik, S. and Reddy, M.V. (2010), "Assessment of municipal solid waste management in Puducherry (Pondicherry), India", *Resources, Conversation and Recycling*, Vol. 54 No. 8, pp. 512-520, doi: 10.1016/j.resconrec.2009.10.008.

Paul, S., Dutta, A., Defersha, F. and Dubey, B. (2018), "Municipal food waste to biomethane and biofertilizer: a circular economy concept", *Waste and Biomass Valorization*, Vol. 9 No. 4, pp. 601-611, doi: 10.1007/s12649-017-0014-y.

Powell, T.H., Kouropalatis, Y., Morgan, R.E. and Karhu, P. (2016), "Mapping knowledge and innovation research themes: using bibliometrics for classification, evolution, proliferation and determinism", *International Journal of Entrepreneurship and Innovation Management*, Vol. 20, pp. 174-199, doi: 10.1504/IJEIM.2016.077960.

Priyadarshini, P. and Abhilash, P.C. (2020), "Circular economy practices within energy and waste management sectors of India: a meta-analysis", *Bioresource Technology*, Vol. 304, doi: 10.1016/j.biortech.2020.123018.

Ranjbari, M., Saidani, M., Esfandabadi, Z.S., Peng, W., Lam, S.S., Aghbashlo, M., Quatraro, F. and Tabatabaei, M. (2021), "Two decades of research on waste management in the circular economy: insights from bibliometric, text mining, and content analysis", *Journal of Cleaner Production*, Vol. 314, 128009, doi: 10.1016/j.jclepro.2021.128009.

Ranjbari, M., Esfandabadi, Z.S., Schevchenko, T., Chassagnon-Haned, N., Peng, W., Tabatabaei, M. and Aghbashlo, M. (2022a), "Mapping healthcare waste management research: past evolution, current challenges, and future perspectives towards a circular economy transition", *Journal of Hazardous Materials*, Vol. 422, 126724, doi: 10.1016/j.jhazmat.2021.126724.

Ranjbari, M., Esfandabadi, Z.S., Gautam, S., Ferraris, A. and Scagnelli, S.D. (2022b), "Waste management beyond the COVID-19 pandemic: bibliometric and text mining analyses", *Godwana Research*. doi: 10.1016/j.gr.2021.12.015.

Rejeb, A., Rejeb, K., Abdollahi, A., Zailani, S., Iranmanesh, M. and Ghobakhloo, M. (2022), "Digitalization in food supply chains: a bibliometric review and key-route main path analysis", *Sustainability*, Vol. 14 No. 1, p. 83, doi: 10.3390/su14010083.

Rizos, V., Behrens, A., Kafyeke, T., Hirschnitz-Garbers, M. and Ioannou, A. (2015), "The circular economy: barriers and opportunities for SMEs", *CEPS Working Documents*, available at: https://ssrn.com/abstract=2664489.

Santeramo, F.G. (2021), "Exploring the link among food loss, waste and food security: what the research should focus on?", *Agriculture and Food Security*, Vol. 10 No. 26, doi: 10.1186/s40066-021-00302-z.

Santeramo, F.G. and Lamonaca, E. (2021), "Food loss-food waste-food security: a new research agenda", *Sustainability*, Vol. 13 No. 9, p. 4642, doi: 10.3390/su13094642.

Schildt, H.A., Zahra, S.A. and Sillanpää, A. (2006), "Scholarly communities in entrepreneurship research: a Co-citation analysis", *Entrepreneurship Theory and Practice*, Vol. 30 No. 3, pp. 399-415, doi: 10.1111/j.1540-6520.2006.00126.x.

Schuster, M. and Torero, M. (2016), "Reducing food loss and waste", *Towards a Sustainable Food System*, Chapter 3, pp. 23-31, available at: https://www.oneplanetnetwork.org/sites/default/files/130422.pdf.

Secinaro, S., Calandra, D., Lanzalonga, F. and Ferraris, A. (2022), "Electric vehicles' consumer behaviours: mapping the field and providing a research agenda", *Journal of Business Research*, Vol. 150, pp. 399-416, doi: 10.1016/j.jbusres.2022.06.011.

Sutherland, D.L. and Ralph, P.J. (2021), "Productivity and community response along an ammonia gradient in cultured wild marine microalgae, using wastewater-derived nutrients for cost-effective feedstock production", *Journal of Applied Phycology*, Vol. 33 No. 5, pp. 2933-2945, doi: 10.1007/s10811-021-02520-1.

Tampio, E.A., Blasco, L., Vainio, M.M., Kahala, M.M. and Rasi, S.E. (2019), "Volatile fatty acids (VFAs) and methane from food waste and cow slurry: comparison of biogas and VFA fermentation processes", *Global Change Biology Bioenergy*, Vol. 11 No. 1, pp. 72-84, doi: 10.1111/gcbb.12556.

Teigiserova, D.A., Hamelin, L. and Thomsen, M. (2020), "Towards transparent valorization of food surplus, waste and loss: clarifying definitions, food waste hierarchy, and role in the circular economy", *Science of the Total Environment*, Vol. 706, doi: 10.1016/j.scitotenv.2019.136033.

Tsai, F.M., Bui, T.D., Tseng, M.L., Lim, M.K. and Hu, J. (2020), "Municipal solid waste management in a circular economy: a data-driven bibliometric analysis", *Journal of Cleaner Production*, Vol. 275, 124132, doi: 10.1016/j.jclepro.2020.124132.

UNEP, United Nations Environmental Program (2021), "Food waste Index Report 2021", available at: https://wedocs.unep.org/20.500.11822/35280 (accessed 9 December 2021).

United Nations (2015), "Sustainable development goals. 17 goals to transform our world", available at: www.un.org/sustainabledevelopment/sustainable-development-goals (accessed 10 December 2021).

van Eck, N. and Waltman, L. (2010), "Software survey: VOSviewer, a computer program for bibliometric mapping", *Scientometrics*, Vol. 84 No. 2, pp. 523-538, doi: 10.1007/s11192-009-0146-3.

Velvizhi, G., Shanthakumar, S., Das, B., Pugazhendhi, A., Priya, T.S., Ashok, B., Nanthagopal, K., Vignesh, R. and Karthick, C. (2020), "Biodegradable and non-biodegradable fraction of municipal solid waste for multifaceted applications through a closed loop integrated refinery platform: paving a path towards circular economy", *Science of the Total Environment*, Vol. 731, doi: 10.1016/j.scitotenv.2020.138049.

Welch, D., Swafeld, J. and Evans, D. (2018), "Who's responsible for food waste? Consumers, retailers and the food waste discourse coalition in the United Kingdom", *Journal of Consumer Culture*, Vol. 21 No. 2, pp. 236-256, doi: 10.1177/1469540518773801.

Zhong, Q., Wang, L. and Cui, S. (2021), "Urban food systems: a bibliometric review from 1991 to 2020", *Foods*, Vol. 10 No. 3, doi: 10.3390/foods10030662.

Zuin, V.G., Segatto, M.L. and Zanotti, K. (2020), "Towards a green and sustainable fruit waste valorisation model in Brazil: optimisation of homogenizer-assisted extraction of bioactive compounds from mango waste using a response surface methodology", *Pure and Applied Chemistry*, Vol. 92 No. 4, pp. 617-629, doi: 10.1515/pac-2019-1001.

Zupic, I. and Cater, T. (2014), "Bibliometric methods in management and organization", *Organizational Research Methods*, Vol. 18 No. 3, pp. 429-472, doi: 10.1177/1094428114562629.

Appendix

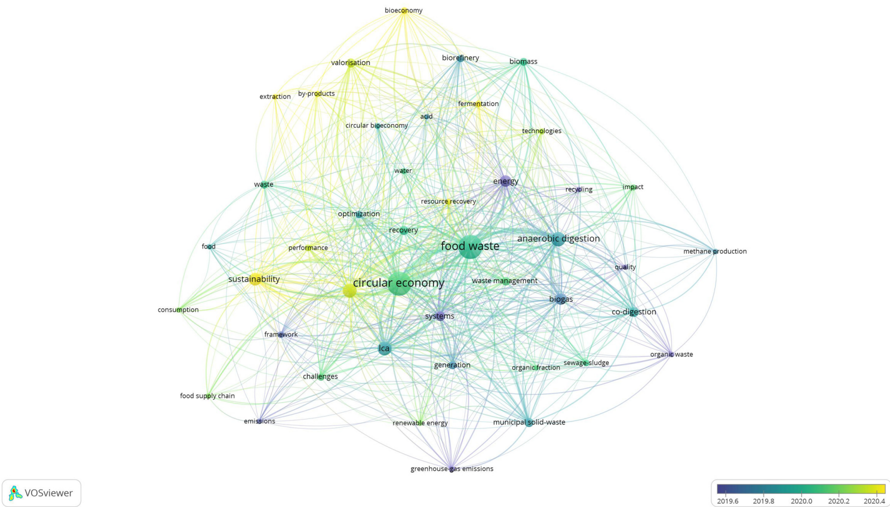
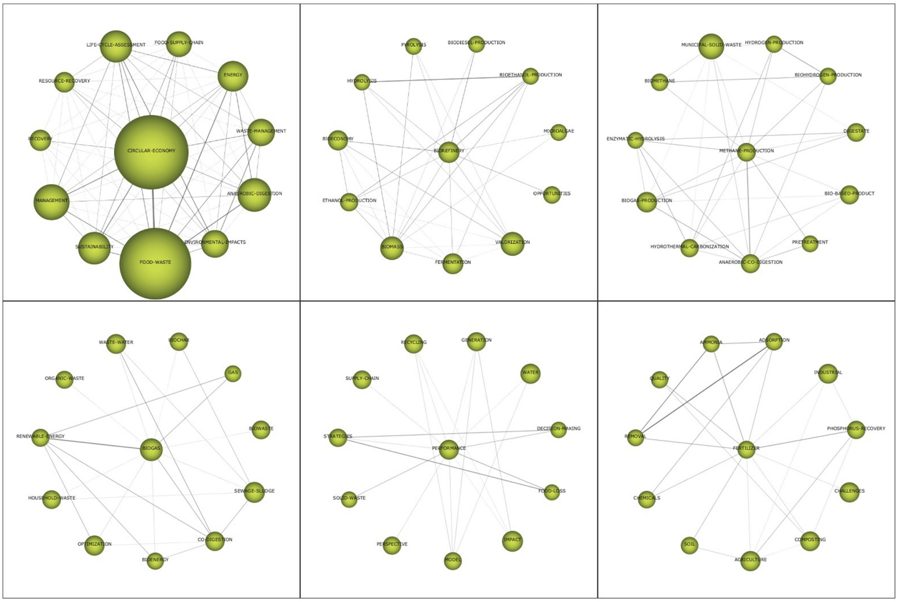
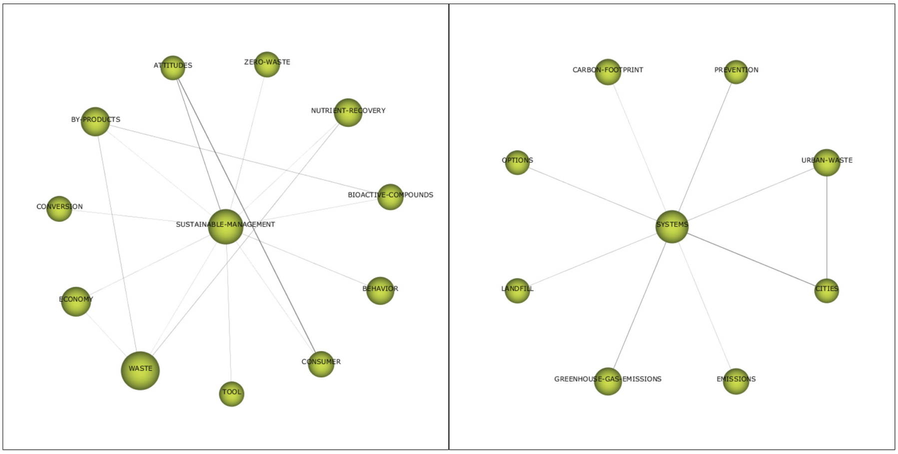


Figure A1. Overlay visualisation of the co-occurrence analysis by VOSviewer software



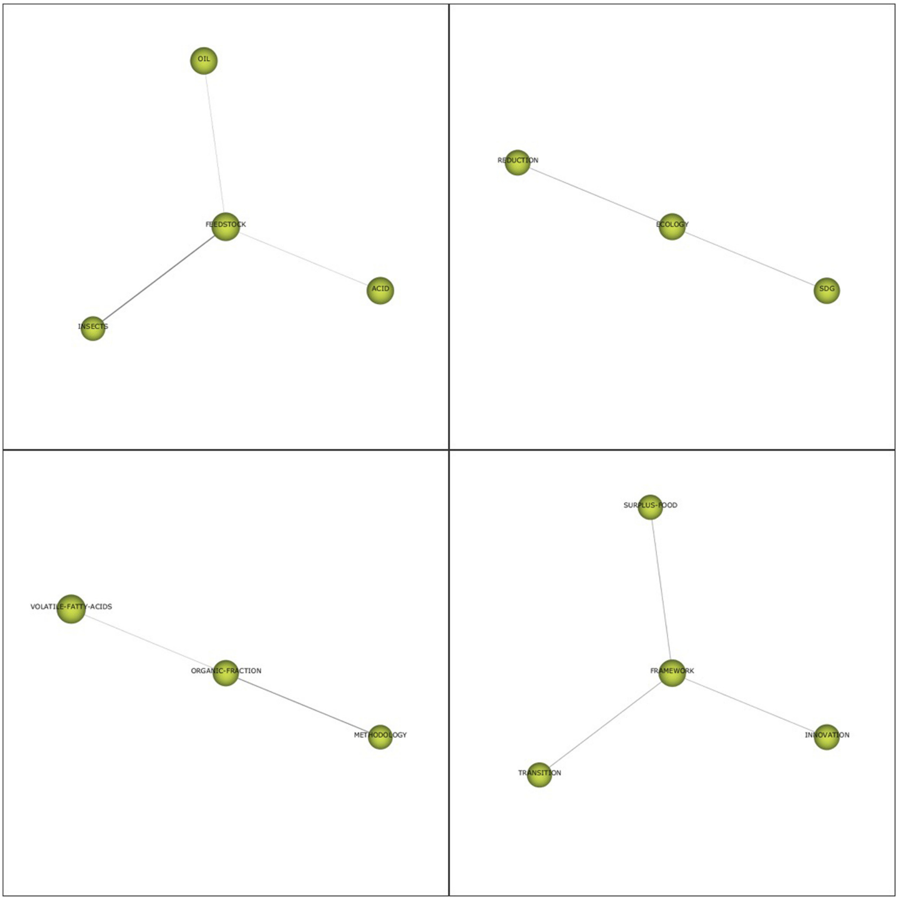
Note(s): Thematic subnets: “circular economy”, “biorefinery’, “methane production”, “biogas”, “performance” and “fertilizer’

Figure A2. Motor themes



Note(s): Thematic subnets: “sustainable management” and “systems”

Figure A3.
Basic and transversal themes



Note(s): Thematic subnets: “feedstock”, “ecology”, “organic fraction” and “framework”

Figure A4.
Emerging themes

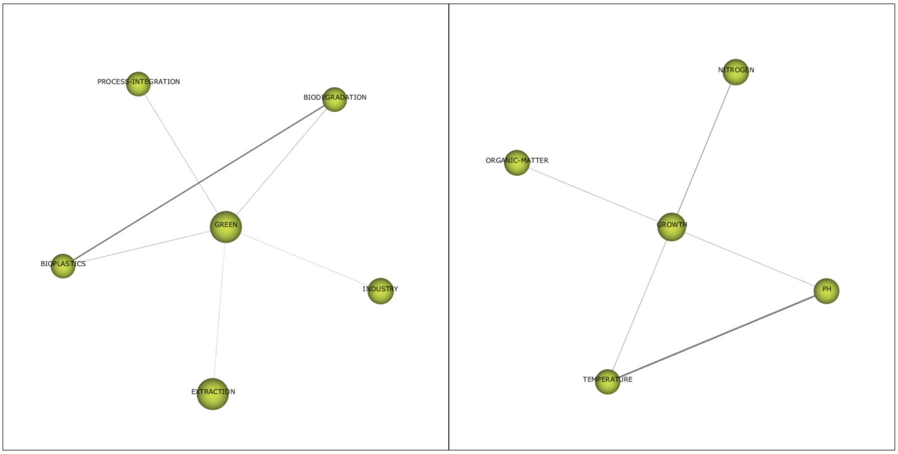


Figure A5.
More developed and isolated theme

Note(s): Thematic subnets: "green" and "growth"

Corresponding author
Sara Alonso-Muñoz can be contacted at: sara.alonso@urjc.es