Two decades of research on waste management in the circular economy: Insights from bibliometric, text mining, and content analyses

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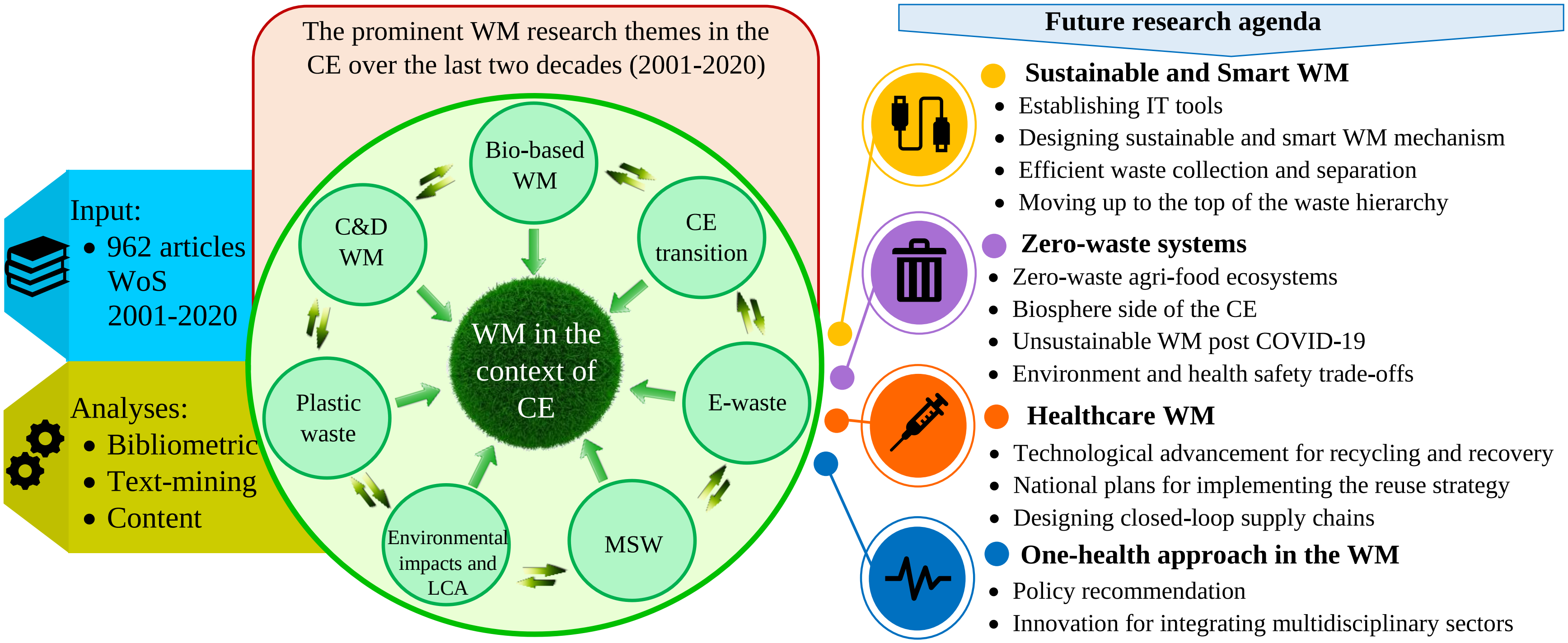
Graphical Abstract



Abstract

Achieving environmental sustainability and transition from a linear economy to a circular economy (CE) highly relies on effective waste management (WM) and how waste is treated as a potential future resource. This research aims to provide an inclusive map of the scientific background of WM in the CE context over the last two decades from 2001 to 2020 to identify its salient research themes and trends, main characteristics, evolution, and potentially valuable directions for future studies. To achieve that, the following research questions were addressed by applying a mixed-method approach including bibliometric, text mining, and content analyses: (i) how has the field of WM research evolved within the CE domain? (ii) what are the salient research themes and trends of WM in the CE? and (iii) what are the possible directions for future research on WM within the CE context? As a result, the synthesized bibliometric networks were constructed and analyzed for a total of 962 journal articles extracted from the Web of Science database to visualize the main body of literature. Consequently, the seven major research themes of WM in the CE context were identified as follows: (1) bio-based WM; (2) CE transition; (3) electronic waste; (4) municipal solid waste; (5) environmental impacts and lifecycle assessment; (6) plastic waste; and (7) construction and demolition WM. The provided inclusive research landscape of WM systems, and its prominent highlight patterns can serve as a base for a real-time guideline to lead further research areas and as a tool to support WM policy-makers and practitioners to support the CE transition (which aims to minimize the waste generation). Finally, the future research directions to better position WM research activities within the CE context as a waste minimization approach are provided.

Keywords: waste management; circular economy; bibliometric analysis; text mining; content analysis; environmental sustainability

Highlights

- The literature on waste management (WM) in the circular economy (CE) was mapped.
- Bibliometric networks were constructed for a total of 962 journal articles.
- The seven major research themes of WM in the CE context were presented.
- Directions for future research on WM towards the CE transition were proposed.

Abbreviations

CE	Circular Economy
WM	Waste Management
MSW	Municipal Solid Waste
C&D	Construction and Demolition
OFMSW	Organic Fraction of Municipal Solid Waste
WEEE	Waste Electrical and Electronic Equipment
E-waste	Electronic Waste
IT	Information Technology
IoT	Internet of Things
OH	One Health

1. Introduction

Circular economy (CE), with a particular focus on the waste hierarchy from waste prevention at the top to disposal at the bottom, intends to close the supply chain loops as much as possible towards making a sustainable and zero-waste environment (Aghbashlo et al., 2018). The proper management of waste plays a significant role in supporting environmental sustainability and human health and transitioning from a linear economy to a CE (Aghbashlo et al., 2019b). Designing and managing efficient waste management (WM) system as a foundation for the CE establishment (Di Foggia and Beccarello, 2021) is crucial to achieving better resource management and more waste prevention (Zeller et al., 2019).

In recent years, extensive research on WM practices corresponding to the CE goals has been increasingly conducted. Those include but are not limited to developing CE indicators for WM (Luttenberger, 2020), WM drivers towards a CE (Calderón Márquez and Rutkowski, 2020), identifying barriers and challenges in the transition to a CE (Zhang et al., 2019), waste hierarchy index for the CE (Pires and Martinho, 2019), and enablers of E-waste management in a CE (Sharma et al., 2020). Bibliometric analysis has assisted researchers in dealing with numerous publications in the WM research arena towards a CE. Accordingly, various research teams have quantitatively analyzed and mapped the development of different lines of WM in the CE on a broader outlook, such as municipal solid waste (MSW) management (Tsai et al., 2020), waste incineration (Xing et al., 2019), and construction and demolition (C&D) waste (Wu et al., 2019). However, WM activities compliant with the CE principles in practice are still blurred in the existing studies (Tsai et al., 2020) and remain a challenge for WM policy-makers and CE practitioners. Consequently, a holistic map of the WM research themes and trends aligned with CE perspectives is lacking in the literature.

The present research aims to provide a body of knowledge for WM in the CE and its salient research themes and trends, main characteristics, evolution, and directions for future studies by scrutinizing the WM literature in the context of CE over the last two decades (2001–2020). The provided analysis can serve as a base for a real-time manner guideline for future research in this area. To achieve the aim of this study, a mixed-method approach, including bibliometric analysis, text mining, and content analysis, is applied to answer the following research questions:

RQ1. How has the field of WM research evolved within the CE domain?

RQ2. What are the salient research themes and trends of WM in the CE?

RQ3. What are the possible directions for future research on WM towards the CE transition?

To the best of our knowledge, there is no comprehensive research in the literature that synthesized bibliometric, text mining, and content analyses concurrently in the field of WM within the CE context. Therefore, our study is expected to immensely contribute to (i) capturing the scientific background of WM research in the CE context and identifying its main themes and trends over the last two decades, (ii) drawing an inclusive research landscape for the WM system and its prominent highlight patterns, as a tool to support WM policy-makers and practitioners towards a CE transition, and (iii) providing future research directions in WM that need more investigation to establish a CE in practice.

The remainder of this paper is structured as follows. Section 2 provides an overview of the WM practices towards a CE. Section 3 presents the adopted research methodology framework. The obtained results from the bibliometric analysis, text mining, and content analysis on the WM literature within the CE domain are discussed in section 4. Implications for research and avenues for future studies are developed in section 5. Finally, section 6 delivers the conclusions and research limitations for further development.

2. Waste management in a circular economy: an overview of opportunities and challenges

Waste management refers to all the activities and actions required to manage waste from its inception to its final disposal through the collection, transport, and treatment phases (Rajaeifar et al., 2017). The appropriate management, mitigation, and valorization of waste are essential for a sound CE to transform our society towards a sustainable and zero-waste environment (Aghbashlo et al., 2019a). A proper WM system enables collecting discarded, worn out, and/or obsolete products to prevent them from being left out in nature and polluting the environment (Nelles et al., 2016). However, such a WM system enables the suitable processing of waste to facilitate their reinjection in CE loops, thus avoiding the extraction of primary materials (Romero-Hernández and Romero, 2018). Several authors have indeed highlighted the importance of WM systems as a key pillar in a CE to realize or make feasible most of the 10R-strategies namely, R0 Refuse/Rethink, R1 Reduce, R2 Resell/reuse, R3 Repair, R4 Refurbish, R5 Remanufacture, R6 Repurpose, R7 Recycle, R8 Recover, and R9 Re-mine (Reike et al., 2018). Waste and pollution prevention are the key reasons or objectives of developing a CE (Bilitewski, 2012). The notion of waste is central in the numerous definitions of a CE: performing a text mining analysis on 70 definitions of a CE, Saidani et al. (2020) found that waste is the sixth most-cited term in those definitions, after economy, circular, resources, materials, and economic; and before, system, use, product, value, production, and recycling.

While the current momentum around the CE concept could foster actions for better managing waste globally, Zhang et al. (2019) remind that WM systems need to be smarter for a zero-waste CE vision. Moreover, through a systematic review of zero-waste studies published between 1997 and 2014, Zaman (2015) found out that although policy-makers had embraced the zero-waste concept, there was still a lack of advanced work or applied research in the domains of zero-waste design, assessment, and evaluation. On this basis, it is of the utmost importance not only to demonstrate that WM practices can be cost-saving and revenue-generating opportunities (Romero-Hernández and Romero, 2018), but also can guide and monitor the activities of companies and businesses towards more circular and zero-waste practices through appropriate circularity indicators (Saidani et al., 2019). For instance, Di Maio and Rem (2015) proposed a "circular economy index" as the ratio of the material value produced by the recycler (market value) by the intrinsic material value entering the recycling facility. According to the authors, such an index takes into account the strategic, economic, and environmental aspects of recycling and offers a manageable amount of information to support decision-making tools. While other indicators or metrics have been developed recently for a CE in WM, such as the "waste hierarchy index" (Pires and Martinho, 2019), there is no widely acknowledged, commonly agreed (Zaman, 2015), or standardized index for WM systems across countries or industrial sectors.

3. Research methodology

This research used a mixed-method approach that involved both quantitative and qualitative analyses in scrutinizing the literature of WM in the CE, as presented in sections 3.1 and 3.2. The overall research design is illustrated in Fig. **1**.

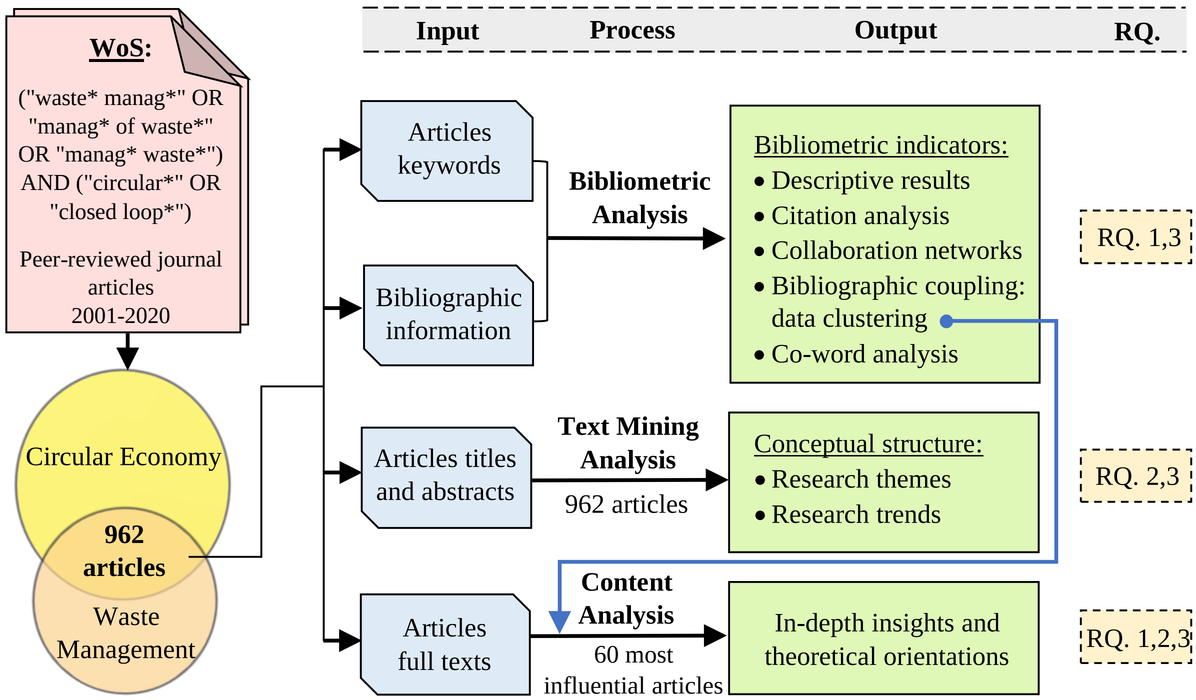


Fig. 1. Research framework design.

3.1. Data sampling, collection, and cleaning

To ensure sufficient coverage of related publications within the field of study, the Web of Science (WoS) Core Collection, as one of the most leading sources of scientific publications, was selected for collecting data in this research. The following search string was used to explore within the title, abstract and keywords fields: ("waste* manag*" OR "manag* of waste*" OR "manag* waste*") AND ("circular*" OR "closed loop*"). The initial search was conducted in January 2021 and was limited to peer-reviewed journal articles and reviews in the English language and the period of 2001–2020. After removing missing values, a total of 962 articles met the selection criteria and were used as the final sample for the analysis. As a fundamental preparation step for the keyword-based analyses, the final dataset was cleaned before conducting the bibliometric and text mining analyses (Ranjbari et al., 2020). In this vein, synonyms such as environmental effect and environmental impact, or E-waste and electronic waste, were merged. Besides, the unification of writing styles and merging singular and plural forms of the keywords was done, and keywords without any explicit meaning for this study's focus, such as "literature review" and "article," were removed from the dataset to increase the analyses' reliability.

3.2. Data analysis

Three analytical methods, including bibliometric, text mining, and content analyses, were employed in this research to examine the evolution and structure of the research field.

3.2.1. Bibliometric analysis

Bibliometric analysis, a quantitative technique and powerful statistical tool to deal with a large number of publications and scientific literature mapping, has been increasingly used during recent years in various fields of research, such as CE (Goyal et al., 2020), sustainable development (Du et al., 2021), and open innovation (Gao et al., 2020). The bibliometric analysis supports researchers in quickly identifying future research directions within a field of study by providing an inclusive visualization of relationships among articles, journals, keywords, citations, and co-citations networks (Feng et al., 2017). VOSviewer version 1.6.16 was used to conduct the bibliometric analysis (van Eck and Waltman, 2010). Different bibliometric parameters, including publications evolution over time, citation analysis for core publications and authors, collaboration analysis for countries and institutions, bibliographic coupling network analysis for data clustering, and finally, co-word analysis for identifying hotspots were presented in this research to statistically map the bibliometric information of scientific publications in WM within the CE context over the last two decades.

3.2.2. Text mining analysis

Text mining technique, a tool for extracting information from an extensive collection of documents in text form and analyzing research themes and trends (Jung and Lee, 2020), has been widely employed by researchers in various fields of CE studies. Text mining analysis can particularly capture semantic structures and phrase patterns that best characterize a vast amount of text data. A text mining analysis based on a term co-occurrence algorithm was employed in this research on the concatenation of the titles and abstracts of the publications within the dataset using VOSviewer version 1.6.16. As a result, the conceptual structure and latent research themes and trends of the WM literature in the CE domain were identified.

3.2.3. Content analysis

In line with the research conducted by Schöggl et al. (2020) and Jia and Jiang (2018), a content analysis, as a complementary qualitative layer, was also carried out in this research to improve the confidentiality of the results and to provide more in-depth insights for the quantitative findings of the investigation. In this sense, a qualitative content analysis using the data clustering technique was conducted for the top 15 most influential articles within each cluster obtained from the bibliographic coupling analysis to investigate the theoretical orientations in the WM towards the CE.

4. Results and Discussion

To clearly address our study's research questions, the results are presented in sections 4.1, 4.2, and 4.3, corresponding to the respective research questions.

4.1. Bibliometric mapping of extant studies

The bibliometric analysis indicators are presented in this section to directly address the first research question:

RQ1. How has the field of WM research evolved within the CE domain?

4.1.1. Descriptive analysis: publications evolution

Fig. ***2*** illustrates the publication trend of WM-related research in the CE from 2001 to 2020. The majority of articles (i.e., 910 out of 962) were published after 2014, accounting for over 94% of the data sample. It could be concluded that the primary research period in terms of the number of publications and academic involvement in WM towards a CE would be 2015 to 2020. Consistent with Reike et al. (2018), this significantly increasing number of scholarly publications in the last five years denotes that the CE establishment has received growing attention within different domains, such as WM.

A total of 254 journals have published 962 articles on WM considering CE from 2001 to 2020. The top 10 journals contain 513 out of 962 items, representing 53% of the publications in the field of WM corresponding to the CE perspectives, and are shown in Fig. ***2***. In this regard, *Journal of Cleaner Production* played the most dominant role in this field, with 141 out of 962 articles, constituting approximately 15% of the publications, and was followed by *Sustainability*, *Waste Management*, and *Resources*, *Conservation & Recycling* with 91, 75, and 73 articles, respectively.

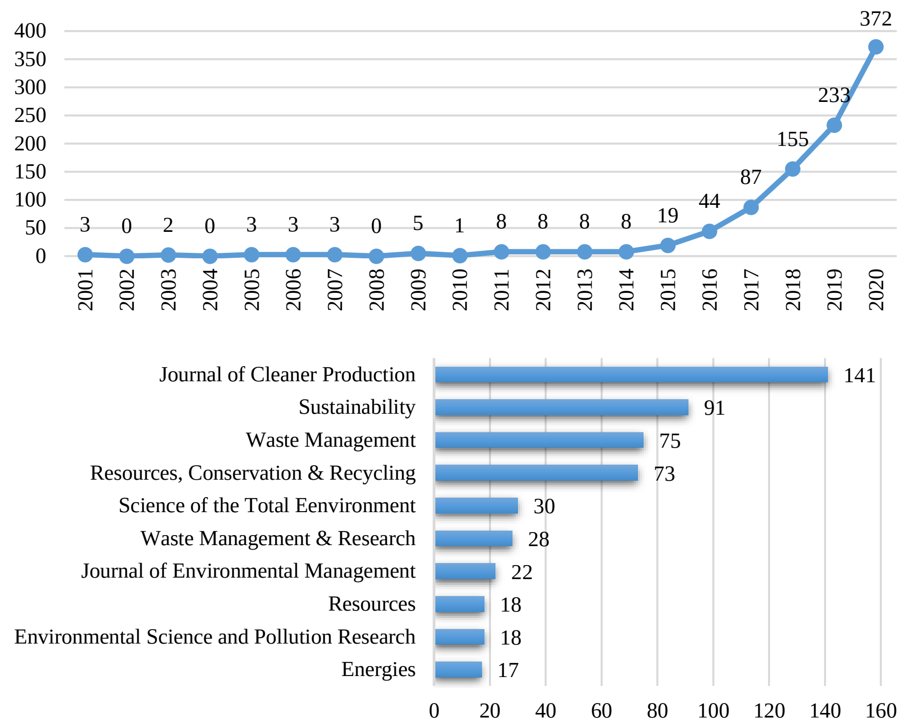


Fig. 2. Publications evolution in terms of number and leading journals over time from 2001–2020.

4.1.2. Citation analysis: core articles and authors

The number of citations received by an article can be considered as a suitable measure for identifying the most influential publications in a research domain (Merigó et al., 2015). The top 10 highly cited articles within our dataset are shown in Table 1. Six out of 10 highly cited articles have been published in *Journal of Cleaner Production*, which denotes this journal's significant contribution to the transition from a linear economy to a CE. The most cited paper is a comprehensive review of the CE implementation conducted by Ghisellini et al. (2016), which has been cited 998 times until January 22, 2021, based on the WoS database. The next highly cited research works have been carried out by Lieder and Rashid (2016), reviewing CE implementation in the manufacturing industry and Su et al. (2013), assessing the CE development in China, respectively. As it can be clearly seen from Table 1, the most cited papers in this research area are review articles focusing on the CE perspectives and implementation. This may have occurred due to two reasons. First, the CE transition, on account of its potential advantages for economic and environmental regimes, has been the focal point of attention for researchers over the last few years. And second, implementing CE in practice is still challenging for policy-makers and lacks a clear guideline for practitioners involved in operation levels.

Table 1. The top 10 highly cited articles in the WM research towards the CE.

Rank	Article title	TC*	TC/Y**	Author(s)	Journal
1	A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems	998	166.33	(Ghisellini et al., 2016)	J Clean Prod
2	Towards circular economy implementation: a comprehensive review in the context of manufacturing industry	501	83.50	(Lieder and Rashid, 2016)	J Clean Prod
3	A review of the circular economy in China: moving from rhetoric to implementation	374	41.56	(Su et al., 2013)	J Clean Prod
4	Concurrent product and closed-loop supply chain design with an application to refrigerators	230	12.11	(Krikke et al., 2003)	Int J Prod Res
5	A review of reverse logistics and closed-loop supply chains: a Journal of Cleaner Production focus	204	40.80	(Govindan and Soleimani, 2017)	J Clean Prod
6	Sewage sludge disposal strategies for sustainable development	198	39.60	(Kacprzak et al., 2017)	Environ Res
7	Strategies on implementation of the waste-to-energy supply chain for the circular economy system: a review	187	26.71	(Pan et al., 2015)	J Clean Prod
8	The history and current applications of the circular economy concept	186	37.20	(Winans et al., 2017)	Renew Sust Energ Rev
9	Municipal solid waste management and waste-to-energy in the context of a circular economy and energy recycling in Europe	178	35.60	(Malinauskaite et al., 2017)	Energy
10	How do scholars approach the circular economy? A systematic literature review	161	40.25	(Merli et al., 2018)	J Clean Prod

* Total citation; ** Total citation per year

The productivity (i.e., the number of publications) and influence (the number of received citations) of the top authors contributing to the WM research towards the CE are presented in Table 2. Ulgiati, Chisellini, and Cialani are the most influential authors with 1131, 1094, and 998 total citations, respectively. On the other hand, Smol with 12 articles, Torretta with 11 articles, and Ferronato with 9 articles are the most productive authors within the study period. Geng with 8 articles and 713 total citations, has appeared in both lists of the top 10 influential and productive authors, making this researcher a leading author within the CE domain.

Table 2. The most influential and productive authors in the WM research towards the CE.

Most influential authors				Most productive authors			
Rank	**Author**	**TC***	**TP****	**Rank**	**Author**	**TP**	**TC**
1	Ulgiati, Sergio	1131	4	1	Smol, Marzena	12	268
2	Ghisellini, Patrizia	1094	3	2	Torretta, Vincenzo	11	158
3	Cialani, Catia	998	1	3	Ferronato, Navarro	9	158
4	Geng, Yong	713	8	4	Geng, Yong	8	713
5	Lieder, Michael	500	1	5	Irabien, Angel	8	101
6	Rashid, Amir	500	1	6	Purnell, Phil	7	137
7	Heshmati, Almas	373	1	7	Bialowiec, Andrzej	6	24
8	Su, Biwei	373	1	8	Koziel, Jacek A.	6	24
9	Yu, Xiaoman	373	1	9	Zabaniotou, A.	6	109
10	Smol, Marzena	268	12	10	Zorpas, Antonis A.	6	65

* Total citation; **Total publication

4.1.3. Collaboration analysis: institutions and countries

Out of 88 countries and 1248 institutions contributing to our sample, the most contributing countries and institutions on the subject are illustrated in

Fig. **3**. In this figure, the larger each circle is, the higher the number of documents the corresponding country and institution have. Moreover, the thicker the link between the circles, the more collaboration has occurred between them. Based on the results, Italy, England, Spain, China, and the USA are the pioneers in the WM research in the context of CE with 118, 117, 95, 93, and 83 articles, respectively. In terms of collaboration, China, with 126 international collaborations, is the leading country within the global network on the subject. England with 112, and Italy and the USA, both with 100 collaboration links, come next in this network. On the contrary, Poland with 25 and Brazil with 22 collaborations have the least developed network among the top 10 contributing countries.

Due to the large number of institutions involved in this study (n= 1248), only the institutions with at least three articles have been plotted in Figure 3 to better visualize the highly contributing institutions. Surprisingly, although The Netherlands and Greece are not among the top 10 contributing countries on the subject, the Delft University of Technology from The Netherlands and Aristotle University of Thessaloniki from Greece are equally the most active institutions with 14 contributions. Polish Academy of Sciences from Poland with 13, University of Cantabria from Italy, the Technical University of Denmark from Denmark, and Chinese Academy of Sciences from China all together with 12 articles are the next most contributing institutions. Besides, the Delft University of Technology, Chinese Academy of Sciences, and Polytechnic of Milan with 36, 31, and 29 collaboration links are the most actively collaborating institutions among all institutions in this study.

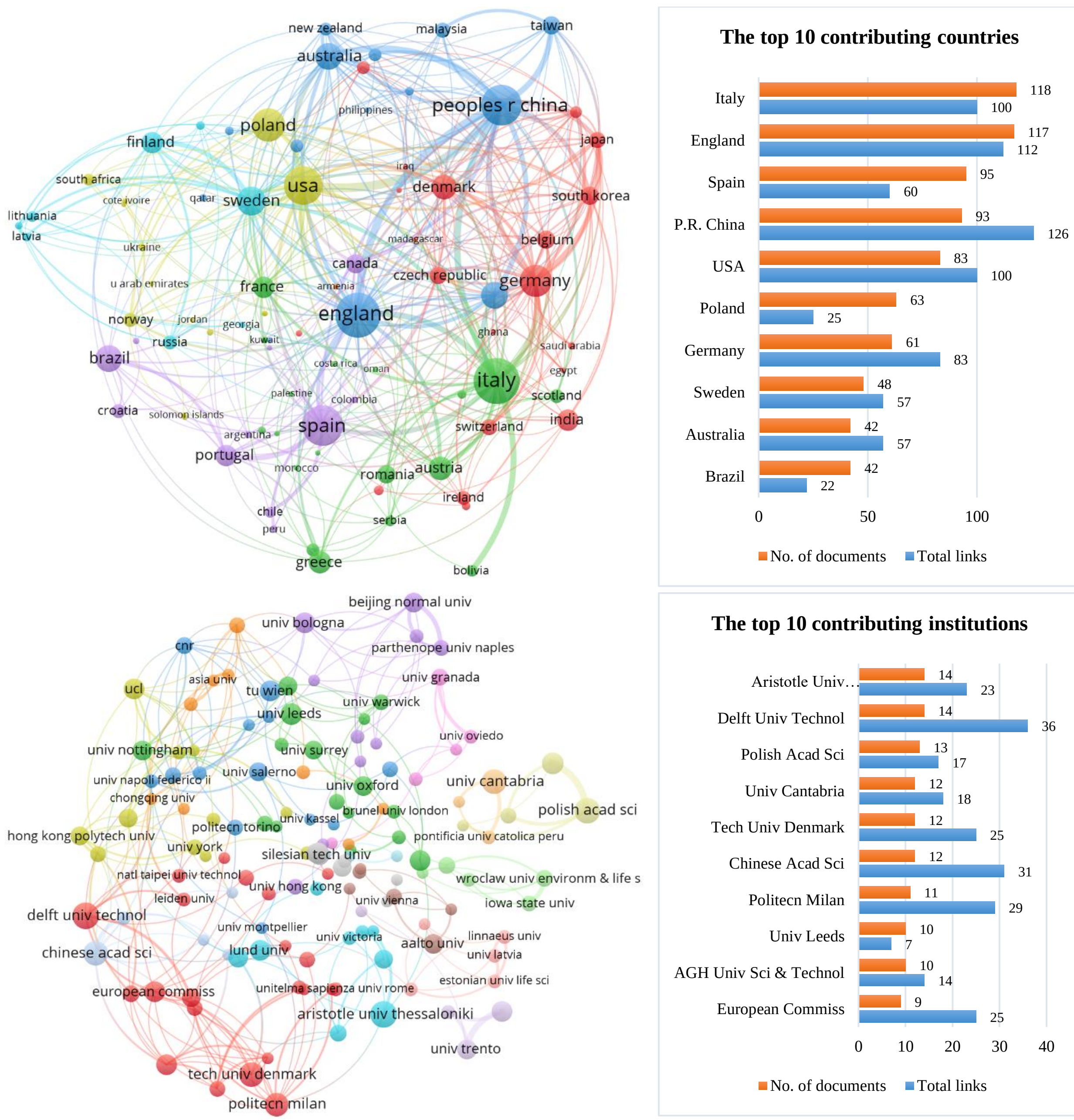


Fig. 3. Collaboration network between countries and institutions in the WM research towards the CE.

4.1.4. Bibliographic coupling network analysis: data clustering

Data clustering technique to group the articles with analogous characteristics from a sample for identifying the research orientations (Du et al., 2021) is a typical application of bibliometric analyses. Bibliographic coupling analysis using VOSviewer was applied to perform data clustering in our research. Bibliographic coupling links between publications indicate the number of cited references they have in common (van Eck and Waltman, 2020). A total number of 926 out of 962 articles in our sample was used to construct the bibliographic coupling network, as shown in Fig. ***4***. According to the results, four clusters of articles were generated, which are shown in different colors in Fig. ***4***.

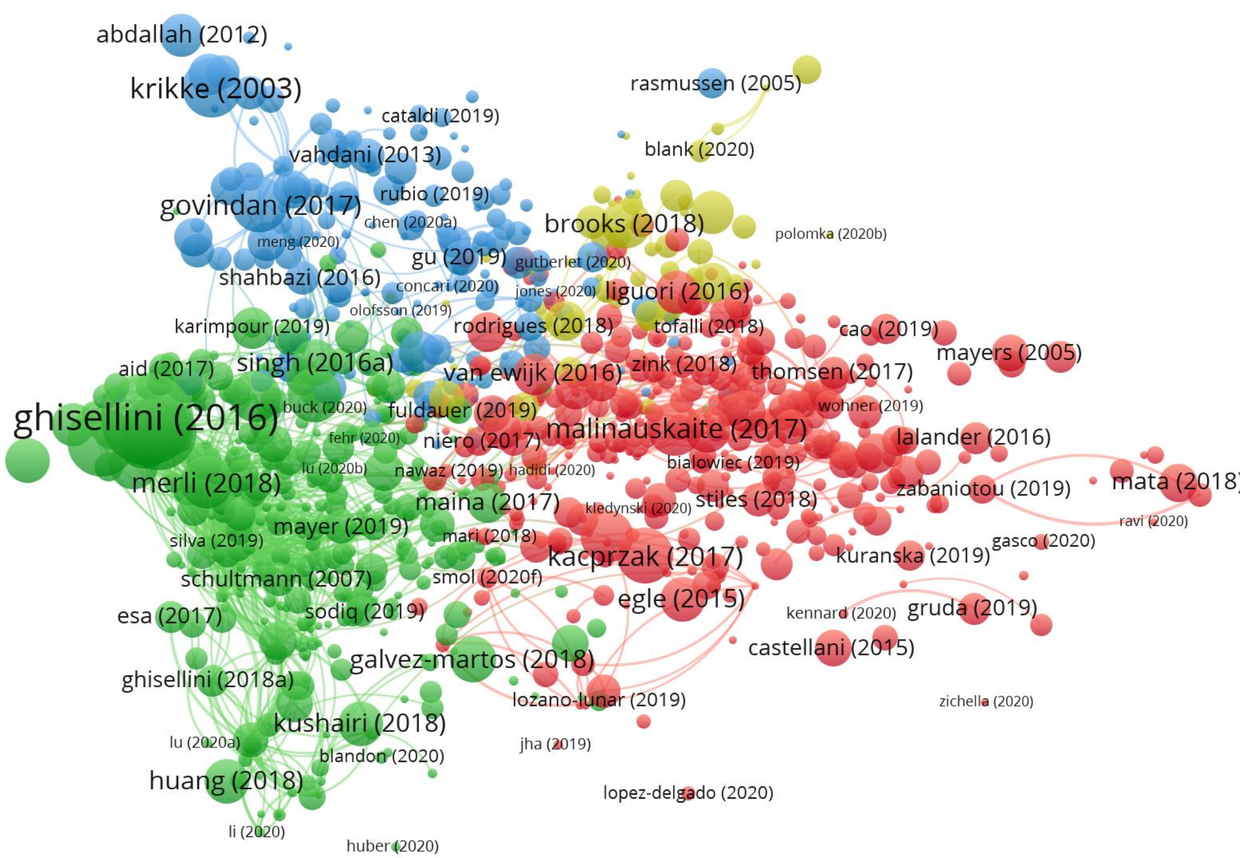


Fig. 4. Bibliographic coupling network of WM research towards the CE.

The four main clusters of articles are CE perspectives on waste hierarchy (cluster 1), CE conceptualization and implementation (cluster 2), WM within closed-loop supply chains (cluster 3), and CE approach to plastic WM (cluster 4). The top 15 most influential articles of each cluster are listed in Table 3. The obtained bibliographic coupling clusters and their influential articles will be addressed in detail in section 4.3 to conduct the qualitative content analysis and uncover the major themes and research orientations.

Table 3. The top 15 most influential articles within main clusters of WM research towards the CE.

Cluster 1: CE perspectives on the waste hierarchy	**Cluster 2:** CE conceptualization and implementation	**Cluster 3:** WM within closed-loop supply chains	**Cluster 4:** CE approach to Plastic WM
Kacprzak et al. (2017)	Ghisellini et al. (2016)	Krikke et al. (2003)	Brooks et al. (2018)
Malinauskaite et al. (2017)	Lieder and Rashid (2016)	Govindan and Soleimani (2017)	Sakai et al. (2011)
Smol et al. (2015)	Su et al. (2013)	Abdallah et al. (2012)	Koop and van Leeuwen (2017)
Sandin and Peters (2018)	Pan et al. (2015)	Lee and Chan (2009)	Horodytska et al. (2018)
Egle et al. (2015)	Winans et al. (2017)	Ferronato and Torretta (2019)	Van Eygen et al. (2018)
Liguori and Faraco (2016)	Merli et al. (2018)	Islam and Huda (2018)	Jambeck et al. (2018)
Van Ewijk and Stegemann (2016)	Reike et al. (2018)	Nikolopoulou and Ierapetritou (2012)	Payne et al. (2019)
Haupt et al. (2017)	McDowall et al. (2017)	Lu et al. (2015)	Pomberger et al. (2017)
Iacovidou et al. (2017b)	Gálvez-Martos et al. (2018)	Ferronato et al. (2019)	Eriksen et al. (2019)
Iacovidou et al. (2017a)	Singh and Ordoñez (2016)	Krikke et al. (2013)	Prieto (2016)
Blengini et al. (2012)	de Jesus and Mendonça (2018)	Vahdani et al. (2013)	Eriksen et al. (2018)
Agudelo-Vera et al. (2011)	Huang et al. (2018)	Gu et al. (2019)	Iacovidou et al. (2019)
Mata et al. (2018)	Bachmann (2007)	Özceylan et al. (2017)	Faraca and Astrup (2019)
Mayers et al. (2005)	Kushairi et al. (2018)	Pedram et al. (2017)	Foschi and Bonoli (2019)
Nižetić et al. (2019)	Dong et al. (2013)	Shahbazi et al. (2016)	RameshKumar et al. (2020)

4.1.5. Co-word analysis: identifying hotspots

Authors' keywords in the articles can represent the main idea and border of their research. The co-word analysis based on the co-occurrence of words can support identifying research hotspots in a particular field of study (Gao et al., 2020). Before conducting the co-occurrence analysis, the keywords list was cleaned reasonably. In the end, 2641 out of 2889 keywords remained for the analysis. Excluding the keywords with the co-occurrence frequency below seven (for clearer visualization), the co-occurrence network of the authors' keywords containing 68 hot keywords is mapped in Fig. ***5***. In this map, the bigger the circles are, the more occurrence the keywords have, and the thicker the links between every two keywords is, the more co-occurrence they have. Besides, the circles' color corresponds to the average publication year of the articles in which a keyword occurs. Moving from dark blue to yellow shows that the documents containing the relevant keywords are more recent on average.

The ten most frequent keywords in our dataset are *circular economy*, *waste management*, *recycling*, *sustainability*, *lifecycle assessment*, *municipal solid waste*, *waste*, *food waste*, *industrial ecology*, and *material flow analysis*. These ten keywords also have the most connection links with the other keywords in the dataset. As shown in Fig. ***5***, keywords such as *waste hierarchy*, *lifecycle*, *closed-loop supply chain*, and *resource efficiency* are older in terms of the average publication year. On the other hand, keywords such as *waste-to-energy*, *food waste*, *bio-refinery*, *solid waste management*, *municipal waste*, and *developing country* have been more recently paid attention to by scholars. Identifying the most recent active keywords within the WM research area towards a CE can provide researchers with the research frontiers and most attractive investigation areas in this field.

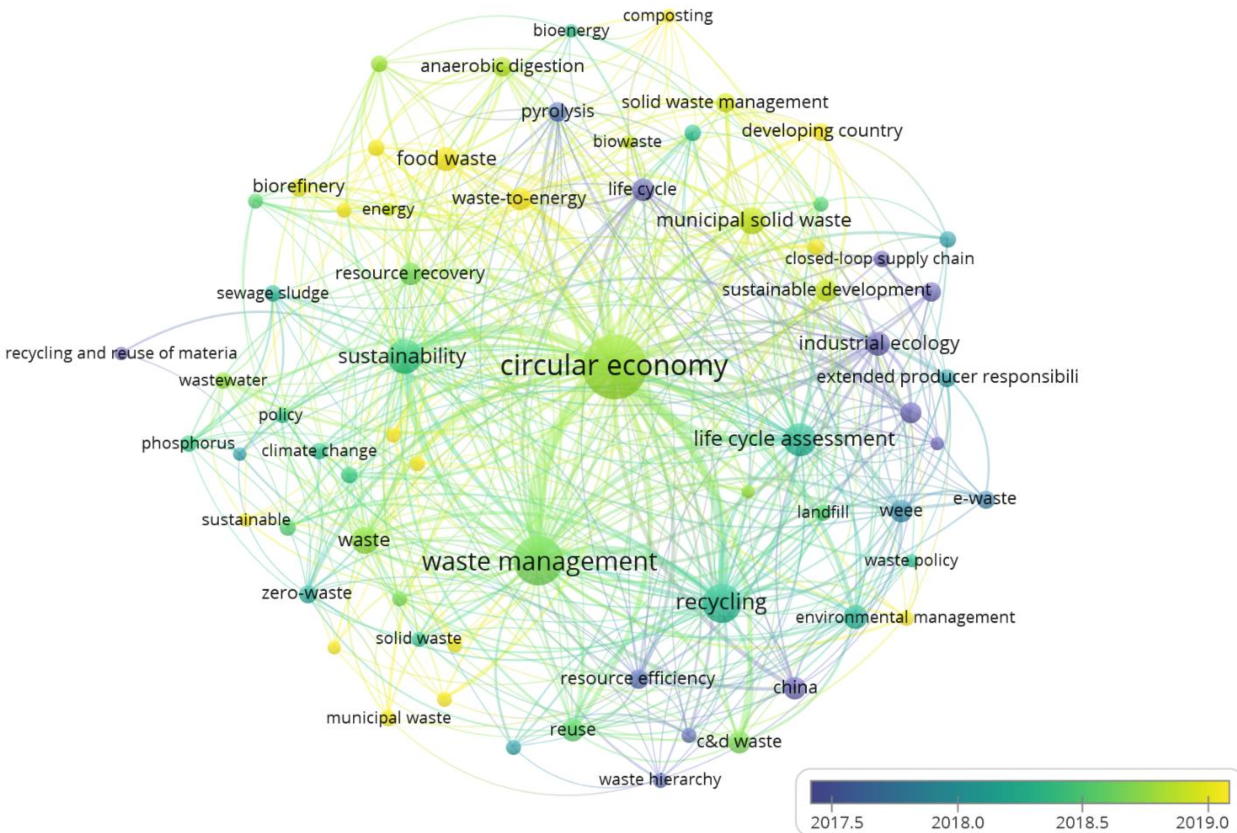


Fig. 5. Co-occurrence network of the keywords.

4.2. Text mining results: discovering main research themes and trends

The obtained results in this section directly address the second question:

RQ2. What are the salient research themes and trends of WM in the CE?

The text-mining results revealed that extant studies of WM within the CE domain focus on seven key research themes, as shown in Table 4. The identified dominant themes, including bio-based WM, CE transition, E-waste, MSW, environmental impacts and lifecycle assessment, plastic waste, and C&D WM, are presented and discussed in this section.

Table 4. Salient research themes in WM towards the CE.

No. and Label of the research theme	Main terms	Exemplary recent references
1. Bio-based waste management	Biochar, Bioeconomy, Bioenergy, Biofuel, Biogas production, Biomass, Biorefinery, Byproduct, Circular bioeconomy, Composting, Food waste, Food waste management, Organic Fraction of Municipal Solid Waste (OFMSW), Organic waste, Waste valorization	Imbert (2017), Ng et al. (2020), Tsai (2020), Zabaniotou and Kamaterou (2019), Loizia et al. (2019), Pérez-Camacho and Curry (2018), Cecchi and Cavinato (2019), Rekleitis et al. (2020), Kakadellis and Harris (2020), Elkhalifa et al. (2019)
2. Circular economy transition	Circular economy, Resource, Sustainability, Sustainable development, Circularity, Supply chain, Business model, Resource recovery, Circular economy model, Circular economy practice, Circular economy strategy, Sustainable Development Goals, Industrial symbiosis, Recycle, Waste reduction	Shpak et al. (2020), Lu et al. (2020), Alvarez and Ruiz-Puente (2017), Okafor et al. (2020), Johansson and Henriksson (2020), Priyadarshini and Abhilash (2020)
3. E-waste	Behavior, Society, Government, E-waste, Consumer, Waste Electrical and Electronic Equipment (WEEE), Producer, Incentive, Manufacturer, Policymaker, Responsibility, Environmental protection, Waste disposal, Extended Producer Responsibility, WEEE directive	Sharma et al. (2020), Lu et al. (2015), Chen et al. (2020), Marke et al. (2020), Ottoni et al. (2020), Cole et al. (2019), Mayers et al. (2005)
4. Municipal solid waste (MSW)	Policy, MSW, Waste generation, Municipality, European Union, Recycling rate, Waste hierarchy, Waste collection, Household waste, Biowaste, Circular economy package, Packaging waste, Waste-to-energy, Secondary raw material, Separate collection	Malinauskaite et al. (2017), Kaza et al. (2018), Hadidi et al. (2020), Petryk et al. (2019), Smol et al. (2020), Abis et al. (2020), Morlok et al. (2017), Agovino et al. (2019), Valenzuela-Levi (2019), Siddiqi et al. (2020), Hadzic et al. (2018)
5. Environmental impacts and lifecycle assessment	Environmental impact, Landfill, Disposal, Emission, Incineration, Lifecycle assessment, Energy recovery, Climate change, Greenhouse gas emission, Environmental performance, Decision making, Recycling process, Material recovery, Environmental burden, Global Warming Potential	Thomsen et al. (2018), Jensen (2019), Peceño et al. (2020), Arushanyan et al. (2017), Boldoczki et al. (2020), Sandin and Peters (2018), Sauve and Van Acker (2020), Cortés et al. (2020), Zeller et al. (2020), Kouloumpis et al. (2020), Slorach et al. (2019), Gallego-Schmid et al. (2018)
6. Plastic waste	Recycling, Recovery, Plastic waste, Packaging, Chemical, Value chain, Human health, Threat, Prevention, Polymer, Rubber, End-of-Life, Recyclability, Contaminant, Single-use plastic	Sherwood (2020), Foschi and Bonoli (2019), Pazienza and De Lucia (2020), Andreasi Bassi et al. (2020), Leissner and Ryan-Fogarty (2019), Milios et al. (2018), Faraca and Astrup (2019), Eriksen et al. (2018), Eriksen et al. (2019)

7. Construction and Demolition (C&D) waste management	Technology, Raw material, Construction, C&D waste, Building, Concrete, Construction industry, C&D waste management, Sewage sludge ash, Industrial waste, Material efficiency, Slag, Steel, Energy consumption, Demolition	Kabirifar et al. (2020), Lederer et al. (2020), Jin et al. (2019), Esa et al. (2017), Li et al. (2020), Mahpour (2018), Smol et al. (2015), Mak et al. (2019)

Bio-based WM has appeared as one of the leading research themes of WM in the CE context. In this regard, food WM poses a significant challenge on the transition from a linear economy to a CE (Imbert, 2017). The studies related to this research theme mainly focus on valorization and turning food waste into value-added resources and bioproducts (Imbert, 2017; Ng et al., 2020; Tsai, 2020; Zabaniotou and Kamaterou, 2019), optimization of energy production through anaerobic digestion in food WM (Loizia et al., 2019), using the anaerobic biorefinery to contribute to a regional bioeconomy (Pérez-Camacho and Curry, 2018), smart approaches to food waste final disposal (Cecchi and Cavinato, 2019), waste biomass from the agricultural-livestock sector (Rekleitis et al., 2020), lifecycle assessment of bioplastic-based food packaging (Kakadellis and Harris, 2020), and food waste to biochars through pyrolysis (Elkhalifa et al., 2019).

The second theme pertains to how a linear economy can be transitioned to a CE with a particular focus on WM practices and activities. Due to the lack of a precise mechanism for collecting, sorting, and distributing waste, the transition to a CE will be long and complicated (Shpak et al., 2020). For instance, developing measurement and index systems (Lu et al., 2020), creating synergies and industrial symbiosis among industrial sectors based on the substitution of raw materials from waste, sub-products or recycled materials (Álvarez and Ruiz-Puente, 2017), end-of-life mismanagement and its profound negative ecological implications (Okafor et al., 2020), discursive framing of CE policies (Johansson and Henriksson, 2020), and energy recovery from waste (Priyadarshini and Abhilash, 2020) have been highlighted in the literature, as some of the main WM challenges towards implementing a CE.

The significant increasing demand for using electrical and electronic products across the globe has made proper E-waste management a top priority for developed and developing countries, particularly those in the CE transition phase (Sharma et al., 2020). E-waste is one of the most challenging subjects for policy-makers in WM since inappropriate E-waste treatment and recycling can hugely affect the environment and human health (Lu et al., 2015). Studies categorized in the E-waste research theme mostly investigate critical barriers and pathways to the implementation of E-waste formalization management systems (Chen et al., 2020), application of the innovative circular business models to support E-waste reduction (Marke et al., 2020), E-waste valorization through developing adequate indicators for E-waste reverse logistics (Ottoni et al., 2020), solutions and incentives to move up on the top of the waste hierarchy in the E-waste treatment, rather than recycling (Cole et al., 2019), and the importance of modifying the E-waste directives and policy guidelines to ensure addressing all lifecycle impacts (Mayers et al., 2005).

Due to the growing population of the world and rising living standards, the consumption of goods, and consequently, waste generation levels have been considerably increasing over the recent years (Malinauskaite et al., 2017). For instance, an estimated 2.01×10^9 t of MSW were generated in the world in 2016, and it is expected to grow to 3.40×10^9 t by 2050 (Kaza et al., 2018), which sounds alarming as a universal issue. The main research articles in the MSW theme mainly concentrate on 3Rs (reduce, reuse, recycle) practices implementation to influence the behavior of citizens (Hadidi et al., 2020), proposing incentives for public engagement in the MSW management (Petryk et al., 2019), providing practical solutions for transformation towards CE (Smol et al., 2020), increasing the collection rates of recyclables (Morlok et al., 2017), assessing the synergy between recycling and thermal treatments (Abis et al., 2020), factors influencing different collection rates and municipal recycling (Agovino et al., 2019; Valenzuela-Levi, 2019), waste-to-energy systems using MSW to produce energy (Siddiqi et al., 2020), and lifecycle assessment of solid waste management (Hadzic et al., 2018).

Through employing efficient WM systems, the CE aims to increase resource efficiency and mitigate the environmental impacts of waste generation. Assessing the environmental implications of WM practices has always been challenging to provide decision support for policy-makers to make the optimal decisions regarding commitment to a clean and sustainable environment (Khoshnevisan et al., 2020). According to the text mining analysis results in our study, the major challenges of environmental evaluation within WM activities have been highlighted in the environmental impacts and lifecycle assessment theme. For example, environmental analysis of integrated organic waste and wastewater management systems (Thomsen et al., 2018), environmental assessment of different recycling processes (Jensen, 2019; Peceño et al., 2020), developing lifecycle assessment models for environmental assessment of possible future WM scenarios (Arushanyan et al., 2017), measuring potential environmental benefits of preparation for reuse before recycling (Boldoczki et al., 2020), environmental impacts of textile reuse and recycling (Sandin and Peters, 2018), environmental impacts of MSW landfills (Sauve and Van

Acker, 2020), environmental burdens of composting as a way to achieve a more circular waste valorization (Cortés et al., 2020), environmental consequences of CE options for biowaste flows (Zeller et al., 2020), plastic waste effects on climate change (Kouloumpis et al., 2020), environmental implications of recovering resources from food waste in a CE (Slorach et al., 2019), and environmental impacts of the entire lifecycle of electrical and electronic waste (Gallego-Schmid et al., 2018), are some of the most critical environmental studies in this research theme.

Due to its extensive applications in the industry and urban life, plastic has made WM face various challenges and environmental concerns, from marine pollution to limited recycling. The main addressed subject areas of the plastic waste theme in our study refer to closed-loop recycling of polymers (Sherwood, 2020), the interaction between plastic value chain stakeholders, and regulations towards implementing a CE (Foschi and Bonoli, 2019), defining a new plastics economy in the agriculture sector (Pazienza and De Lucia, 2020), extended producer responsibility for plastic packaging waste (Andreasi Bassi et al., 2020), challenges and opportunities for reduction of single-use plastics (Leissner and Ryan-Fogarty, 2019), identifying critical barriers for plastic recycling across the regional plastics value chain (Milios et al., 2018), evaluation of plastic recyclability (Faraca and Astrup, 2019), contamination in plastic recycling and the quality of reprocessed plastics (Eriksen et al., 2018), and circularity-potential assessment of recovery systems for household plastic waste (Eriksen et al., 2019).

Finally, C&D waste generated throughout the construction cycle has been identified through the text mining analysis as the last research theme of WM in the CE in our study. The rapid urbanization in the world has increased the C&D waste (Kabirifar et al., 2020), which is considered one of the largest waste streams (Lederer et al., 2020). Sustainable treatment of C&D wastes should be employed globally as an urgent social, environmental, and economic issue (Jin et al., 2019). In this regard, the scholars have paid close attention to developing strategies for managing C&D wastes based on CE principles (Esa et al., 2017), application of information technologies in C&D WM (Li et al., 2020), prioritizing barriers to adopt CE in C&D WM (Mahpour, 2018), using sewage sludge ash in the construction industry as a way towards a CE (Smol et al., 2015), and behavior and attitudes towards recycling of C&D waste in the community (Mak et al., 2019).

The revealed research themes of WM practices towards a CE obtained from the text mining analysis on the abstracts of articles within our dataset allow mapping how WM subject areas have evolved over the years based on their average publication year. Fig. ***6*** illustrates the timeline of dominant research themes and their WM subject areas in the CE context over the recent five years. As shown in Fig. ***6***, biochar, Organic Fraction of Municipal Solid Waste (OFMSW), plastic waste, C&D waste, food waste, biofuels, circular bioeconomy, and single-use plastics have been attracting attention very recently, rather than material cycles, closed-loop supply chain, carbon emission, industrial ecology, and liquid waste.

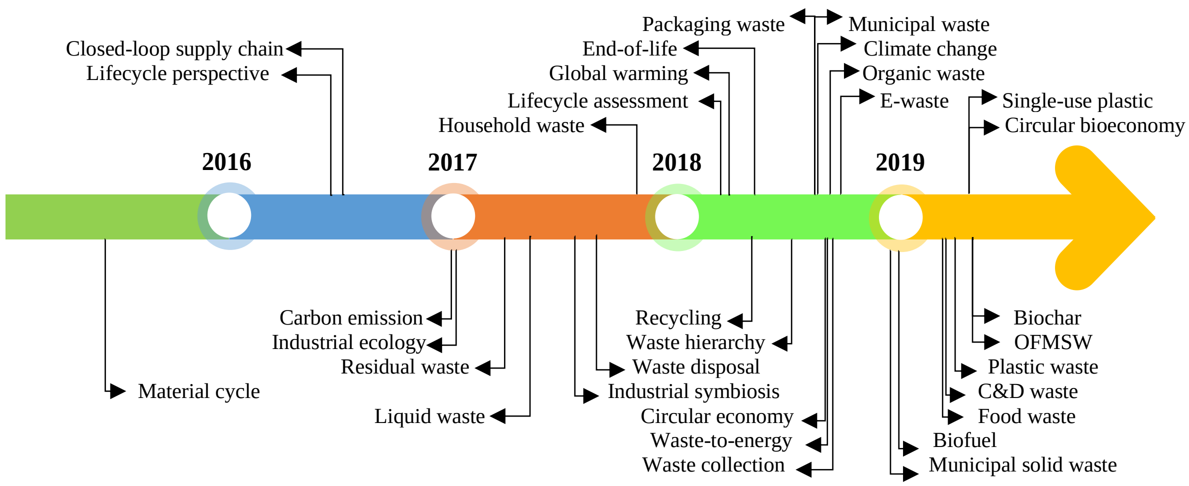


Fig. 6. Timeline of dominant research themes and their WM subject areas in the CE context.

4.3. Qualitative content analysis of the four clusters: more in-depth results

The data clustering of bibliographic coupling analysis revealed four main clusters of WM research in the context of CE (Fig. ***4*** and Table 3). The fifteen most influential articles within each identified cluster, including CE perspectives on waste hierarchy, CE conceptualization and implementation, WM within closed-loop supply chains, and CE approach to the WM of plastics, are scrutinized to conduct the qualitative content analysis of our study in this section.

4.3.1. Cluster 1: CE perspectives on the waste hierarchy

The fifteen most influential articles from the last two decades of research making up this cluster on "CE perspectives on waste hierarchy" are relatively recent, including two articles published in 2015, two in 2016, five in 2017, two in 2018, and one in 2019. *Journal of Cleaner Production*, with six articles, has the largest representation in this cluster, followed by *Journal of Industrial Ecology*, and *Bioresource Technology*, with two articles each, and then *Environmental*

Research Energy, *Resources, Conservation & Recycling*, *Waste Management*, and *Journal of Environmental Management*, with one article each. With different affiliations and coming from diverse countries, various authors are also noticed, with Iacovidou being the only lead author appearing two times within this cluster.

The first group of articles from this cluster can be drawn, including five articles sharing the "generic" feature, meaning their findings or the framework and tools they develop could be applied across sectors and businesses. While Van Ewijk and Stegemann (2016) discuss the barriers and potential solutions to take waste hierarchy to the next level for achieving absolute reductions in material throughput, the other authors from this group both question and develop the measuring and monitoring instruments (Iacovidou et al., 2017a) for WM systems (Haupt et al., 2017) in a CE perspective (Iacovidou et al., 2017b). More recently, Nižetić et al. (2019) started to discuss the integration of smart technologies (e.g., smart cities and the Internet of Things) to achieve more sustainable management of resources and waste.

The second group of articles from this cluster is focused on industrial sectors of high interest. Among the ten articles from this second group, multiple specific sectors of utmost importance for the future of enhanced WM practices are highlighted: (i) waste treatment, including sewage sludge management solutions (Kacprzak et al., 2017; Smol et al., 2015), technologies for recovering phosphorus from municipal wastewater (Egle et al., 2015), glass recycling (Blengini et al., 2012), and waste electrical and electronic equipment at end-of-life (Mayers et al., 2005); (ii) textile reuse and recycling (Sandin and Peters, 2018); (iii) MSW (Malinauskaite et al., 2017) and sustainable urban planning for augmented resource management and valorization (Agudelo-Vera et al., 2011); and (iv) concrete examples of waste valorization following the waste hierarchy (Mata et al., 2018), such as specific lignocellulosic biorefineries converting biomass to bioethanol (Liguori and Faraco, 2016).

These articles challenge the waste hierarchy to move "from waste to resources" (Kacprzak et al., 2017) through concrete examples from the field. In fact, different but complementary CE principles and loops are recommended depending on the industrial sector. For instance, sewage sludge is increasingly seen as a valuable resource for energy generation (waste-to-energy) or use in the construction industry, e.g., as feedstock for cement or concrete production (Smol et al., 2015). Yet, these articles also highlight several gaps and margins for improvement to reach zero-waste systems, such as the need for developing more waste-to-energy plants and technologies

(Malinauskaite et al., 2017) or the potential rebound effect and impact transfer caused by inefficient reverse supply chains to collect and reuse products (Sandin and Peters, 2018), necessitating optimized or better-dimensioned value chains.

4.3.2. Cluster 2: CE conceptualization and implementation

The majority of the articles from this cluster are literature review papers, both from a historical (Winans et al., 2017) and a geographical perspective (Ghisellini et al., 2016; McDowall et al., 2017; Su et al., 2013), as an attempt to conceptualize and clarify the CE (Merli et al., 2018; Reike et al., 2018), for which an advanced and more integrated WM system is praised and required. According to the research conducted by Merli et al. (2018), WM recently emerged as the most relevant sub-concept of CE. In this line, the drivers and barriers of eco-innovation for enhanced waste management from a CE perspective have been analyzed by de Jesus and Mendonça (2018).

The second group of articles from this cluster addresses the actual implementation of CE principles in diverse key businesses, e.g., in the building (including both the construction and demolition phases) industry (Gálvez-Martos et al., 2018), in the manufacturing industry (Lieder and Rashid, 2016), within industrial symbiosis (Dong et al., 2013) or within the waste-to-energy supply chain for augmented CE systems (Kushairi et al., 2018; Pan et al., 2015). Discussions on the best practices from specific industries are particularly valued, such as in the building industry (Gálvez-Martos et al., 2018) with a particular interest in the management of construction and demolition waste through CE loops (Huang et al., 2018). Lastly, lessons learned from the implementation of CE principles within WM systems are also highly valued by researchers and practitioners (Bachmann, 2007; Pan et al., 2015; Singh and Ordoñez, 2016). It should be noted that the management of plastic waste, which is also a significant challenge, is not mentioned yet in clusters 1 and 2 and has its own cluster (cluster 4) and is addressed in sub-section 4.3.4.

4.3.3. Cluster 3: WM within closed-loop supply chains

While waste mismanagement can lead to serious environmental issues, such as marine litter, air, soil and water contamination, and hazardous waste leakage (Ferronato and Torretta, 2019), the implementation of a CE can improve current solid waste management activities in developing economies based on the principles of effective waste valorization and recycling (Ferronato et al., 2019). To achieve material efficiency and reduce virgin material and industrial waste volumes towards the CE transition, it is necessary to manage various barriers such as budgetary, information, management, employee, engineering, and communication within the supply chain (Shahbazi et al., 2016). An integrated WM system benefits from a closed-loop supply chain and reverse logistics simultaneously (Islam and Huda, 2018; Pedram et al., 2017). The closed-loop supply chain approach integrates both forward and reverse supply chains with a particular focus on end-of-life products in the most environmentally friendly manner possible (Govindan and Soleimani, 2017).

The significant impact of product design in terms of modularity, reparability, and recyclability within the closed-loop supply chain network structure on the waste functions was highlighted by Krikke et al. (2003). In this regard, reuse at a module level was identified as the most beneficial recovery option, followed by material recycling and thermal disposal as the next best choices (Krikke et al., 2003). Sustainable optimal design and planning for chemical processes and supply chains focusing on energy efficiency and WM to minimize waste and energy requirements and guarantee long-term sustainability is a significant challenge in supply chain management (Nikolopoulou and Ierapetritou, 2012). Besides, a proper returns management not only in a specific stage but also in the full lifecycle of products, as a key driver of value creation rather than a cost of the business in closed-loop supply chains, can save the environment and support resource efficiency (Krikke et al., 2013). The application of online mobile platforms within the supply chain of MSW, where recycling practitioners or individuals can make appointments for on-site waste collection, was evaluated as beneficial by Gu et al. (2019) in terms of overall environmental performance for WM systems. Effective designing of closed-loop supply chains under uncertainty is a highly complex and challenging task because of the interconnection of many factors such as product variety, the short lifecycle of products, increased outsourcing possibilities, and globalization of businesses (Vahdani et al., 2013). Lee and Chan (2009) developed an optimization model to minimize the total reverse logistics cost and high utilization rate of collection points for product returns, which improves the efficiency of logistics operations and supports reasonable recycling economically and ecologically. Moreover, a closed-loop supply chain network was designed by Özceylan et al. (2017) considering the end-of-life vehicles treatment, including reverse operations such as shredding, recycling, dismantling, and landfilling to reintegrate the reverse material flows into forwarding supply chains.

Recently, WM systems have been facing the challenge of E-waste, as one of the main end-of-life products within the closed-loop supply chains, due to its severe adverse environmental and human health impacts. Policy-makers and WM practitioners dealing with E-waste should particularly consider all the disposition alternatives (i.e., recycling, remanufacturing, reuse and repair) in an integrated manner within the closed-loop supply chain network design (Islam and Huda, 2018). However, despite the increasing legal pressure on E-waste treatment policies, efficient E-waste management due to the lack of an effective collection system and public participation, as well as lax enforcement of regulations, is still in its infancy (Abdallah et al., 2012; Lu et al., 2015).

4.3.4. Cluster 4: CE approach to plastic WM

Increasing environmental concerns regarding the accumulation of plastic waste in the natural environment have pushed policy-makers to develop renewable alternatives and suitable WM strategies during recent years (Payne et al., 2019). The European Commission has strongly contributed to regulate production and consumption patterns on plastic and packaging in a CE to support sustainability along the entire plastic value chain from producers to waste collectors and recyclers (Foschi and Bonoli, 2019). Moreover, increasing the plastic recycling rate for both plastic packaging and plastic from household waste has been highlighted as a priority in the European Union strategy towards a CE (Eriksen et al., 2018). Adopting a new plastic economy based on the CE principles, as an alternative to the linear economy, has gained momentum (Ellen MacArthur Foundation, 2016) to reduce plastic waste and mitigate its damage to the environment and wildlife. By applying a CE approach, plastic products are designed to be reused or recycled to reduce plastic leakage into the environment before waste mismanagement occurs (Jambeck et al., 2018). As an environmentally friendly alternative for fossil-based plastics, designing sustainable bioplastics opens up opportunities to reduce carbon footprint at the production level and overcome resource depletion by relying on the development of valorization protocols of renewable resources (RameshKumar et al., 2020).

Payne et al. (2019) highlighted the significant role of using chemical recycling instead of mechanical recycling for biodegradable plastics, such as polylactic acid, due to this approach's potential for further integration of polylactic acid into a circular economy. Faraca and Astrup (2019), in their study on plastic recyclability, highlighted the direct link between detailed characteristics of plastic waste and recycling and showed that the recyclability of "High Quality" plastic waste was 12–35% higher than "Low Quality" application. China's recent ban (late 2017) on imports of low-quality recyclates has significantly affected the WM systems, which denotes the importance of quality of resources at different parts of the materials, components, and products characteristics lifecycle to facilitate the transitions towards resource efficiency (Iacovidou et al., 2019). Van Eygen et al. (2018) denoted that setting recycling targets for plastic packaging in line with the recycling process's actual output and maintaining the quality of output product is necessary to 1) improve the circularity of plastic packaging and resource efficiency and 2) assess the performance of the waste management system accurately. Moreover, closing the plastic loop using mass-based recycling targets towards a CE transition is still challenging, and the focus of WM strategies should be on decreasing impurities and losses through product design and technological advancements (Eriksen et al., 2019) and minimizing the material degradation during mechanical processes (Horodytska et al., 2018). The urgent need for regulating the standardized labeling and sorting instructions for WM of bio-based plastics by governmental policy-makers and material producers was outlined by Prieto (2016) to facilitate the CE transition. However, although CE and sufficient recycling have been touted to managing plastic waste, over 50% of the plastic waste has been exported to hundreds of countries across the world, which denotes the necessity of adopting new policies to deal with the importation and exportation of plastic waste (Brooks et al., 2018). Besides, hazardous waste requires more managerial consideration for the circulation use of resources and increasing resource efficiency in developing a CE that targets waste reduction and turning waste into a resource (Koop and van Leeuwen, 2017; Sakai et al., 2011).

5. Implications for research: directions for future studies

According to the insights provided by the bibliometric, text mining, and qualitative content analyses conducted, implications for future studies are presented in this section to address the third research question:

RQ3. What are the possible directions for future research on WM towards the CE transition?

After careful consideration, four lines of research were identified as potential research gaps and directions for future studies to better position the WM research agenda in line with the CE perspectives, sustainable environment, and human well-being as follows.

- The possibility of using Information Technology (IT) tools with the advent of the Internet of Things (IoT) and Industry 4.0 has provided promising opportunities to improve the global WM systems towards a cleaner environment and sustainable CE transition, in particular in developed countries (Fatimah et al., 2020). For instance, developing a smart reverse system for efficient E-waste management based on interactive online maps of users' requests as an intelligent IT tool (Shevchenko et al., 2021), and applying IoT devices to monitor human activities and alert the WM centers to support taking appropriate actions (Alqahtani et al., 2020), are some examples of incorporating IoT-based tools into the current WM systems. However, research in this area is still in its infancy, and developing an inclusive, sustainable, and smart WM mechanism reinforced by IT tools and IoT facilities, especially in developing and less-developed countries, is still missing. Therefore, focusing on designing smart WM systems by expanding the application of IoT-based tools and devices to specifically contribute to (i) efficient waste collection and separation; (ii) supporting the long-term sustainability from environmental, social, and economic points of view; (iii) encouraging WM activities and practices from recycling to move up to the top of the waste hierarchy; and (iv) minimizing the adverse environmental implications, is a timely and promising direction for future research in the WM domain towards the CE transition.
- As depicted in Fig. ***6***, two main WM-related research streams have attracted attention recently. First, the biosphere side of a CE – with the keywords "biochar", "food waste", "biofuels", "circular bioeconomy" – presents significant research challenges that need to be addressed to reach a zero-waste agri-food ecosystem. Second, plastic WM (see cluster 4 in Table 3) and, more recently, the issue of single-use plastics have received more attention recently in the context of COVID-19 (Klemeš et al., 2020), where new trade-offs between environmental sustainability and health safety of waste and product recovery occur. Such trade-offs still have to be addressed, solved, or optimized by researchers. In this line, the resilience of reverse supply chains is a topic of the utmost importance in response to the disruptions and shortages caused by the pandemic (Singh et al., 2020; Yu et al., 2020). The unprecedented COVID-19 situation has led several sectors to both unsustainable WM and many disruptions all along the supply chain (Ranjbari et al., 2021;

You et al., 2020). While several authors (Sarkis et al., 2020; Wuyts et al., 2020) initiated the discussion on lessons learned from the COVID-19 crisis for transitioning to sustainable supply and production, further research is encouraged in the field of WM.

- Healthcare waste, as a matter of great concern for the environment, health, and well-being due to its infectious and hazardous nature (Chauhan et al., 2021), needs more sustainable and safe management. Voudrias (2018) argues that adopting a CE model for the current healthcare WM as a whole would be unlikely. Putting the CE in place, dealing with different streams of healthcare waste such as medical, clinical, and pharmaceuticals wastes would also be challenging and need more effort and engagement by interdisciplinary sectors. The main reason is that reusing, recycling, and recovering materials in this sector are concerned with infectious, toxic, and hazardous sources, which expose the community to health risks. According to the results of this study, the literature of WM towards implementing the CE strategies lacks reliable and comprehensive research considering waste generated by the healthcare sector. The existing studies in this domain are mainly limited to suitable treatment methods for the safe disposal of healthcare waste (Chauhan et al., 2021; Singh et al., 2021). Developing an inclusive CE model to incorporate different activities and practices of healthcare WM, in particular by (i) exploring technological advancement for recycling and recovery of healthcare waste, (ii) drafting national plans for minimizing the waste generated and implementing the reuse strategy for non-hazardous healthcare waste, and (iii) designing closed-loop supply chains for healthcare WM, is highly recommended for further investigations in the future.
- As a conceptual and operational framework, the One Health (OH) approach aims to integrate the collaborative efforts between interdependent sectors to link human health, food-producing organisms, and the environment (Frazzoli and Mantovani, 2019) to achieve optimal health for human, animals, and the environment. Although a considerable amount of research has been conducted on the environmental impacts of different WM activities, such as MSW landfills (Sauve and Van Acker, 2020), textile reuse and recycling (Sandin and Peters, 2018), and recovering resources from food waste (Slorach et al., 2019), human well-being and animal health, have been paid less attention. In particular, there is minimal research considering the OH framework in the WM practices (Oliveira et al., 2019). Therefore, conducting well-established research projects to involve the OH framework in

the waste hierarchy and planning and policy-making in the macro, meso, and micro levels of WM systems for disease prevention and health promotion is highly recommended for future research.

6. Conclusions

This study aimed to provide an inclusive map of WM research in the context of CE over the last two decades by (i) mapping the evolution of the field over time; (ii) identifying the main research themes and trends; and (iii) offering possible directions for future research to better position the WM practices towards a CE. To achieve this, a mixed-method approach was followed by conducting bibliometric, text mining, and content analyses on a total of 962 peer-reviewed journal articles extracted from the WoS database, published from 2001 to 2020.

The obtained results unfolded four main clusters of WM research in the CE context, including CE perspectives on waste hierarchy, CE conceptualization and implementation, WM within closed-loop supply chains, and CE approach to Plastic WM. Besides, seven dominant research themes of WM practices within the CE context, including bio-based WM, CE transition, E-waste, MSW, environmental impacts and lifecycle assessment, plastic waste, and C&D WM, were identified. Subject areas, such as OFMSW, plastic waste, C&D waste, food waste, biofuels, circular bioeconomy, and single-use plastics, have attracted attention very recently, rather than material cycles closed-loop supply chain, carbon emission, industrial ecology, and liquid waste.

The main findings of the present study shed light on the WM research agenda and considerably contribute to the positioning of WM activities and practices aligned with the CE principles in the future. The provided inclusive research landscape of WM systems, and its prominent highlight patterns can serve as a base for a real-time guideline to lead further research areas and as a tool to support WM policy-makers and practitioners to support the CE transition (which aims to minimize the waste generation). Finally, four specific directions for the future research agenda of WM to support the CE establishment, sustainable environment, and human well-being were proposed. The provided research directions for the future particularly help with (i) establishing smart, sustainable WM mechanisms employing IT tools and IoT-based facilities, (ii) alleviating the COVID-19 pandemic implications for plastic waste, (iii) developing a CE model for healthcare waste, and (iv) converging the joint efforts of multidisciplinary sectors towards the optimal health for human, animals, and the environment based on the OH approach.

This research is bound to have its limitations too. First, we clustered the research themes of our dataset based on the bibliographic coupling of articles. Using other data clustering techniques, such as co-citation analysis of articles, is recommended to further develop and compare the results. Second, we considered only the WoS database in this study. Extracting valuable data from other well-known scientific databases, such as Scopus, could provide more information in future bibliometric analyses. And finally, our sample was chosen only among articles published in the English language. Further investigation into non-English articles in this domain is recommended to harmonize the research findings.

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