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# A comprehensive analysis of food waste through historical context: A bibliometric study from 2019 to 2024

Tímea Gál [a,1], Sándor Kovács [b,2,*], Erzsébet Buglyó-Nyakas [a,3]

[a] University of Debrecen, Faculty of Economics and Business, Institute of Rural Development and Functional Management, Department of Logistics Management, 138 Böszörményi Street, Debrecen H-4032, Hungary
[b] University of Debrecen, Coordination Center for Research in Social Sciences, 138 Böszörményi Street, Debrecen H-4032, Hungary

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ABSTRACT

Food waste is a critical issue with implications for consumers, environmental sustainability, and supply chain dynamics. The primary objective of this research was to conduct a bibliometric analysis of recent literature on food waste, using Web of Science Core Collection and Scopus to identify gaps for future research projects especially on the field of food waste and sustainable food waste management. This approach allowed for a comprehensive assessment of the performance and efficiency of scientific research in this area. The use of both databases was a distinctive aspect of the study, as previous research has typically relied on a single database. The study analyzed publication trends between 2019 and 2024, focusing on highly cited documents, research areas, and keyword co-occurrence patterns, highlighting the growing relevance and importance of sustainability. In particular, there has been a significant increase in research published in environmental sciences, engineering, and energy fuels since 2020, reflecting the growing recognition of the role of food waste in reducing environmental footprints and enhancing energy efficiency and sustainability. The keyword analysis showed that between 2021 and 2023, the dominant themes were circular economy, sustainable development, development goals, supply chains, and life cycle assessments. More recent publications have shifted towards topics such as artificial intelligence, Sustainable Development Goals, empirical analysis, energy transition and green marketing. The research shows that the hospitality industry plays a crucial role in the sustainable food waste management, with effective strategies involving management practices, employee training, consumer behavior, and digital technologies offering both environmental and economic benefits. Further research is needed to explore the influence of cultural, institutional, emotional, and demographic factors, as well as the potential of circular economy models and platform-based solutions to enhance waste reduction and sustainability in different contexts.

## Introduction

Food waste (FW) is a recent global problem and its importance is clear (Klaura et al., 2023; Beuving et al., 2024; Mehta and Oh, 2024). Food waste occurs when food that is not fit for human consumption is thrown away when it could have been avoided (Kasza et al., 2020). Most of the waste is generated on land, including household waste, especially food industry waste (Poore and Nemecek, 2018). According to FAO (Food and Agriculture Organization of the United Nations) research, 33 % of all the food produced globally ends up as waste somewhere in the supply chain (FAO, 2023).

According to the European Commission, 46 % of food waste occurs at the consumption stage (Sanchez Lopez et al., 2020), 69 % in households, food services or retail, where much food is also discarded after processing (Cuffey et al., 2023), mainly due to overstocking by retailers or inadequate storage (Trento et al., 2021).

In households, it is often consumer carelessness and negligence that leads to food ending up in the bin (Li et al., 2024; Mayanti, 2024).

According to Edjabou et al. (2016), waste depends on the size of the household, as the probability of food waste increases in direct proportion to the increase in the number of people living in the household. Households throw away approximately 94.64 kg of food per year, which

* Corresponding author.
*E-mail addresses:* gal.timea@econ.unideb.hu (T. Gál), kovacs.sandor@econ.unideb.hu (S. Kovács), nyakas.erzsebet.tunde@econ.unideb.hu (E. Buglyó-Nyakas).
[1] ORCID ID: 0000-0002-9021-7363.
[2] ORCID ID: 0000-0002-1216-346X.
[3] ORCID ID: 0000-0003-2039-9920.

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corresponds to a waste of €4.9 per week (Masotti et al., 2019).

According to Jörissen et al. (2015), single-person households are the most wasteful in terms of per capita waste. They emphasised that because of differences in lifestyles and the food packaging units are measured in households of two to four people, so the risk of waste is greater in smaller households.

The UN Food Waste Index Report 2021 estimated 74 kg of food per household, revised to 79 kg per household in the 2024 report (United Nations Environment Programme, 2021), which is the result of transforming national data with a correction factor. Including the waste generated by other segments of the food chain (restaurants, shops, etc.), the waste rate was estimated at 132 kg/person/year (United Nations Environment Programme (UNEP), 2024).

According to statistics, almost 59 million tonnes of food are thrown away every year in the EU, which corresponds to a waste of 131 kg per capita and is mainly generated during household activities (53 %) (Eurostat, 2023). Food waste affects both developed and less developed countries, as they all produce large amounts of food waste (Rahman et al., 2024). In addition to the environmental impact of waste, it can also increase the risk of supply chain insecurity, which is why the study of food waste and the reduction of waste generated has become a key issue (United Nations Environment Programme, 2022). In line with the UN's sustainability goals, EU Member States have committed to reducing food waste per capita by 50 % by 2030, and the reduction of global food waste at both the production and consumption levels, at every stage of the supply chain, is set as a long-term strategic goal (European Commission, 2024). The aim of this study was to map and analyze the literature on food waste in order to provide a basis for future research.

Many factors can be the reason for the increased household's food waste, such as consumers not paying attention to the expiry date or misinterpreting it (Farr-Wharton, 2014; Canali, 2014; Schanes et al., 2018; Ghinea and Ghiuta, 2019), or when too much food is prepared, a part of it is usually thrown away (Schanes et al., 2018; Quested et al., 2011). Another problem is careless planning (Schanes et al., 2018) and improper handling and storage of food (Kasza et al., 2020; Falasconi et al., 2019). Another problem with food waste is that consumers in developed countries expect food to be aesthetically pleasing (Lagerkvist et al., 2023; Narvanen et al., 2018). The aim is to reduce the amount of food already purchased that ends up in the bin and to consume as much as possible, which is also important. Food safety risks are very important, such as not delaying the consumption of leftovers and ensuring that reusable containers are disinfected (Silva et al., 2023).

A large proportion of food waste occurs after the preparation period, due to a misunderstanding of the terms "use by" and "best before". According to a study conducted by the EU in 2018, food waste is mainly related to the date on the food label (European Commission, 2018).

The waste hierarchy aims to identify the top levels of the waste pyramid, which are prevention and more environmentally sound waste management practices. Landfilling is the least favorable option, followed by recovery, recycling and reuse. Complete separate collection of bio-waste collection has been a practice in some Member States for years or even decades, while in Hungary and many other countries, only green garden waste is collected for green municipal waste, but not food waste. One of the main challenges for waste management is therefore the recovery of these waste streams. The current system needs to be improved at EU level, as the latest figures show that 60 % of bio-waste is not recovered (Siebert et al., 2020). Based on the growing relevance of the topic, this study analyzed publication trends between 2019 and 2024, focusing on highly cited documents, research areas, and keyword co-occurrence patterns. The main objective of this research was to perform a bibliometric analysis of recent literature on food waste and its management, as well as sustainability issues relating to consumption, production, development and the environment. This was achieved by merging two major databases, which helped to identify gaps for future research projects, particularly in the field of food waste and its management.

## Methodology

### *Database*

A bibliometric review is a method used by researchers to identify trends in a particular area of research by using statistical tools and a significant sample size to analyze a large number of publications. These tools provide insight into the impact of research trends and facilitate the analysis of structural characteristics in a given research field. There is a growing number of publications using this methodology in the fields of business management and economics. However, to the best of the authors' knowledge, no bibliometric study has been carried out on the subject of food waste with analyzing multiple sources. Other researcher used mostly Scopus or WoS or other databases solely and not merging more of them. In order to contribute to the existing literature, this paper employed a bibliometric analysis to identify the main research trends and to gain insight into the research patterns related food waste. In conducting the bibliometric analysis, the authors focused on peer-reviewed, open access publications in English in the field of business management and economics. Consequently, Google Scholar was not included, which tends to yield a higher proportion of unpublished materials and a significant number of non-English publications (Martín-Martín et al., 2018). The authors used the R programming language and the dedicated Bibliometrix package to perform the bibliometric analysis (Aria and Cuccurullo, 2017; Gupta et al., 2021).

Publications that met the search criteria of including multiple terms (Fig. 1) in the title, abstract, or author keywords were selected. The search was conducted on 5 December 2024 and included hits available up to that date. The initial database yielded over 9297 hits, but after excluding duplicates and removing irrelevant studies, the final database for the bibliometric analysis consisted of 7199 articles (Fig. 1).

### *Technical details*

The novelty of the analysis was also that the authors managed to merge the two databases, WoS and Scopus, and analyzed them together, overcoming many technical difficulties. The secret of the merging process was that the Scopus data was saved in a bibtex (.bib) format when downloaded, while the WoS data was saved in a simple text format (.txt). The two data sources were converted into a data frame in R using the "convert2df" function, and then merged by using the "mergeDbSources" function by removing the duplicates. At the end of the conversion, the openxlsx package was used to convert the merged bibliometric data into an.xlsx format. This file can then be loaded directly into the biblioshiny interactive web interface for further use.

The Overview menu provided access to key information about the data (Table 1) and the annual scientific production (Fig. 2). The general citation structure (Table 2) has been created using the "Most local cited documents" option under the "Documents" menu. The information summarized in the table „Top 10 most published and most cited authors" (Table 3) can be found in the "Authors" menu using the „Most relevant authors" and „Most local cited authors" options. Table 4 (most productive country map) was created using the „maptools" and „wesanderson" packages with the „Zissou1" palette. The data for this figure can be found in the "Authors and Countries" menu using the "Corresponding author's country" option. Table 5 (local citations and number of publications) can be constructed using the „Most local cited sources" and „Most relevant sources" options in the "Sources" menu. Information on the most influential documents (Table 6) can be obtained using the „Most local and global cited documents" in the "Documents" menu. Thematic evolution (Fig. 6) and the thematic map (Fig. 7) can be accessed via the "Conceptual structure" menu, while trend topics (Fig. 5) can be found under Documents and Words using the Trend Topics option. Author collaboration can be accessed from the "Social Structure"

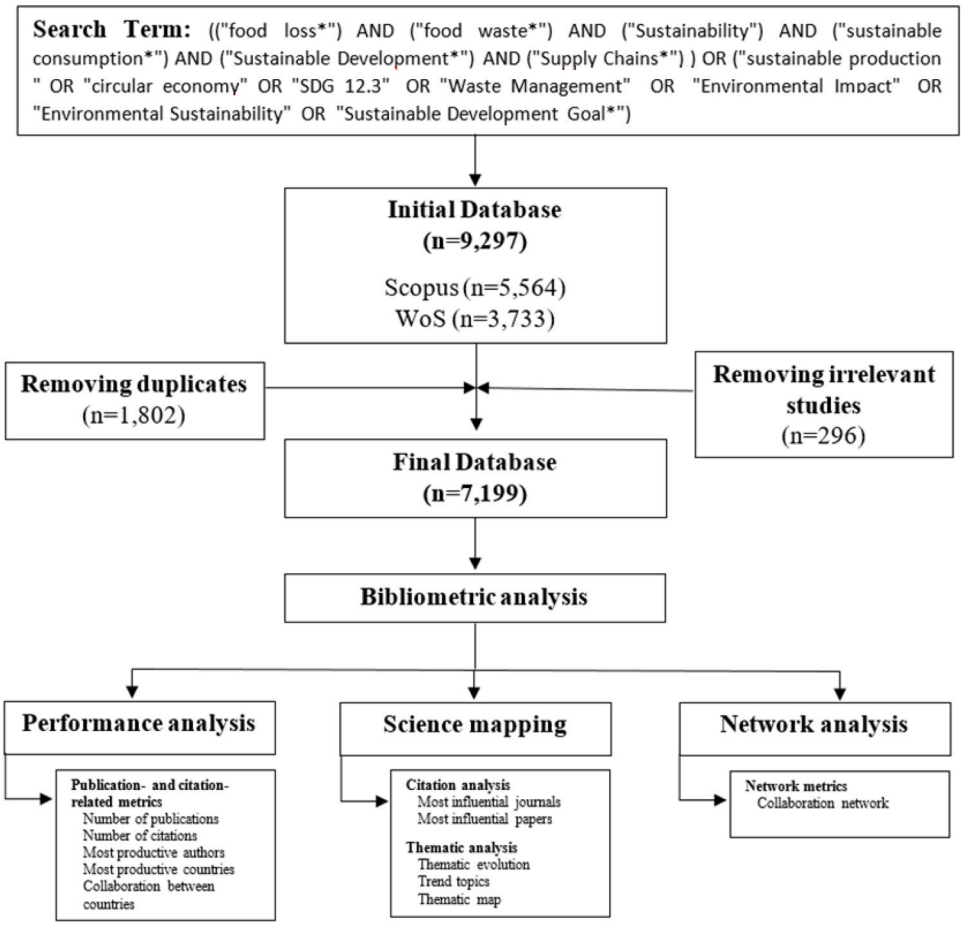


**Fig. 1.** Research design of the study.

**Table 1**
Key information about the data.

| Items | Record |
|---|---|
| Documents (open access articles) | 7199 |
| Sources (journals, books, etc.) | 1040 |
| Keywords plus | 16,354 |
| Author's keywords | 18,071 |
| Time-period | 2019–2024 |
| Average citations per article | 20.75 |
| Documents' average age | 1.98 |
| References | 387,525 |
| Authors | 21,347 |
| Authors of single-authored articles | 580 |
| Single-authored articles | 621 |
| Co-authors per article | 3.83 |
| International co-authorships % | 19.74 |

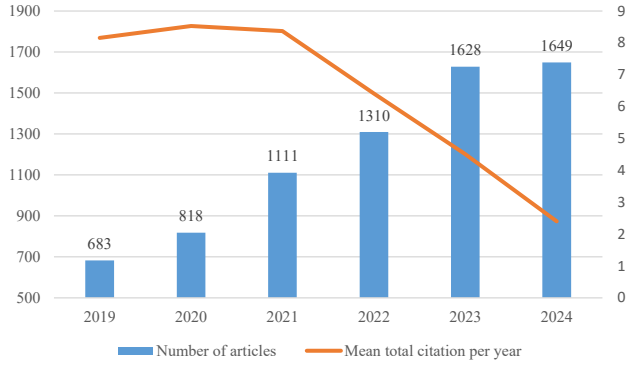


**Fig. 2.** Development of citations and the number of articles published (2019–2024).

menu (Fig. 8).

## Results

The articles were analyzed from the period 2019 to 2024. The database contained 7199 documents (open access journal articles), 1040 sources, 387,525 references, 18,071 keywords. The number of single-authored articles was 621, written by a total of 580 authors (one author wrote more than one single-authored article). The total number of authors was 21,347, with an average of 3–4 authors per publication (3.83), and the percentage of co-authors from other countries was 19.74 %, which was relatively very high. The average age of the articles was 2 years, the average number of citations per article was 20.75, and the average annual increase in the number of articles was 7.31 %. The number of articles (7199) was calculated by adding 3733 Wos and 5564 Scopus documents in the first search. After removing 1802 duplicates, 7495 documents were available. Approximately 296 irrelevant documents were removed (1 book, 9 conference proceedings, 27 book chapters, 259 early access).

The number of articles published increased steadily over the period studied, from 683 in 2019 to almost three times as many in 2024 (1649). Moreover, the number of published papers in 2024 will be even higher, because in the beginning of 2025 many journals publish their end-of-year issues later. The years 2019–2021 were relevant in terms of

**Table 2**
Top 10 journals in terms of relevance and citations (between 2019 and 2024).

| Source | Published articles/ Total citations per article | Source | Local citations |
|---|---|---|---|
| 1. JOURNAL OF CLEANER PRODUCTION | 1662/34.5 | 1. JOURNAL OF CLEANER PRODUCTION | 12,787 |
| 2. BUSINESS STRATEGY AND THE ENVIRONMENT | 269/34.2 | 2. SUSTAINABILITY | 5527 |
| 3. TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE | 121/54.1 | 3. BUSINESS STRATEGY AND THE ENVIRONMENT | 4420 |
| 4. ECOLOGICAL ECONOMICS | 105/33.4 | 4. JOURNAL OF BUSINESS ETHICS | 3281 |
| 5. HUMANITIES AND SOCIAL SCIENCES COMMUNICATIONS | 83/7.1 | 5. RESOURCES, CONSERVATION & RECYCLING | 2546 |
| 6. COGENT BUSINESS & MANAGEMENT | 67/4.0 | 6. TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE | 2336 |
| 7. CORPORATE SOCIAL RESPONSIBILITY AND ENVIRONMENTAL MANAGEMENT | 63/32.5 | 7. JOURNAL OF BUSINESS RESEARCH | 2206 |
| 8. SUSTAINABLE FUTURES | 63/8.2 | 8. ECOLOGICAL ECONOMICS | 2195 |
| 9. JOURNAL OF BUSINESS RESEARCH | 62/51.3 | 9. CORPORATE SOCIAL RESPONSIBILITY AND ENVIRONMENTAL MANAGEMENT | 1648 |
| 10. WORLD DEVELOPMENT | 59/34.3 | 10. INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS | 1544 |

**Table 3**
Top 10 authors with the highest number of local citations and published articles.

| Authors | Published articles | Authors | Number of local citations |
|---|---|---|---|
| Liu, Y. | 38 | Kirchherr, J. | 91 |
| Kumar, A. | 29 | Blomsma, F. | 83 |
| Wang, Y. | 28 | Hekkert, M. | 79 |
| Govindan, K. | 25 | Kristoffersen, E. | 76 |
| Zhang, Y. | 23 | Bauwens, T. | 75 |
| Li, Y. | 21 | Kraus, S. | 73 |
| Zhang, H. | 18 | Liu, Y. | 63 |
| Chen, Y. | 17 | Mikalef, P. | 61 |
| Dhir, A. | 17 | Ferraso, M. | 55 |
| Li, J. | 17 | Beliaeva, T. | 54 |

average citations, with an average of 8–9 articles per year citing publications on the topic. It also shows the relevance and the increasing importance of the topic that more and more researchers are dealing with these issues.

The three-field plot shows the most important authors, the journals in which they published and the keywords they used most frequently. It is also called as the Sankey diagram, which gives insights into individual researchers' priorities for selecting important keywords and publishing their articles in specific journals. The key elements in Fig. 3 are the authors Liu, Y. and Kumar, A. who have the highest number of publications in the topic of circular economy. They are followed by Dhir A., Govindan K., Li J., Zhang J., Li Y. Wang Y., Chen Y. and Zhang H. According to the analysis, the highest trend (light green color part) is the circulary economy, followed by sustainability and related keywords as SDGs, sustainable development, environmental sustainability, environmental impact, sustainable, waste management and life cycle management.

**Table 4**
The most productive and the most cooperative countries (%).

| Country | TP (MCP %) | % TP | Country | TP (MCP %) | % TP |
|---|---|---|---|---|---|
| **UNITED KINGDOM** | **784 (29.3)** | 10.9 | UKRAINE | 141 (9.9) | 2 |
| **ITALY** | **483 (18.4)** | 6.7 | PORTUGAL | 136 (14.7) | 1.9 |
| **SPAIN** | **463 (10.8)** | 6.4 | NORWAY | 125 (24.0) | 1.7 |
| **CHINA** | **407 (24.6)** | 5.7 | MALAYSIA | 120 (24.2) | 1.7 |
| **USA** | **286 (22.4)** | 4 | DENMARK | 107 (22.4) | 1.5 |
| AUSTRALIA | 244 (25.4) | 3.4 | SOUTH AFRICA | 103 (21.4) | 1.4 |
| SWEDEN | 243 (18.1) | 3.4 | ROMANIA | 91 (12.1) | 1.3 |
| NETHERLANDS | 241 (18.3) | 3.3 | CANADA | 88 (18.2) | 1.2 |
| GERMANY | 200 (20.5) | 2.8 | SWITZERLAND | 78 (23.1) | 1.1 |
| FRANCE | 190 (28.4) | 2.6 | BELGIUM | 69 (23.2) | 1 |
| BRAZIL | 171 (13.5) | 2.4 | AUSTRIA | 67 (20.9) | 0.9 |
| FINLAND | 167 (21.6) | 2.3 | IRELAND | 63 (27.0) | 0.9 |
| INDONESIA | 161 (8.1) | 2.2 | CZECH REPUBLIC | 52 (21.2) | 0.7 |
| INDIA | 154 (18.2) | 2.1 | COLOMBIA | 51 (17.6) | 0.7 |
| POLAND | 151 (18.5) | 2.1 | LITHUANIA | 50 (30.0) | 0.7 |

Multiple Co-authored Papers (MCP); TP: Total number of Papers.

**Table 5**
The highest locally cited articles and their global citation.

| Document | Local Citations | Global Citations |
|---|---|---|
| FERASSO et al. (2020), BUS STRATEG ENVIRON | 54 | 275 |
| KRISTOFFERSEN et al. (2020), J BUS RES | 50 | 322 |
| TURA et al. (2019), J CLEAN PROD | 49 | 442 |
| HENRY et al. (2020), J CLEAN PROD | 48 | 260 |
| ROSATI et al. (2019), J CLEAN PROD | 47 | 401 |
| MILLAR et al. (2019), ECOL ECON | 40 | 242 |
| PARIDA et al. (2019), J BUS RES | 34 | 211 |
| ROSA et al. (2020), INT J PROD RES | 34 | 454 |
| MONTIEL et al. (2021), J INT BUS STUD | 30 | 140 |
| BARREIRO-GEN – LOZANO (2020), BUS STRATEG ENVIRON | 28 | 134 |

**Table 6**
The highest globally cited articles in the topic of food waste and its management.

| Document | Year | Global Citations | Local Citations |
|---|---|---|---|
| FILIMONAU V, 2019, TOUR MANAGE | 2019 | 257 | 0 |
| FILIMONAU V, 2020, J CLEAN PROD-a | 2020 | 131 | 2 |
| ANNOSI M, 2021, IND MARK MANAGE | 2021 | 114 | 0 |
| FILIMONAU V, 2020, J CLEAN PROD | 2020 | 84 | 3 |
| NG P, 2023, INT J HOSP MANAGE | 2023 | 29 | 0 |
| SADRAEI R, 2023, BUS STRATEG ENVIRON | 2023 | 18 | 0 |
| ANANDA J, 2023, J CLEAN PROD | 2023 | 16 | 0 |
| GAO H, 2024, J MARK RES | 2024 | 6 | 0 |
| FAZAL-E-HASAN S, 2024, J SUSTAINABLE TOUR | 2024 | 6 | 0 |
| MAGNO F, 2024, J RETAIL CONSUM SERV | 2024 | 5 | 0 |

Global citations refer to the total number of citations received by a document or a journal across all publications indexed within a given source (Scopus, WOS), while Local citations (7199) refer to the number of citations a document or a journal receives from other documents within the specific search performed or sample. The top 10 most locally cited journals and the top 10 most relevant journals in terms of published articles were shown in Table 2. It can be stated that based on the published articles the Journal of Cleaner Production is in the first rank with 1662 published articles between 2019 and 2024 in the examined

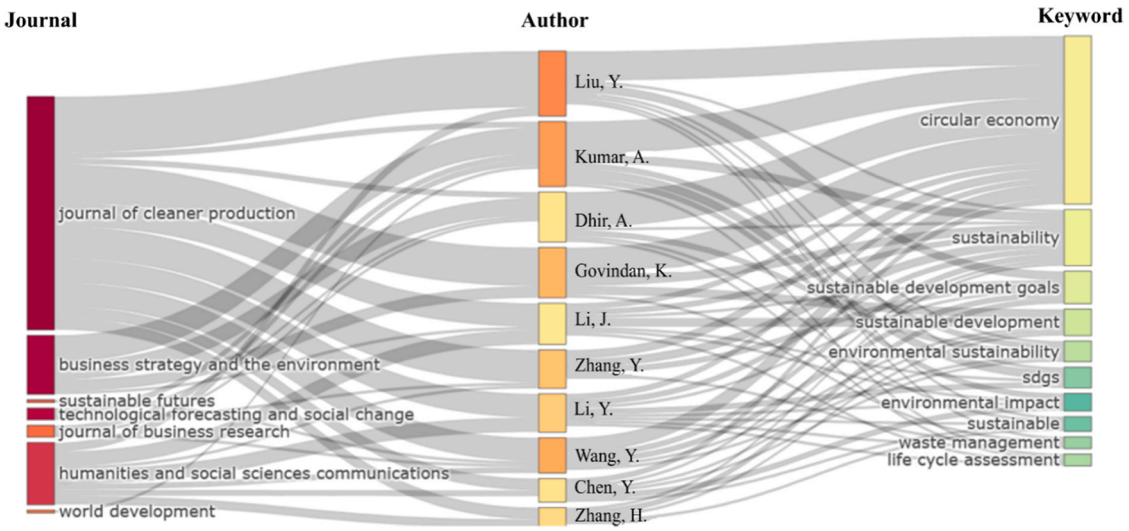


**Fig. 3.** Three-field plot of the most important authors and their preferences.

topic. The 2nd place belongs to the journal of Business Strategy and the Environment with 269 articles, however, on the 3rd place with 121 published articles is the Technological Forecasting and Social Change. Even though, this journal has higher citations per article (54,1) than those which are on the two first places in the ranking (34.5 and 34.2 total citations/article). In conclusion, articles published in Technological Forecasting and Social Change and Journal of Business Research were the most cited globally. The first three places are followed by Ecological Economics, Humanities and Social Sciences Communications, Cogent Business & Management, Corporate Social Responsibility and Environmental Management, Sustainable Futures, Journal of Business Research, and World Development in order.

If local citations are considered in the given subject area, the Journal of Cleaner Production is still on the first place with 12,787 local citations in the ranking, however, the journal of Sustainability comes to the second place with 5527 local citations which was not mentioned in the previous rank list. Business Strategy and the Environment journal is on the second place (5527 local citations) which is followed by the Journal of Business Ethics, Resources Conservation and Recycling, Technological Forecasting and Social Change, Journal of Business Research, Ecological Economics, Corporate Social Responsibility and Environmental Management, and the International Journal of Production Economics. Five journals out of 10 did not appear in the first ranking, they are in prestigious places based on the number of local citations only.

After that the authors were analyzed based on their published articles. The top 10 authors with the most citations and the most publications (in terms of local citations only) are shown in Table 3. In this respect, Liu Y. is the most productive author in the given subject area with 38 articles between 2019 and 2024. After the first author Kumar, A., Wang, Y., Govindan, K., Zhang, Y. had the most publications (29, 28, 25, and 23 in order). The 3 most cited authors were Kirchherr, J. with 91 citations, Blomsma, F. with 83 citations, and Hekkert, M. with 79

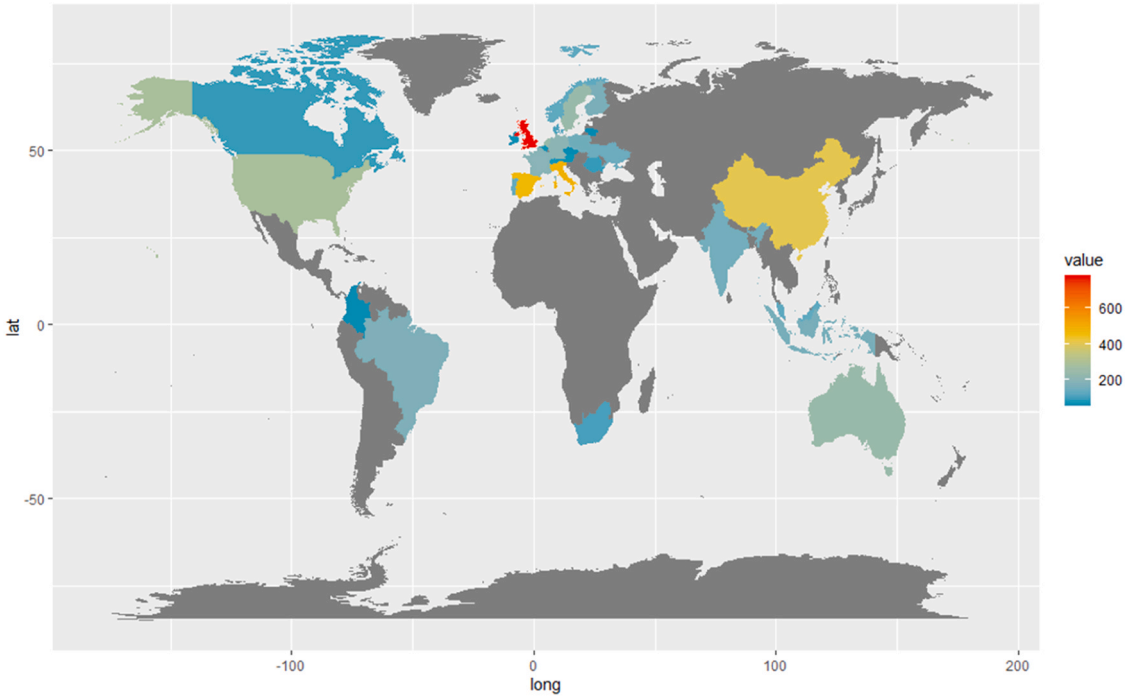


**Fig. 4.** The most productive and the most cooperative countries.

citations. But Kristoffersen, E., Bauwens, T. and Kraus, S. have also similar number of citations (76, 75, 73), so they were not lagging with so much.

If the countries are investigated, the scientific production on this topic is mainly spread over 30 countries where some authors have produced at least one article on this topic (Fig. 4). Examining the countries of the corresponding authors of the publications, the United Kingdom was the leading country with 784 publications (10.9 % of the total number of articles in our database). The topic was also popular in Italy (486 publications) and Spain (463 publications). The United States of America and China came fourth and fifth place with 407 and 286 documents, respectively.

Table 4 presents the countries whose publications had a relatively high number of collaborations with authors from other countries. Lithuanian authors produced 50 articles, 30 % of which were written in collaboration with foreign authors. The second country with the highest proportion of collaborations is the United Kingdom (29.3 %), followed by France (28.4 %) and Ireland (27 %). However, China (24.6 %), Malaysia (24.2 %) and Norway (24 %) were not far behind in terms of multiple co-authorship.

Table 5 shows the top 10 most locally cited articles. It can be stated that according to the local citations, Ferrasso et al. (2020) is the most influential author with 54, but if the global citations are also considered, Rosa et al. (2019), Tura et al. (2019), and Rosati et al. (2019) are on the first three places in the ranking with 454, 442 and 401 global citations.

The research of Ferasso et al. (2020) investigated the importance and evidence of circular economy and related business models. A total of 253 articles were retrieved from the Scopus, Web of Science and ScienceDirect databases. The main finding is that the most emerging topics in the retrieved publications are connected with the managerial, supply-side, demand-side, networking, performance, and contextual considerations of circular business models. In line with Stewart's research (Niero, 2018), the topics investigated include the relationship between sustainability and the circular economy and how companies are integrating the circular economy into their sustainability efforts. Kristoffersen et al. (2020) highlights that the circular economy (CE) and digital technology (DT) are both emerging fields, and shows how DT can be applied to the circular economy to improve company efficiency and productivity. The results highlight a framework involving three segments: data transformation level, resource optimization capabilities and data flow processes.

Tura et al. (2019) developed an integrative framework of the drivers and barriers of the circular economy business. 7 different categories were created: *environmental, economic, social, institutional, technological and informational, supply chain,* and *organizational factors*. Between the main findings can be found that the initiation of CE business idea was effected by drivers (social pressure, regulation, legislation). It can be summarized that the central influencing factor was information technology.

Henry et al. (2020) focused on the concept of the circular economy, creating new tipology of circular startups: design-based, waste-based, platform-based, service-based and nature-based startups. Research also confirms that Circular Economy startups strengthen the transition towards CE.

Rosati and Faria (2019) mainly focused on sustainable development goals, seeking information from 2413 sustainability related report in order to achieve SDG-s worldwide. This study fills a significant gap in the field and can play a key role in SDG topics. Authors first investigated 27 factors related to organization SDG reporting and tested these factors empirically. Between the main results there can be found that organizations reporting from SDG-s can be found mainly in countries with greater climate change vulnerability, stronger national commitments to CSR and higher corporate investments in tertiary education.

Millar et al. (2019) research confirmed that there is a strong link between Sustainable Development and Circular Economy, but the exact relationship has never been defined and although Circular Economy is always mentioned as a tool for Sustainable Development, it is unclear if circular economy can elevate economic growth protecting environment and enhancing social equity.

Parida et al. (2019) research presents a two-step transformation model for large manufacturing companies. The focus of this paper is the development of a process model involving 6 manufacturing companies (ecosystem managers) and ecosystem partners. The key result of the article is that ecosystem managers implement the transition to a circular economy in 2 stages: the first stage is the measurement of ecosystem readiness, the second stage is the transition to an ecosystem1) ecosystem readiness assessment and 2) ecosystem transformation.

Rosa et al. (2019) shows that CE and Industry 4.0 are two of the most popular and relevant topics today. The results reflect the influence of I4.0 on new types of circular business models, mainly resulting from the digitalization of processes or innovative management strategies.

Montiel et al. (2021) will help multinational companies to develop a new approach to integrate the United Nations 2030 Sustainable Development Goals into their corporate functions and decisions. The researchers consider it important because it forces the rethinking of the predictions of current theorization on multinational behavior through the integration of positive and negative externalities into the calculus of optimal strategy for multinationals.

Barreiro-Gen and Lozano (2020) research reinforces the theme that circular economy is a very relevant and important issue in the life of organizations. There are 3 different levels of CE research, macro, meso and micro, although there is no doubt that while research at the macro and meso levels is extremely high, the amount of research at the micro level is limited. The research focuses on identifying and analyzing companies implementing 4 R (reduction, repairing, remanufacturing and recycling). The results show that companies focus on reduction and recycling in Circular Economy rather than repairing and remanufacturing, although many are not aware that these are part of CE, so companies should be trained in this respect.

Given the nature of this research area, characterized by its borderline status, it is important to acknowledge that the results of a keyword search may not always be directly proportional to the specific needs of the analysis. In such cases, the results may be narrowly related to the topic, and the analysis may not encompass all the relevant information. Consequently, a meticulous evaluation of the articles was undertaken, with the aim of identifying those that are directly pertinent to the subject of analysis with respect to their content. Therefore, the authors analyzed the first couple of published documents, focusing specifically on food waste management, which resulted in 84 documents. Within these documents the subtopics of food waste and food waste management were analyzed thoroughly, and the co-occurrence of the abstract bigrams can be seen on Fig. 5. It shows that food waste is strongly connected with waste management, waste reduction, reduce food and food management.

From the documents the first 10 highly cited were chosen (Table 6.) and further analyzed. It was crucial to do this, because these papers are the mostly connected to meet the research questions. As food waste management is a borderline area, articles on this topic are more closely related to the global database. Consequently, fewer citations were received from the local database, indicating that these articles were not included in Table 5.

Filimonau and De Coteau (2019) provides a comprehensive analysis of the occurence of food waste in the food industry. Use a systematic approach, the authors identify the main causes of food waste generation, current management practices, and opportunities for more sustainable solutions. They highlight that, despite its significant environmental and economic impact, hospitality businesses often lack effective strategies to reduce food waste. The study' main outcome is to emphasize the role of management in introducing waste reduction measures, training employees, managing inventory more accurately, and influencing consumer behavior. The authors propose developing a comprehensive framework that integrates waste prevention, recycling, and disposal


**Fig. 5.** Co-occurence network of abstract bigrams.

strategies, while taking organizational, regulatory, and cultural factors into account. The research highlights the need for further empirical studies to identify best practices that can be applied in different hospitality settings, with the aim of promoting sustainable food waste management.

The aim of the study by Filimonau et al. (2020) is to explore the importance of consumer participation in reducing food waste in restaurants in Poland, i.e. (Central and Eastern Europe). The study examines the impact of environmental knowledge and concern, predicted regret and of eco-friendly behavior at home on positive consumer attitudes towards reducing food waste in restaurants, as well as the combined effect of these factors on action. The study offers policy and management recommendations on how to reinforce these behavioral intentions.

Annosi et al. (2021) investigates the use of digital technologies in food supply chains to reduce food waste. The authors conducted 18 in-depth interviews with leaders of multinational and local organizations to explore the impact of digitalization on organizational and supply chain processes. Their main finding is that big data solutions facilitate collaboration and improve business performance, but there are also many obstacles that can arise during digital transformation. The research highlights the need for organizations to rethink the design and operation of their supply chains following the integration of digital technologies. The study emphasizes the role of institutional forces that can limit or facilitate the proliferation of digital food supply chains.

Filimonau et al. (2020) comprehensively analyze the topic of food waste generated in the hospitality and catering services. The authors carried out a systematic literature review in which they identified nine main topics from the generation of food waste to its management and reduction (e.g. residue management, the impact of food waste, controlling of demographic factors and food waste, and the causes of food waste). They emphasize that although food waste is a significant sustainability challenge, research on the topic is incomplete. The study also presents a framework to help determine the direction of future empirical research and to develop strategies that can be applied in practice.

Ng and Sia (2023) investigates the intention to separate food waste in the hospitality industry among Malaysian restaurants. Questionnaire research was conducted with 395 restaurant managers to analyzes how coercive, normative and mimetic pressures influence the intention to separate food waste, based on institutional theory. The results showed that all three pressures had a positive effect on intention, with normative pressure proving to be the strongest in particular. Furthermore, corporate social responsibility (CSR) plays an intermediary role between these pressures and intent, while restaurant size reinforces the link between CSR and the intention to separate food waste. This study contributes to institutional theory by demonstrating how external and internal factors influence environmentally conscious behavior in restaurants in developing economies.

Sadraei et al. (2022) investigates strategies to increase sustainable production in the food industry. To this aim, the authors conducted a systematic literature review of publications from 2000 to 2021 (163 in total) to explore the industrial and business strategies that promote sustainability in this area. Their analysis identified the key drivers and barriers influencing the adoption of sustainable practices by food companies. The study highlights the role of the circular economy, green innovation and digital technologies in promoting sustainable production. The authors propose future research directions, emphasizing the importance of a multidisciplinary approach and collaboration between stakeholders to achieve sustainability goals in the food industry.

One such approach is the circular economy (CE), which focuses on reducing food waste, waste management and recovery, and converting organic waste into production raw materials. This study uses the CE concept implemented by Prieto-Sandoval et al. (2018) to discuss how it can address food waste in industries. According to Lieder and Rashid (2016), CE is defined as a closed-loop material flow in the economic system that takes financial aspects into account while minimizing material use and limiting economic growth.

Ananda et al. (2023) investigates food management habits aimed at reducing food waste in households. The study aims to quantify the impact of routines such as planning before shopping, storing food properly, and making creative use of leftovers on the amount of food wasted. The results show that conscious food management practices can significantly reduce household food waste. The authors emphasize the importance of educational programs and campaigns that promote the

spread of these habits, and suggest that future research should investigate differences in food management routines between different demographic groups.

Gao et al. (2023) examines consumers' perception of resource abundance or scarcity and self-determination (independent or interdependent), and how these factors influence their food waste habits. The study states that a sense of lack reduces food waste, regardless of self-determination. However, when resources are plentiful, individuals with interdependent self-determination waste less food because they feel a stronger obligation to share resources. The study suggests that emphasizing the importance of sharing and highlighting the food needs of others could be effective strategies for reducing food waste.

Fazal-e-Hasan et al. (2023) investigates how tourists' negative emotions, such as guilt and regret, and positive emotions, such as hope, influence their intention to reduce food waste. Two experiments and a survey show that feelings of guilt and regret increase tourists' willingness to reduce food waste, while feelings of hope further reinforce this intention. Using the Fuzzy-Set Qualitative Comparative Analysis (fsQCA) method, four categories of tourists who strive to reduce food waste in different ways are identified. The research suggests that tourism service providers should emphasize positive emotions in their marketing communications to encourage more sustainable behavior among tourists. This is the first study to investigate the interaction between negative and positive emotions in developing of intentions to reduce food waste among tourists.

Cobo et al. (2011) investigates the factors influencing restaurants' intention to continue using platforms to sell surplus food. The researchers integrate the Technology Acceptance Model (TAM) with self-determination theory to create a model which is tested using data from 214 such restaurants. The analysis uses the Partial Least Squares method (PLS-SEM) and the Necessary Condition Analysis (NCA). According to the results, perceived ease of use, economic motivations and environmental motivations are significant and necessary factors in terms of continued intention to use the platform. This study contributes to a deeper understanding of the relationship between sustainable behavior and technology adoption in the restaurant sector.

In order to create the trending topics graph, the authors chose to use the title of the article for practical reasons. Firstly, analysing the abstracts would have resulted in a much larger data set. Secondly, the title basically contains the most important words that reflect the content of the article. The analysis of trending topics was carried out using only one word (unigrams) and two consecutive words (bigrams). Both were shown in Fig. 6. The trending topics have evolved between 2019 and 2024. Fig. 6 illustrated the most frequent words (word pairs) in the title per year and the period in which they were popular. The size of the node indicates the frequency of occurrence. The most common bigrams (circular economy, sustainable development, development goals, supply chains, life cycle) were used between 2021 and 2023, while the most recent publications tended to cover artificial intelligence, SDGs, empirical analysis, energy transition and green marketing.

The process of identifying research themes (Fig. 7) was based on the bigrams (word pairs) in the titles of all publications from the bibliometric database. The first step was to create the so-called co-occurrence frequency matrix of all bigrams by counting the number of times two bigrams appeared together in an article title. The second step was to define the equivalence index, $e_{ij}$ as follows (Magno and Cassia, 2024):

$$e_{ij} = c_{ij}^2 \Big/ c_i c_j,$$

where i and j denote different bigrams and $c_{ij}$ is the number of co-occurrences, $c_i$ and $c_j$ denote the single occurrences of bigrams i and j, respectively. In the third step, the Louvain clustering algorithm (Blondel et al., 2008) algorithm was used to detect groups of bigrams (themes). In the last step, a network was created to visualize the keyword groups and connections. The strength of each link between two bigrams is measured by the equivalence index. Based on this network two measures

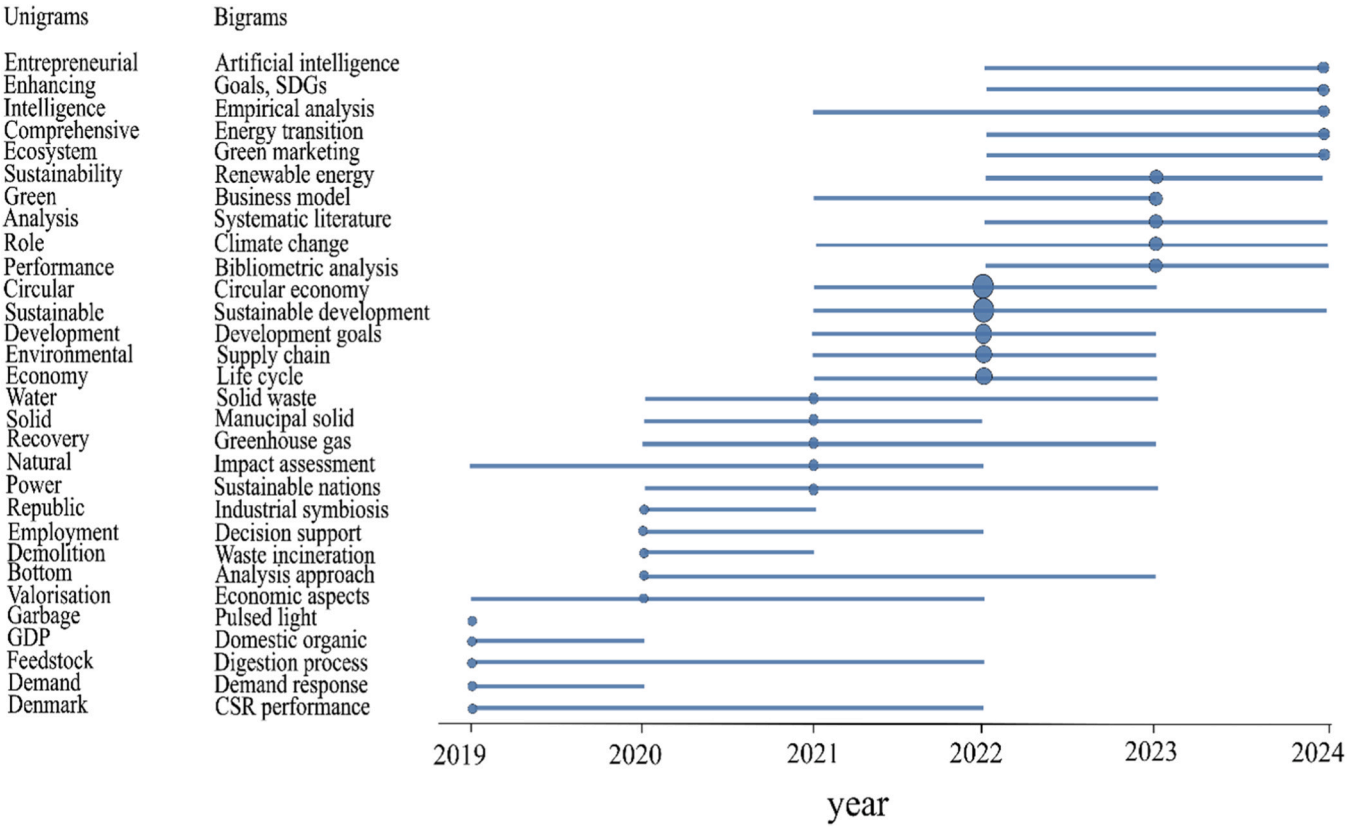


**Fig. 6.** Trending topics regarding the title of the publication.

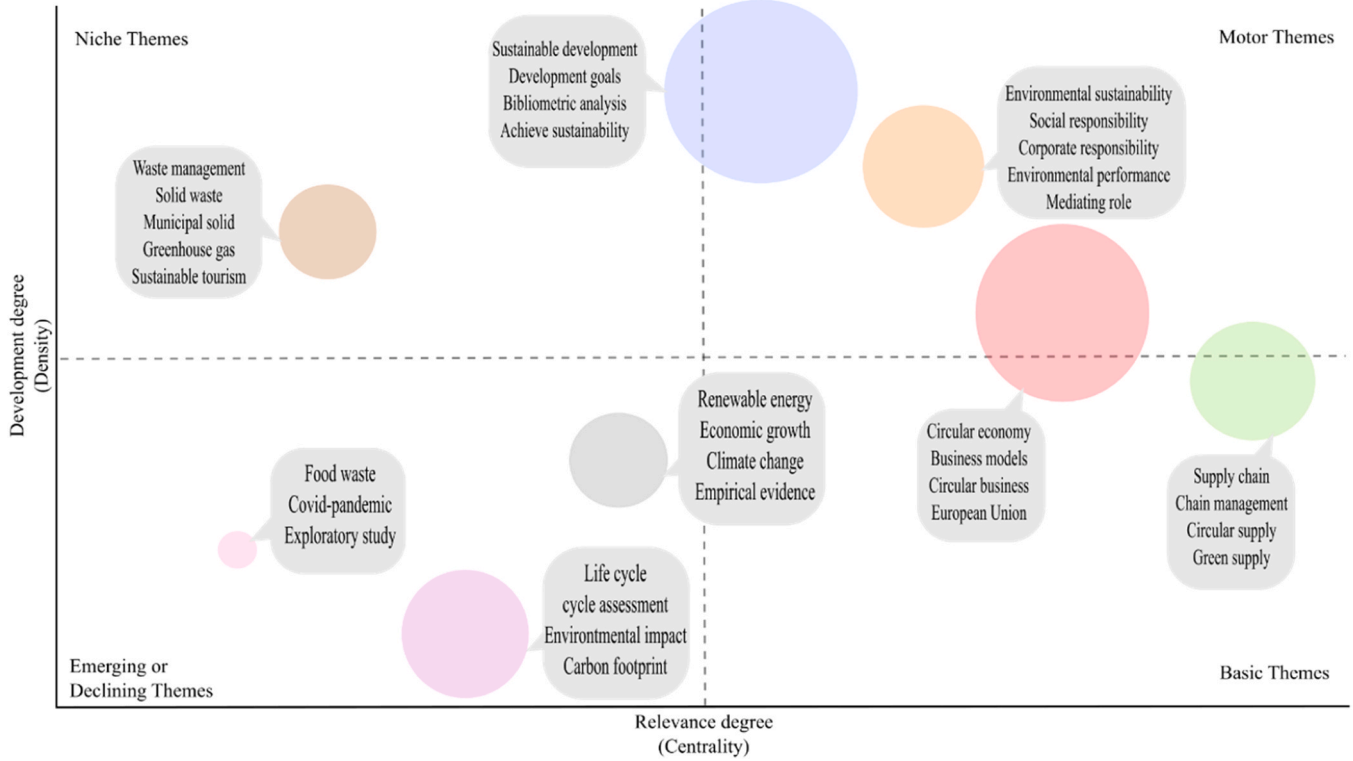


**Fig. 7.** Thematic map with respect to bigrams in the titles of publication.

(centrality and density) are calculated which can be used to create the thematic map. Callon's centrality (or degree of relevance) represents the strength (based on the equivalence index) of a given topic's external relationships with other topics, while Callon's density (or degree of development) shows the strength (based on the equivalence index) of internal relationships within a given topic (Callon et al., 1983). Themes can be classified as „motor themes" with high centrality and density, „basic themes" with high centrality but low density, „emerging or declining themes" with low centrality and low density, and „niche themes" with low centrality and high density. Motor themes are closely linked to other themes and are highly developed in their own context. Fig. 6 illustrated the three motor themes, namely sustainable development and bibliometric analysis, environmental sustainability and responsibility, and circular business and economy. The basic themes were clearly linked to other areas of interest and were of significant relevance, although less developed. A single basic theme has been identified which related to green supply chain management. The themes that were either emerging or declining were less developed and have fewer connections to other themes. The main reason for this was that they were actually in a state of emergence or decline. It was evident that issues related to the impact of the pandemic were declining in relevance, while new areas such as life cycle assessment, carbon footprint and environmental impact were emerging. The most emerging and central themes were renewable energy, economic growth, climate change and empirical evidence.

Finally, niche themes are marginal and highly specialized. These issues are well developed and have a high degree of internal coherence, but they are less relevant to other themes. The most prominent areas of focus within the niche themes were waste management, municipal and solid waste, greenhouse gas emissions and sustainable tourism.

Fig. 8 depicted the thematic evolution of the food waste literature between 2019 and 2024. It illustrates well how the themes have evolved based on the bigrams in the titles of the publications. Authors have divided the period under study into covid and post-covid periods. It can

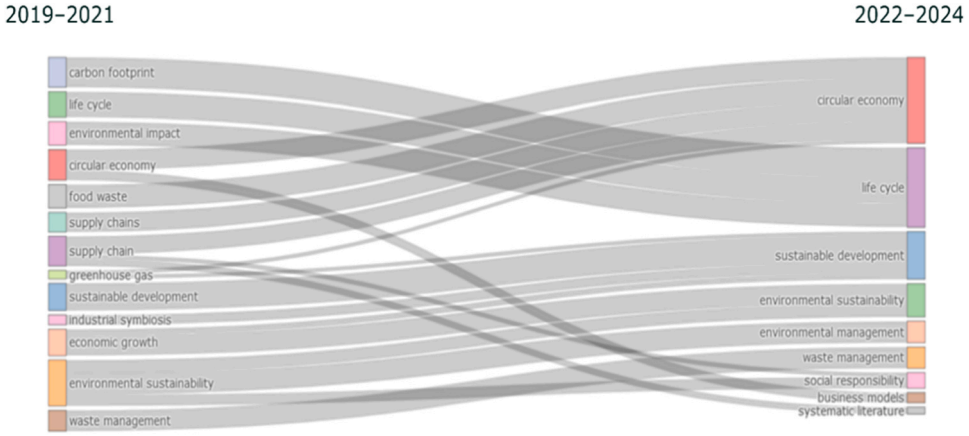


**Fig. 8.** Thematic evaluation between 2019 and 2024.

be seen, for example, that food waste and supply chains, greenhouse gasses were being incorporated into the circular economy. There was one issue, waste management, that was retained for the second period, but in general there were significantly fewer issues that were retained. There were also some themes that were split, e.g. environmental sustainability becomes social responsibility, environmental sustainability and management.

Global citation is the total number of citations available in Scopus and WoS, which includes citations from outside the database. In contrast, local citation is the number of times a publication has been cited by others within the studied database of 7199 articles. Table 7 showed that the average number of global citations varied enormously. On the one hand, there were only 62 publications with more than 200 global citations (0.86 % of the total), and only 286 publications with more than 100 global citations (3.97 %). On the other hand, 1172 papers (16.28 %) had no citations at all, and most papers were cited less than 50 times (72.83 % of the total).

In Fig. 9, the nodes' size refers to the importance of the author, and the analysis revealed 7 smaller clusters with only 2–4 authors and 3 larger collaborative groups (Kumar, A., Liu, Y., Li, Y. as central authors). In the red cluster there are three authors who had a publication in 2019 (Farooque et al., 2019) dealing with the barriers to circular food supply chain in China. This study proposed a theoretical framework to identify key barriers to integrating circular economy principles into food supply chain management. Based on 105 responses from stakeholders across the Chinese food supply chain - including food processors, distribution and sales channels, consumers, and government officials - the study employs a fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) method to explore the causal relationships among the identified barriers. The study provides valuable insights for addressing the challenges of incorporating circular economy principles into supply chain management within the Chinese food sector, as well as in other sectors facing similar obstacles. Additionally, it highlights the organizational theories that are most effective for guiding research on similar issues.

In the blue network (Luthra et al., 2022) published an influential research paper on the analysis of operational and behavioral factors that drive the adoption of circular economy (CE) practices in SMEs within emerging economies, aiming to support sustainable development in these societies. The research was conducted in three phases: an extensive literature review, a brainstorming session with experts, and an empirical analysis based on 162 responses from SMEs. The study also involved developing a factor structure model using Exploratory Factor Analysis (EFA) and constructing a Network Relationship Map (NRM). By incorporating personal determinants into the assessment, the study contributes to the theory of planned and operational behavior, offering insights into the behavioral factors that influence CE adoption in SMEs.

## Conclusion

Food waste is a very topical issue that affects people around the world. The EU's targets to reduce per capita food waste by 50 % by 2030 make it even more relevant.

Bibliometric analysis is a great tool to filter out documents already published on the subject. The surfaces selected for the research are tools, which provide insight into the impact of research trends and facilitate analysis of structural characteristics in a given research field. Actual research provides deeply insights into the evolution of academic job and focus on food waste documents. This study merged two leading databases, Web of Science and Scopus. The final database of the bibliometric analysis consisted of 7.199 open access articles, merging Scopus (5.564) and Web of Science (3.733) items, after removing duplications and irrelevant studies. Selected documents have an average 20,75 average citations per docs, 387.525 references, 21.347 authors, and 19,74 % international co-authorships.

Publications highlights growing recognition of food waste global problem, as an environmental, economic and social implication. It can be summarized that between 2019 and 2024 the number of published articles has increased a lot, from 683 in 2019 to almost 3 times higher in 2024, in which the most relevant citations are considered to be in 2021 and 2024.

In accordance with the examined timeframe the most important authors were Kumar and Liu, in the topic area the Journal of Cleaner Production, Business strategy and the Environment, Humanities and Social Sciences Communications journals were chosen most frequently. Kumar and Liu are considered highly professional, others like Kirchherr and Blomsma are recognized for their impactful citations, suggesting a balance between quantity and influence.

The most prominent keywords were circular economy, sustainability and related keywords (SDGs, sustainable development, environmental sustainability).

Examining the countries of the corresponding authors of the publications, the United Kingdom (784 publications), Italy (486 publications) and Spain (463 publications) were the leading countries The United States of America and China came fourth and fifth place with 407 and 286 documents. International collaborations account for 19.74 % of the studies, reflecting the transnational importance of food waste issues.

Analyzing the title of the published articles abstracts that the most common bigrams were circular economy, sustainable development, development goals, supply chains, life cycle between 2021 and 2023, while the most recent publications cover artificial intelligence, SDGs, empirical analysis, energy transition and green marketing.

The three *motor themes* were namely sustainable development and bibliometric analysis, environmental sustainability, social and corporate responsibility, environmental performance and mediating role. The most marginal, specialized (niche topics) were waste management, municipal and solid waste, greenhouse gas emissions and sustainable tourism. Between basics themes circular economy, business models, circular business and European Union can be determined, while food waste, COVID-pandemic, life cycle, cycle assessment, carbon footprint, environmental impact and exploratory study are defined as emerging or declining themes. So overall, the trends identified in the research abstracts are moving towards sustainable development and bibliometric analysis, environmental sustainability and responsibility, circular business and economy within it is possible to identify several specialized topics.

In connection with the analysis on food waste and food waste management, the following conclusions and suggestions can be set:

1. **The hospitality industry is a key player in sustainable food waste management**

Management, employee training, and influencing consumer habits play a fundamental role in waste reduction (Filimonau and De Coteau, 2019; Filimonau, Matute, et al., 2020). Effective waste management can bring not only environmental but also economic benefits, reducing operating costs and improving the company's image. Therefore, it would be necessary to carry out empirical research in different hospitality environments: it is necessary to identify best practices and strategies that work across regions, cultures or types of restaurants (Filimonau and De Coteau, 2019; Filimonau, Matute, et al., 2020). Furthermore, it is worth

**Table 7**
General citation structure.

| Number of global citations | Number of papers | % of paper |
|---|---|---|
| Over 200 | 62 | 0.86 % |
| Between 100 and 200 | 224 | 3.11 % |
| Between 50 and 100 | 498 | 6.92 % |
| Less than 50 | 5243 | 72.83 % |
| 0 citations | 1172 | 16.28 % |
| ***Total*** | ***7199*** | ***100 %*** |

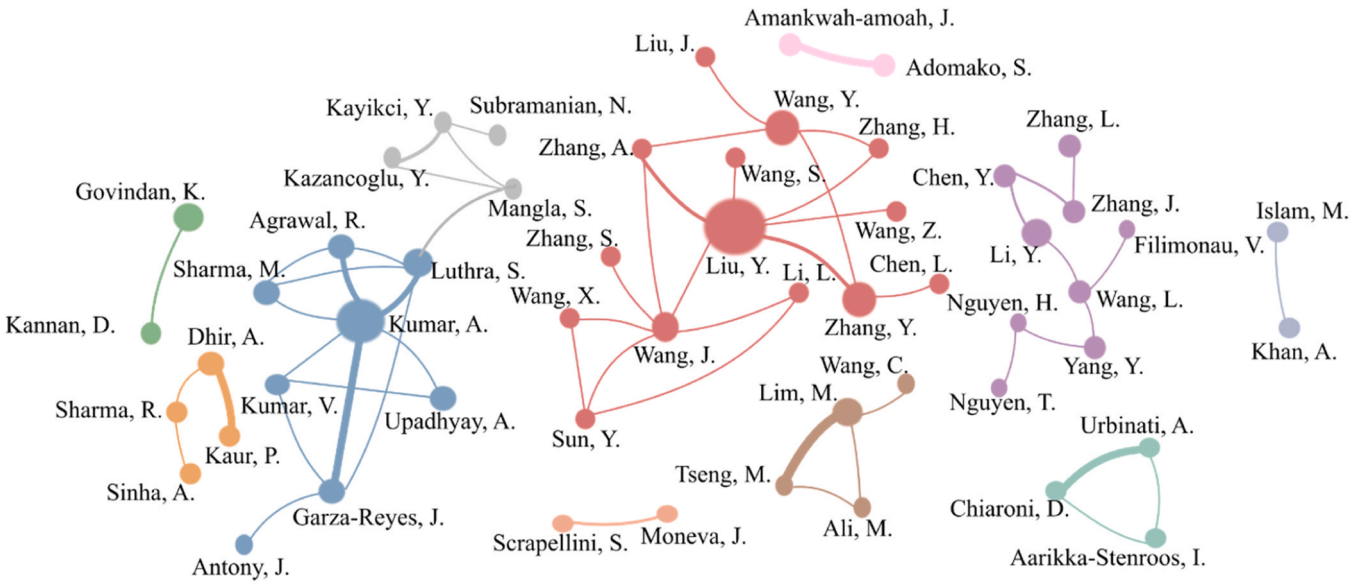


**Fig. 9.** Author collaboration network.

exploring how different company sizes and organizational structures affect the effectiveness of the measures.

2. **Consumer behavior and emotional factors have a significant impact on waste production**

Environmental awareness, anticipatory regret, and positive and negative emotions (e.g., guilt, hope) have an impact on consumer intentions (Filimonau, Todorova, et al., 2020; Ananda et al., 2023; Gao et al., 2023; Fazal-e-Hasan et al., 2023). These emotional and attitudinal factors provide the basis for developing effective communication and marketing strategies to reduce food waste. Further research would be needed to explore how positive and negative emotions are combined in the development of sustainable behaviors (Gao et al., 2023; Fazal-e-Hasan et al., 2023). It may be particularly useful to examine culture-specific differences and the role of social norms in consumer decision-making.

3. **The role of digital technologies is dual**

While data analytics and digitization can facilitate collaboration and performance improvements, there are also a number of barriers that can arise during the digital transition (Annosi et al., 2021). The introduction of such technologies involves challenges not only in terms of technology, but also in terms of organizational culture and skills. It is important to understand the long-term impact of digital tools on waste reduction and sustainability, and it is also necessary to examine how their application is changing corporate decision-making and internal processes.

4. **The impact of institutional and cultural factors on waste management**

Factors such as normative, mimetic, or coercive pressures and their relationship with CSR require further research (Ng and Sia, 2023). It is worth conducting comparative studies between developed and developing economies on the relationship between external pressures and internal motivations.

5. **Examination of household practices and demographic differences**

It is worth further investigating how age, income, education, etc., affect the spread of conscious food management habits (Ananda et al., 2023). The research results can help to develop targeted educational programs and communication campaigns.

6. **The concept of the circular economy (CE) serves as an important guideline**

The integration of CE principles is key to achieving sustainability in the food industry (Sadraei et al., 2022; Prieto-Sandoval et al., 2018; Lieder and Rashid, 2016). The closed material cycle reduces the use of raw materials and increases the flexibility of companies to adapt to changing market and environmental conditions. It would be necessary to examine the application of CE models in different food chains. There is further research potential in exploring the role of the regulatory environment and incentive schemes in the success of CE strategies.

7. **Platform-based solutions can increase sustainability**

The use of platforms that sell surplus food to restaurants is influenced by motivations for technological acceptance and self-determination (Cobo et al., 2011). These tools allow to optimize inventories and create new revenue streams in the name of sustainability. This could be implemented and investigated in other countries as well to manage food waste more efficiently and to increase sustainability.

To sum up, the hospitality industry plays a crucial role in sustainable food waste management, with effective strategies involving management practices, employee training, consumer behavior, and digital technologies offering both environmental and economic benefits. Further research is needed to explore cultural, institutional, emotional, and demographic influences, as well as the potential of circular economy models and platform-based solutions to enhance waste reduction and sustainability across various contexts.

## Challenges and opportunities

Despite the increase in publications, the analysis revealed that 16.28 % of articles were not cited, indicating gaps in dissemination or application. Moreover, the declining relevance of pandemic-related themes pointed to the need for adaptability in research priorities.

## Implications and future directions

Policymakers and industry stakeholders can benefit from these

findings by adopting data-driven strategies to minimize food waste across supply chains. Collaboration efforts between academia, industry, and governments will be crucial in translating research into actionable solutions. In conclusion, the bibliometric study not only highlighted the progress made in food waste research but also set the stage for more targeted and impactful efforts to address this critical issue. The integration of emerging technologies, coupled with sustained international collaboration, will be key to moving the field toward.

## CRediT authorship contribution statement

**Sándor Kovács:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Funding acquisition, Data curation. **Tímea Gál:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Erzsébet Buglyó-Nyakas:** Writing – review & editing, Writing – original draft, Project administration, Data curation.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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