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VISUALIZATION OF CIRCULAR ECONOMY RESEARCH TRENDS AND NETWORKS

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Abstract

The purpose of this research is to map and analyze trends and development patterns related to the integration of circular economy concepts with sustainable development and waste management. This research uses bibliometric analysis using the Scopus database from 2010-2025. The results obtained in the form of a dataset consisting of 674 documents and processed using the R Package (Biblioshiny) and VOSviewer. The results showed that there was an increase in publications in 2019-2024. The results also show that the most contributing authors are Liu Y and Singh S. Then institutions that contribute to publications include Chulalongkorn University, RMIT University, and the University of Southern Denmark, and the most influential journal is the Journal of Cleaner Production with 57 publications. The country that published the most articles on circular economy was India, with the most international collaboration pattern between China and the UK. Furthermore, the most cited article is Ghiselini P, 2012, J Clean Prod. The results of the network visualization of circular economy topics are divided into five clusters. Cluster 1 consists of 35 items, cluster 2 consists of 34 items, cluster 3 consists of 19 items, cluster 4 consists of 9 items, and cluster 5 consists of 6 items, with 3905 links, and a total link strength of 24,609. The findings of this study are expected to generate a greater understanding of research trends and networks in the circular economy, and serve as a reference for future research topics.

Keywords: Circular Economy, Sustainable Development, Waste Management, Bibliometrics

INTRODUCTION

In today's globalized world, where scientists predict resource demand will reach 3 times the earth's capacity by 2050 (Ellen McArthur Foundation, 2022), a circular economy is no longer an option but a survival necessity. However, the road to this transition is still filled with paradoxes and implementation gaps. According to the United Nations Development Programme (UNDP), the circular economy aims to minimize waste and promote sustainable use of natural resources through smarter product design, longer use, and natural regeneration (United Nations Development Programme, 2023). In practice, however, the traditional linear economic model (take-make-dispose) still dominates, with only 9.1% of the global economic system actually implementing circularity principles (World Economic Forum, 2023). This fact shows a significant gap between the ideal concept and the real implementation of circular economy at the global level.

A fundamental problem faced in the implementation of the circular economy is the excessive focus on recycling and recovery aspects, while neglecting upstream solutions such as sustainable design and innovative business models (Ghisellini et al., 2016). Current policy targets that only focus on waste recycling or burning waste for energy do not encourage systematic change (Morseletto, 2020). In fact, various studies have proven that recycling approaches are only able to provide limited environmental impacts. The study of Korhonen et al. (2018) specifically shows that recycling strategies can only reduce 5-10% of environmental impacts compared to waste prevention strategies through product design innovation.

Research on the circular economy in a global context has become a significant concern, driven by the increasingly alarming crisis of waste and resource exploitation. This statement is reinforced by recent data showing that by 2023, the world generated 2.24 billion tons of solid waste, with only

7.2% successfully recycled (Circle Economy, 2023). Reliance on new raw materials exacerbates this situation, characterized by a 254% increase in natural resource utilization since 1970 (UN Environment Programme, 2024). For example, the EU in 2022 imported 1.8 million tons of plastic waste due to minimal domestic recycling capacity (Eurostat, 2024), while 90% of global CO_2 emissions are related to material extraction and processing (Ellen McArthur Foundation, 2021). Although many countries have implemented stringent policies to encourage a circular economy-such as the European Union with the European Green Deal (2021) and Digital Product Passport (2023), the United States with the Inflation Reduction Act (2022), and China with its plastic waste import ban and Extended Producer Responsibility policy (2023)-the implementation of these policies remains uneven. In Indonesia, for example, 60% of plastic waste ends up in landfills, reflecting the gap between regulation and practice. Previous studies have explored the policy aspects and challenges of the circular economy, but research that provides a comprehensive understanding of recent developments, categorization of literature, and their interconnections on a global scale is limited. Therefore, this study aims to fill the gap by analyzing the latest trends and challenges of circular economy implementation in various countries.

Research on circular economy approaches has been conducted and shows that there are limitations. First, the "zero-waste" claim is technically impossible due to the law of entropy, where any recycling is not 100% efficient and still produces other waste (Richa et al., 2017). Secondly, 96% of research on the integration of circular economy and industry 4.0 has only been covered in the last 5 years, indicating a lack of understanding of the role of technology in supporting circular economy (Cagno et al., 2021). Thirdly, there is a clear geographical imbalance in circular economy research, with 85% of publications coming from Europe and North America (Ricca et al., 2020), thus underrepresenting the challenges faced by developing countries.

This research aims to provide empirical evidence through a trend mapping study and research network of the circular economy phenomenon at the global level from 2010-2025. To support the achievement of the research objectives, the research questions are as follows:

1. What are the trends in scientific publications on circular economy topics? And when is the peak of publication activity?
2. Who are the authors, institutions and journals that have contributed the most publications on the circular economy?
3. Which countries are most active in publishing circular economy related publications? And what are the patterns of international collaboration?
4. Which are the most influential or most cited articles?
5. What are the most frequently used keywords in the circular economy literature? And how do topics in the circular economy field cluster?
6. What are the research gaps visible from the bibliometric analysis on the topic of circular economy?

By understanding the circular economy related trends inherent in research, industry players can practice and apply circular economy principles. In addition, this study provides a more objective and theoretically and practically relevant perspective that can serve as a reference for future research in this field, particularly in the area of circular economy clustering.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

Circular Economy

The concept of circular economy was first introduced by Peace and Turner in the 1990s (Uwuigbe et al., 2024), which was pioneered by contributions from experts such as John Lyle, William McDonough, Michael Braungart, and Walter Stahel (Winans et al., 2017). The fundamental theory in the circular economy is the cradle to cradle strategy design proposed by Stahel & Reday-Mulvey(1981) which focuses on product life extension, product reuse, and recycling with the aim of promoting a sustainable economic model. McDonough & Braungart (2002) developed a cradle to

cradle design strategy that focuses on the approach of using materials that can be returned to nature or recycled into new products, with the aim of creating a closed cycle to reduce waste and environmental impact and produce products that have a positive impact on design effectiveness (Ellen McArthur Foundation, 2019; Uwuigbe et al., 2024) .

The circular economy is an economic system that aims to minimize waste and maximize resource use by preserving raw materials and ensuring products remain in use for as long as possible (Ren et al., 2023). According to Bilancia et al. (2025), the circular economy can complement principles related to environmental sustainability with the design and production of products that can be reused, repaired, renewed, and recycled, which will extend the product's life cycle and ultimately reduce waste. The circular economy is a key cornerstone in achieving sustainable development, simultaneously supporting economic progress, protecting finite resources, and reducing waste (Ospina-Mateus et al., 2023).

Sustainable Development

Sustainable development is a global effort that leads to the achievement of equitable economic, social, and environmental development (S et al., 2025). Another definition defines sustainable development as a development that meets the needs of the present without compromising the ability of future generations to meet their needs (d'Angella et al., 2025). According to Halkos & Gkampoura (2021), sustainable development focuses on protecting the environment, while providing economic and social development and well-being for current and future generations. Therefore, the three main pillars of sustainable development are social sustainability, economic sustainability and environmental sustainability. The United Nations established sustainable development as the 2030 Agenda which focuses on 17 Sustainable Development Goals (SDGs) that aim to end poverty, fight inequality, and tackle climate change while ensuring no one is left behind (United Nations, 2015).

Waste Management

Waste management is defined as an activity that is carried out in a systematic and sustainable manner, including waste reduction and handling. Waste management consists of 3 stages, namely collection, transportation, and final disposal with the aim of improving public health and environmental quality and converting waste into resources (Kushendar et al., 2023). Proper waste management practices, including waste reduction, safe and proper waste handling, are important to reduce the consequences of waste problems such as climate change, environmental damage, and human health problems (Najar et al., 2024). According to Schmidt & Laner(2025), waste management is expected to play an important role in mitigating the climate crisis by closing the material cycle, providing energy by utilizing non-recyclable waste, and reducing emissions through safe and environmentally friendly waste treatment and disposal.

RESEARCH METHODS

Research Design

This study uses a bibliometric approach with quantitative techniques applied to bibliometric data to review publications related to the scope of the study, in order to identify research trends, concepts, and necessary keywords (Gupta & Bhattacharya, 2004). In other words, bibliometric analysis can explore the scientific literature to collect data such as grouping according to relevant information, analyzing methodologies, and trends in research subjects, as a first step to help the process of identifying the most relevant documents (Patyal et al., 2020). Following Pritchard's model (1969), bibliometric analysis refers to the application of mathematical models using specific statistical algorithms on documents and communication data.

This method of analysis is used aiming to examine the scientific results in this research area and highlight important issues for future research, as described by (Caviggioli & Ughetto, 2019).

According to Donthu et al. (2021), many perspectives on this method of analysis highlight the ability to evaluate the results of scientific literature and assess its relevance in a particular field through quantitative, mathematical, and statistical methods, on a publication or a set of publications by looking at its bibliography, namely authorship, year of publication, citations, graphic images, and so on. Bibliometric analysis has also become more widespread and is now standard practice in many fields of scientific research (Hood & Wilson, 2001).

The stages of bibliometric analysis in this study were adapted from Zupic & Čater (2015), which has five stages as follows: 1. study design (determining objectives, selecting databases, and setting filters to be applied to limit the sample) 2. data collection and processing (selecting, retrieving, and processing bibliometric data after the application of filters set in the previous stage) 3. data analysis (using software to help analyze bibliometric data) 4. visualization (network analysis and selection of appropriate software to implement visualization) 5. interpretation (interpreting and describing the findings).

Figure 1. Stages of Analysis Flow (Zupic & Čater, 2015)

The bibliometric method was chosen based on the purpose of this study, which is to map and analyze trends and development patterns related to the integration of circular economy concepts. Bibliometric analysis can be used to reveal emerging trends in the performance of articles and journals collaboration patterns and research constitution and explore the intellectual structure of a particular domain (Donthu et al., 2021). The use of published articles can be a research reference by examining through bibliometric analysis, these scientific articles become the unit of analysis in research to determine the development of focus, and potential future orientation in research (Rowley & Slack, 2004). According to Donthu et al. (2021), the division of techniques for bibliometric analysis materializes in two categories namely (1) performance analysis and (2) science mapping. In detail, performance analysis allows researchers to contribute constituents to a particular field, as performance analysis summarizes key research indicators such as number of publications and citations. Knowledge mapping, on the other hand, allows researchers to examine the relationship between research constituents and the intellectual interactions and structural relationships among constituents, which includes citation and authorship analysis and exploration of research themes and topics.

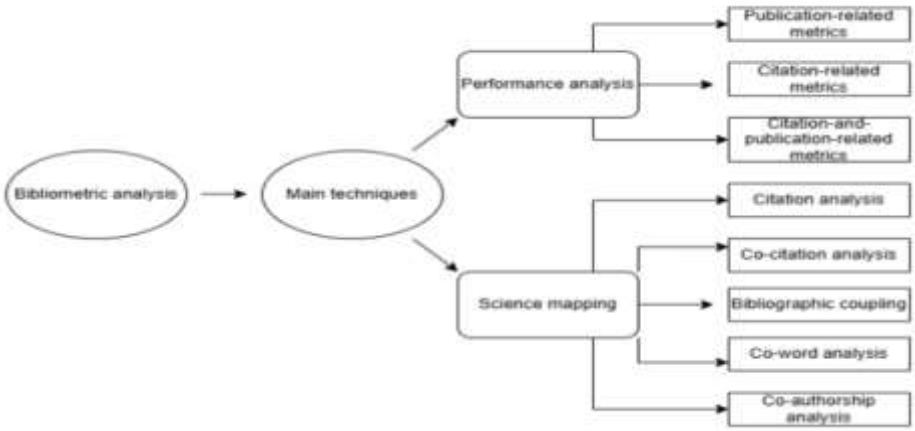

Figure 2. Bibliometric Research Structure (Donthu et al., 2021)

Population and Sample

Population is a general field consisting of objects and subjects that have certain qualities and characteristics, determined by researchers and then drawn conclusions (Sugiyono, 2013). While the sample is data determined by the researcher based on consideration of the problem of hypothesis objectives, methods, and research instruments, as well as considering time energy and financing (Darmawan et al., 2024). The population and sample in this study are journals indexed in Scopus. Based on the search results on the Scopus database from 2010-2025 with keywords, 674 documents were found. The search results were determined as the population and sample because there were no changes after inputting into the Biblioshiny and VOSviewer applications. The starting point of bibliometric analysis of publications on circular economy with sustainable development and waste management began in 2010 and began to increase from 2016 to 2024. This is because, during this period there was an increase in consumer awareness of environmental issues (Bali et al., 2022).

Data Collection Techniques and Instrument Development

The data collected in this study is Scopus data which can be accessed through (www.scopus.com) as a bibliographic data source. Scopus is a database of abstracts and citations from literature reviewed by researchers including scientific journals, books, and conference proceedings. According to Mongeon & Paul-Hus (2016), Scopus is a well known database used to analyze bibliometrics that allows access to scientific literature and can complement each other. In addition, the advantages of Scopus are also seen from its strong reputation, extensive content, and global citations. The platform provides access to articles published by renowned publishers (Baas et al., 2020). Scopus supports research planning and decision making for institutions, ranking organizations, funding agencies, and governments around the world. Thus, given its internationally recognized quality and reputation among universities and research institutions, the selection of Scopus as a database retrieval site was deliberately done using keywords that have been compiled based on literature and research discussions.

The identification of emerging themes related to the circular economy follows co-occurring keywords and the incorporation of data sets retrieved from the Scopus database. According to Van Eck & Waltman (2014), the relationship or network between keywords is determined by the number of articles in which the keywords co-occur. Keyword analysis is done manually for checking and cleaning data, after cleaning the data to improve the quality of bibliometric analysis data, researchers use VOSviewer and R studio software to analyze data in script. The set of keywords used in the search through the Scopus database was ("circular economy") with the search string ("sustainable development" AND "waste management"). Therefore, the search in this research data collection obtained 674 documents, with the database retrieved until June 1, 2025.

Data Analysis Technique

In this study, researchers used the most popular software VOSviewer and R Package (Biblioshiny) for reliable results. R language, with Bibliometric package Biblioshiny, which is a Java-based software developed to conduct functional combination research using bibliometric packages and web applications used as a package in R-studio (Khan et al., 2023). The results obtained by incorrectly using R Bibliometrics are datasets in the form of key information of scientific production years and three-field graphs. And VOSviewer software used for mapping and processing clustering analysis with visualization of maps based on co-occurrence (Small, 1997). In addition, VOSviewer makes it possible to determine indicators of collaborative structure that measure the relationship between authors, institutions, countries, research trends based on keyword usage. According to Van Eck & Waltman (2014), VOSviewer provides a distance based visualization of bibliometric networks where the distance separating two vertices exactly implies the existence of a relationship between them, the resulting visualization depicts a broader network.

RESULTS AND DISCUSSION

RESULTS

Descriptive and Trend Analysis

The number of publications reflects the quantity of scientific work and interest in a particular topic. The number of data collection with Scopus base that can be processed is 674 documents, with data retrieval until June 1, 2025.

Figure 3. Key Figure of the Data Collection

Figure three (3) is a summary of the statistical data collected. The analysis shows that there is a comprehensive dataset on circular economy of 675 documents from 2010 to 2025, with an annual growth rate of 31.95%. The documents were mainly sourced from 307 journals and books, with an average citation per document of 50.14 and an average document age of 2.85. There were 2,499 authors involved in writing the documents, with 51 documents written by single authors. In collaborative authorship, there were co-authors per document with an average of 4.23, as well as international author collaboration of 36.65%, reflecting a strong global research network. In addition, in the data set analysis, there were 1742 author keywords and 4136 plus keywords.

Publication Trend

Through analysis using Biblioshiny, it was found that the publication trend on the topic of circular economy generally experienced a gradual increase from 2010 to 2025. Although it looks stagnant in the first few years, the graph shows a significant increase, which is only 1 article in 2010 and can reach 172 articles in 2024. In 2025, the data collection process was conducted in June, resulting in a decrease of only 64 articles. However, this does not rule out the possibility of a further increase until the end of 2025.

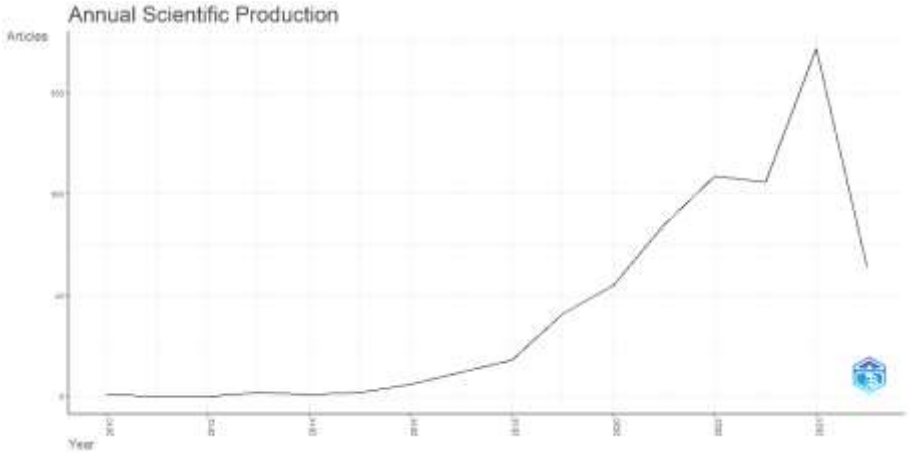

Figure 4. Publication Trend

In the Scopus database, research on circular economy topics has increased dramatically. From 2010 to 2015, only 1-2 articles were published each year, and no articles were even published in 2011 and 2012. Subsequently, there was a significant increase in publications from 2016 to 2018. Starting from 2019 to 2025, the publication trend of circular economy topics is increasing until it reaches its peak in 2024 with the highest publication achieved as many as 172 articles.

Most Contributing Authors

Based on the results of the analysis using R-Studio and Biblioshiny, visualized in Figure 5, several authors stand out in advancing this research agenda. The most influential authors can be identified based on the size and intensity of their relationships within the research network. Liu Y and Singh S emerge as among the central figures with significant contributions to this topic, indicated by their position at the center of the largest cluster with a publication count of 8 articles each. This demonstrates their widespread influence through frequently cited research and their role as a nucleus in the research network. In addition, Belmonte-Urena LJ, Ghosh S, Kumari A, Kumar R, Ramakrishna S, and Zorpas AA with a publication count of 7 articles show intense collaboration and relevant influence in sustainable development and waste management in the circular economy.

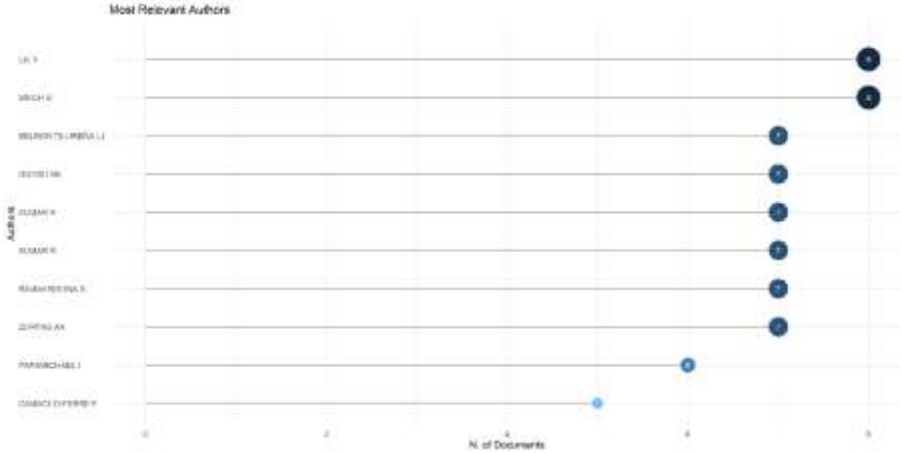

Figure 5. Most Contributing Authors

Based on figure 5, Papamichael I also stands out as an influential author with 6 articles. Camacho Ferrel F with 5 articles. These authors made significant contributions in expanding the discussion on circular economy with sustainable development and waste management. Thus, authors such as Liu Y, Singh S can be considered as key drivers in the circular economy research agenda with their work having a major impact on the academic community in this field.

Most Contributing Affiliations/Institutions

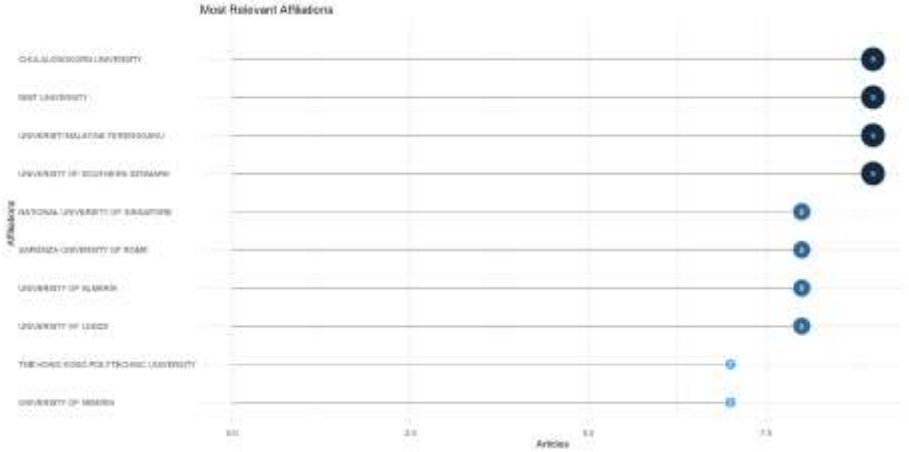

Figure 6. Most Contributing Affiliations/Institutions

Figure 6 shows the most contributing affiliations, based on the number of publications on circular economy research topics. Chulalongkorn University, RMIT University, Universiti Malaysia Terengganu, and University of Southern Denmark have the most research on this topic with a total of 9 publications. Followed by the National University of Singapore, Sapienza University of Rome, University of Almeria, and University of Leeds with 8 publications each. The Hong Kong Polytechnic University and the University of Nigeria each showed contributions with 7 publications.

Most Contributing Journal

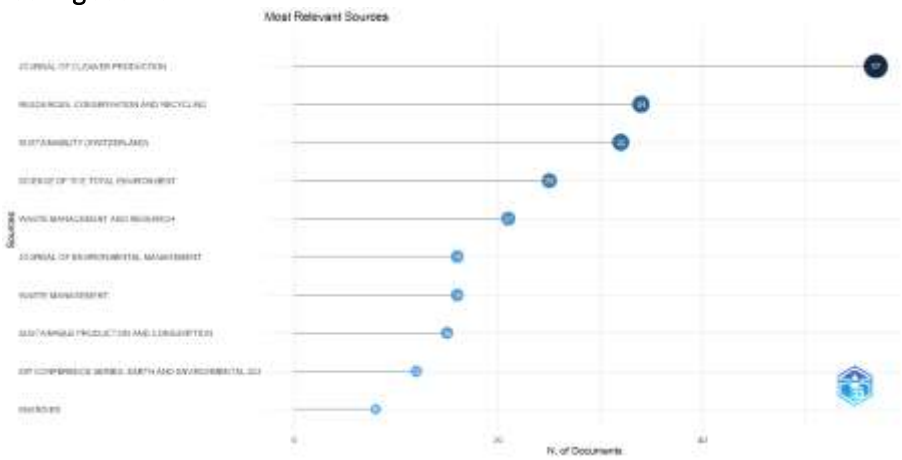

Figure 7. Most Contributing Journal

Figure 7 shows the journals that made the most significant contribution based on the number of documents published on the topic of circular economy. The journal with the highest number of articles is the Journal of Cleaner Production with 57 publications. This demonstrates's role as a major source of literature on this topic. It is followed by Resources, Conservation and Recycling with 34 publications and Sustainability (Switzerland) with 32 publications, both of which are important contributors. Other journals such as Science of the Total Environment with 25 publications and Waste Management and Research with 21 publications, Journal of Environmental Management and Waste Management have 16 publications, followed by Sustainable Production and Consumption with 15 publications, IOP Conference Series: Earth and Environmental Sci with 12 publications, and Energies with 11 publications show relevant journals that are important reference sources for researchers in this field.

Country Network Analysis

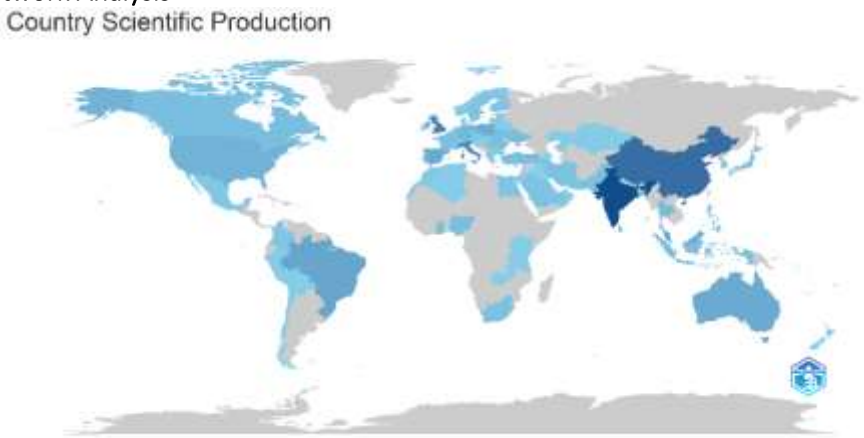

Figure 8. Country Network Analysis

In figure 8, it can be seen that India is in the first position as the main driver of the research agenda in the circular economy. Furthermore, table 1 shows the findings of the global analysis

relating to a country's scientific production. There are 84 countries in the world that contribute to research on circular economy topics. India is the country that publishes the most research on circular economy with a total of 235 publications. This is followed by China with 173 publications, the UK 140 publications, Italy 126 publications, Brazil and Malaysia both produced 70 publications. Meanwhile, Spain produced 64 publications, Australia 63 publications, Poland 56 publications, and the United States 48 publications. Data from the top 10 countries shows that India has the highest level of scientific production compared to other countries. China and the UK are also major contributors to circular economy topics.

Table 1. Country Scientific Production

Country	Frequency
India	235
China	173
United Kingdom	140
Italy	126
Brazil	70
Malaysia	70
Spain	64
Australia	63
Poland	56
USA	48

The country collaboration map is a visual representation of the collaboration patterns and networks of researchers working in the circular economy. This map was obtained through bibliometric analysis using Biblioshiny. The figure above represents how the country collaboration network identifies the main groups involved in research collaboration in the relevant field. As shown in the figure above, there are significant differences in international research collaboration. Some countries, such as India, China, United Kingdom and Australia are highly connected with other countries and produce many collaborative scientific publications.

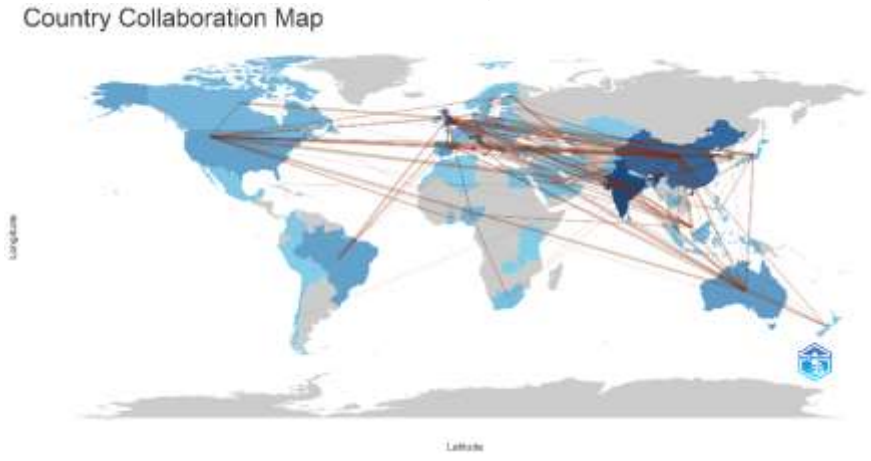

Figure 9. Country Collaboration Map

Most Frequently Cited Documents

Figure 10 shows the most globally cited articles in this study with high impact and academic relevance. The article by Ghiselini P, 2012, J Clean Prod occupies the most positions with more than 4150 global citations. This suggests that the article is likely a frequently used cornerstone in the field under study, significantly shaping the direction of future research.

Furthermore, there are a series of other publications that also show substantial citation impact, namely Su B, 2013, J Clean Prod with 1048 citations, followed by Merli R, 2018, J Clean Prod with 1030 citations, and IBN-Mohammed T, 2021, Resour Conserv Recycl with 992 citations. Similarly, articles by Kumar R, 2021, Sustainability (952 citations), Kristensen Hs, 2020, J Clean Prod (927 citations), Gregson N, 2015, Econ Soc (912 citations), Fattimah YA, 2020, J Clean Prod (887 citations), Ghiselini P, 2018, J Clean Prod (875 citations), and Geng Y, 2013, Science (850 citations) represent that this research topic has fundamental works that are repeatedly referenced in the literature.

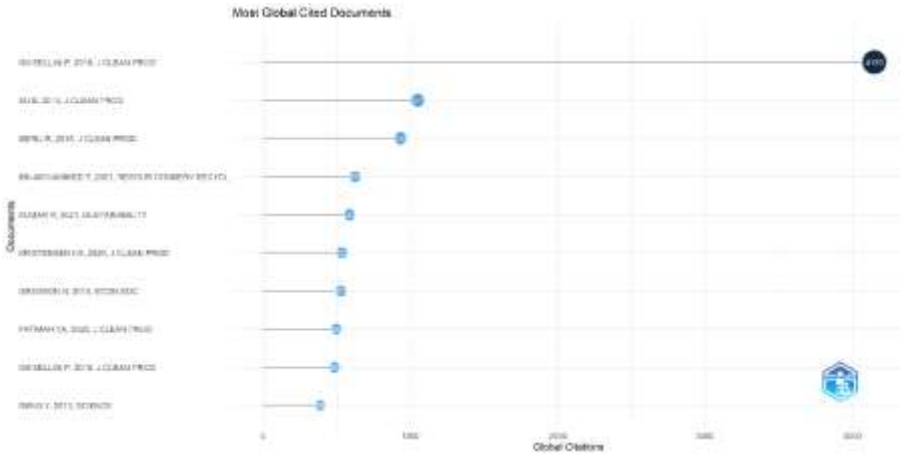

Figure 10. Most Frequently Cited Documents

Keyword Analysis and Clustering

Analysis of keyword occurrences shown in the graph and wordcloud image above shows that circular economy, sustainable development, waste management, sustainability, and recycling are words with the largest and most prominent dimensions compared to other topics because they appear most often in scientific publications with the highest number of occurrences of 548 of circular economy keywords. In addition, wordcloud analysis also shows that economic aspect, life cycle, and environmental impact are words that are often cited and related to circular economy topics.

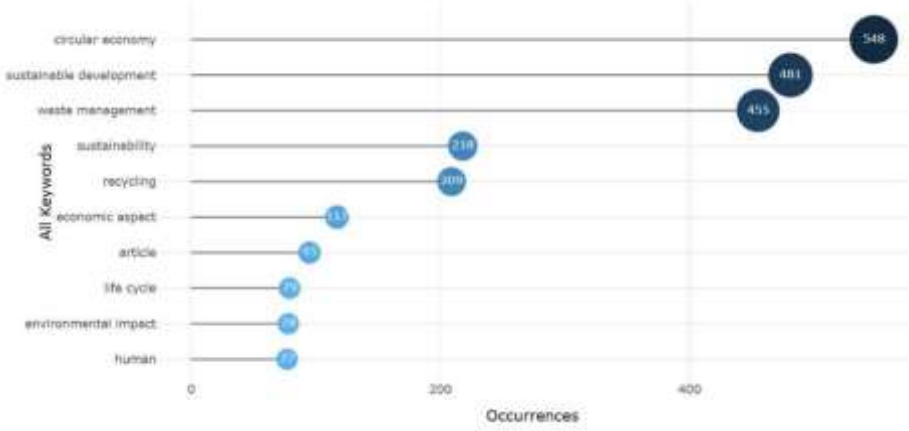

Figure 11. Keyword Occurrences

Figure 12. Wordcloud

In the results of data processing using VOSviewer software, the results of network visualization of circular economy topics 674 documents 103 items were selected with 5 clusters (cluster 1 consists of 35 items, cluster 2 consists of 34 items, cluster 3 consists of 19 items, cluster 4 consists of 9 items, and cluster 5 consists of 6 items), with 3905 links, and a total link strength of 24609. However, out of 103 items, not all of them have coherence with each other, therefore they form their own clusters according to their coherence.

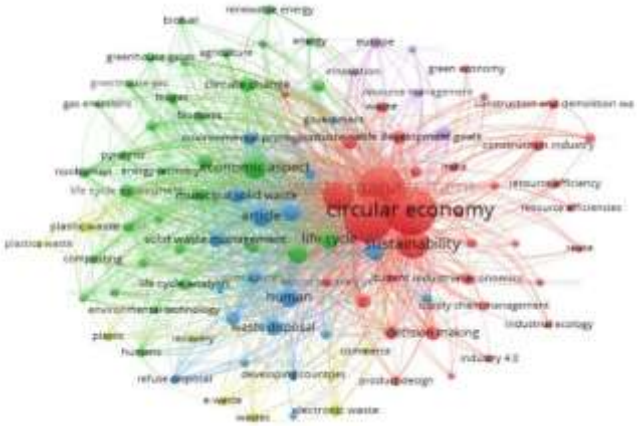

Figure 13. Network Visualization of 103 Items with 5 Clusters

Based on Figure 13, there are large clusters containing the concepts of sustainable development, circular economy, waste management, and then various concepts of a series of further concept development. In cluster 1 marked in red, the words included in this cluster such as circular economy, business models, and construction industry, with a focus on economic and social aspects. These include bibliometric analysis, industrial ecology, and industry 4.0, which show the integration of circular economy technologies and principles in industrial practice. The topics of waste management, recycling, and resource efficiency also emphasize the importance of sustainable resource management. In cluster 2, marked in green, the words included in this cluster are specific to agriculture, biofuels, and anaerobic digesting, with an emphasis on climate change and greenhouse gas emissions. There are also topics that show environmental-based approaches to managing organic waste and generating renewable energy, such as composting, food waste, and energy recovery.

Cluster 3, marked in blue, reflects the challenges and solutions in managing waste in developing countries from the topics of waste management and environmental regulation. It also includes the topics of environmental policy, municipal solid waste, and developing countries, with a focus on China and economic development. Cluster 4 is marked in yellow, which focuses on e-waste, plastic waste, and recovery, with an emphasis on sustainable management. It focuses on the importance of circular economy approaches to address e-waste and plastic waste, including innovations in recycling and material recovery. Cluster 5 is highlighted in purple, which covers

European Union, industrial waste, and innovation, with a focus on resource management and environment, aiming to showcase the role of regional policies and technological innovation in supporting a circular economy in Europe.

Research Gap Analysis

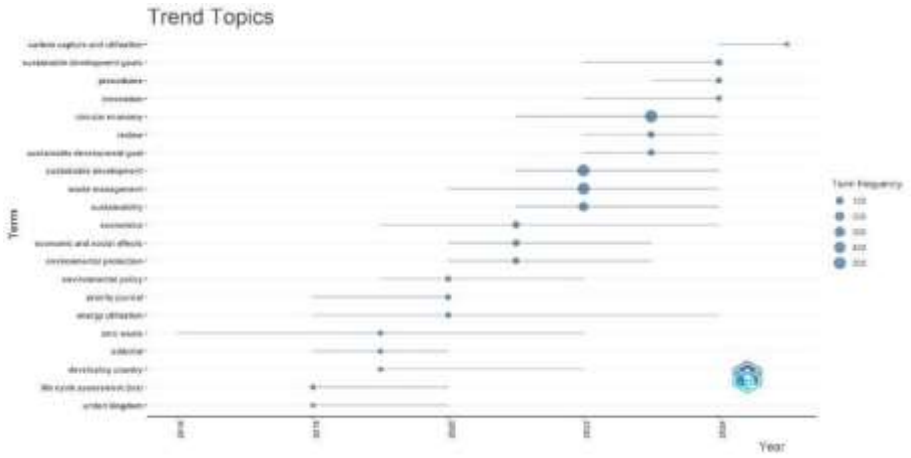

Figure 14. Trend Topic

The analysis to determine the research gap and novelty in the topic of circular economy can be seen by collaborating the trending topic data with the co-occurrence data that is still very little connected to the main topic, namely circular economy. In the collaboration analysis, a new trending topic can be found, namely carbon capture and utilization or carbon capture, utilization, and storage (CCUS), and also co-occurrence which is still slightly connected to the main topic, namely carbon. Based on these two findings, future research is recommended to discuss the topic of carbon loop which includes carbon capture, utilization, and storage (CCUS) and integrated with circular economy.

DISCUSSION

RQ1: What is the trend of scientific publications on circular economy topics? And when is the peak of publication activity?

Research on the topic of circular economy has grown significantly over the years, starting in 2010 to 2015, which focused on circular economy models as a strategy in sustainable development. From 2016 to 2025, research has become more diverse with topics such as sustainable development, waste management, sustainability, and sustainable development goals. Furthermore, the first theme highlighted is "circular economy", with the first research related to the topic being an article titled "Countermeasures on Circular Economy of Small and Medium Enterprises Development" by Liu Biao-weng in 2010. The study identifies how circular economy development by SMEs is dependent on government leadership and supervision (Biao-weng, 2010). As per the visualization, the theme "circular economy" has the largest node indicating that it has a high degree of centrality to the field of study.

The second theme highlighted was "sustainable development". This theme focuses on how circular economy becomes a strategy towards sustainable development. This theme illustrates that good circularity metrics with the aim to measure the circular economy's contribution to sustainable development should be comprehensive enough to avoid shifting the burden from reduced material consumption to increased environmental, economic, and social impacts (Corona et al., 2019). Furthermore, the third theme is "waste management". This theme highlights the importance of integrating circular economy models into waste management systems to meet sustainable development goals. Waste management based on circular economy such as recovery, recycling, repurpose, remanufacture, refurbish, repair, re-use, reduce, rethink, and refuse can accelerate in

achieving sustainable development goals (Sharma et al., 2021). Overall, these patterns show that circular economy research continues to dynamically evolve and adapt to the innovations and changes of the modern era.

RQ2: Who are the most influential authors, institutions and journals driving the research agenda on sustainable development and waste management in the circular economy?

In terms of authors, Liu Y and Singh S stand out as the most influential authors on the topic of circular economy with 8 publications each. Their contributions played a role in building the foundation and developing the core of the circular economy literature with waste management and sustainable development hence they are often cited and become key references. Other authors such as Belmonte Urena LJ, Ghosh S, and Kumar R with 7 publications each address the technical aspects of circular economy implementation at the policy and industry level.

In terms of institutions, Chulalongkorn University, RMIT University, and University of Southern Denmark are the three universities that stand out as major research centers with 9 publications each. These institutions not only excel in the number of publications, but also actively build international research networks, especially in Asia and Europe. Meanwhile, the National University of Singapore and Sapienza University of Rome with 8 publications and The Hong Kong Polytechnic University with 7 publications strengthen their position through a multidisciplinary approach that combines environmental economics, engineering, and public policy (Kumar et al., 2021). In addition, being followed by institutions from Asia and Europe reflects the regional commitment to the circular economy transition, supported by government policies such as the European Green Deal and the ASEAN Circular Economy Framework (Su et al., 2013).

An analysis of literature sources identified the Journal of Cleaner Production as the most relevant journal with 57 articles proving its position as a key platform for circular economy research. The journal publishes many studies on industrial symbiosis and product life cycle assessment, which are key pillars of the circular economy (Merli et al., 2018). Other journals such as Resources, Conservation and Recycling with 34 articles and Sustainability (Switzerland) with 32 articles also play an important role especially for the topic of managing waste into new resources, as identified in the research.

RQ3: Which countries are most active in publishing circular economy-related publications? And what is the pattern of international collaboration?

On the country side, India is the most prolific country in producing circular economy related research, with a total of 235 publications and is characterized by the darkest color in the visualization. This productivity is supported by the waste problem in India that requires management towards the implementation of a circular economy (Hossain et al., 2022). Many studies from India focus on the circular economy in relation to waste management. This is followed by China, United Kingdom, and Italy, which also show substantial international collaboration.

International collaboration patterns regarding research on circular economy topics are mostly carried out by countries such as China, India, United Kingdom, and Australia. The most collaborations were conducted by China with the United Kingdom, resulting in 15 international collaborations. Furthermore, India's collaboration with China resulted in 12 research collaborations, China with Malaysia resulted in 10 research collaborations, and the United Kingdom with Australia resulted in 10 research collaborations. China conducts many research collaborations with other countries, because China has developed broad ambitions regarding the circular economy and has implemented comprehensive circular economy policies. This is in line with other countries such as the EU, UK, and USA (Bleischwitz et al., 2022), thus increasing the number of existing research collaborations.

RQ4: Which are the most influential or most frequently cited articles?

In terms of the most cited articles, Ghiselini P, (2012) with a review article on circular economy models became the main reference for the theoretical framework reaching more than 4150 citations, while Su B et al. (2013) contributed quantitative metrics to assess circular economy performance in the context of urban waste management (Kumar et al., 2021). A recent article by Ibn-Mohammed T, (2021) offers a new perspective by linking the circular economy with climate strategies, demonstrating the development of this research field in a more holistic direction (Fattimah et al., 2020). Fundamental works such as Ghiselini (2012) and Su (2013) have set the initial paradigm, while recent research such as Ibn-Mohammed (2021) shows the potential of expanding the discourse to broader issues related to sustainability and climate change.

RQ 5: What are the most frequently used keywords in the circular economy literature? And how do topics in the circular economy field cluster?

This research shows a multidisciplinary approach between the circular economy and sustainable development and waste management (Su et al., 2013). Sustainable development and waste management are the most frequent keywords after circular economy with 481 and 455 respectively, indicating that many studies collaborate these keywords with circular economy. In addition, there are also other multidisciplinary approaches between circular economy and sustainability and recycling (Ghisellini et al., 2016; Merli et al., 2018) with 218 and 209 occurrences.

This scientific development is also reinforced by the literature sources referenced in a number of studies, which creates a variety of new research themes that emerge, so that these new themes still have bibliographic links and interrelationships with each other. This connection can be seen through the results of the network visualization analysis, which identifies five clusters of referenced articles. The first cluster with the largest point is in the article (Ghisellini et al., 2016), entitled "A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems", this study found that the implementation of circular economy (CE) in the world is still in its early stages, with the main focus on recycling. In addition, the study highlighted the importance of collaboration of community actors as well as economic incentives to accelerate the transition to a more sustainable economic model.

Then in cluster 2 the biggest point is in the study (Ghisellini et al., 2018), entitled "Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A literature review", this study found that the implementation of circular economy in the construction and demolition sector can provide environmental and economic benefits, especially through maximizing efforts in material reuse and recycling. However, the study also points out various technical, economic, and regulatory barriers that hinder the optimal implementation of the circular economy. While in cluster 3 marked with the largest dot on the article (Su et al., 2013), entitled "A review of the circular economy in China: moving from rhetoric to implementation", this study provides an overview of the implementation of the circular economy in China contributes to improving the efficiency of using materials and energy, as well as reducing environmental degradation and resource scarcity. In addition, this study also emphasizes the importance of applying the 3R principles (Reduce, Reuse, Recycle) throughout the production and consumption chain to achieve sustainable development.

The cluster 4 with the largest point is the article (Merli et al., 2018), entitled "How do scholars approach the circular economy? A systematic literature review", this study found a growing application of the circular economy. However, there are many challenges related to consolidating definitions, expanding training on social and institutional aspects, and exploring more diverse business models for optimal implementation. While in cluster 5 the biggest point is in the article (Hartley et al., 2020), entitled "Policies for transitioning towards a circular economy: Expectations from the European Union (EU)", this study found that circular economy policies in the European Union are still too narrow and need to be expanded to be more effective, through a comprehensive and innovative policy approach to accelerate the transition to a circular economy. According to with

the analysis that has been done related to this research, it is found that the study of circular economy has grown from the last 15 years, with more authors, institutions, and countries collaborating on this science. This supports a wider cooperation to promote a better understanding of circular economy trends, subjects, and research.

RQ 6: What are the research gaps revealed by the bibliometric analysis on the topic of circular economy?

In this research, a gap was found regarding carbon capture and utilization or Carbon Capture, Utilization, and Storage (CCUS) which is a trend topic and still not widely researched based on analysis using biblioshiny and VOSviewer software. Integration between the circular economy and Carbon Capture, Utilization, and Storage (CCUS) needs to be done, because it still has a connection such as research conducted by Huang et al. (2024), which states that the global plastics sector urgently needs a circular economy and carbon reduction, and a new strategy is proposed to close the plastic cycle and carbon cycle using carbon capture, utilization, and storage (CCUS), which involves recycling waste plastics into adsorbents for CO2 capture and converting the recaptured CO2 into new plastics. Research by Goh et al. (2025) also states, that transitioning to biogas and solar energy can reduce the carbon footprint by 40-50%, while the application of carbon capture and storage (CCS) can capture 90% of CO_2 emissions, equivalent to 1.2 million tons per year.

CONCLUSION

This research systematically aims to map and analyze trends and development patterns related to the integration of circular economy concepts with sustainable development and waste management using bibliometric analysis with Scopus database from 2010-2025. The results of this study show that circular economy research topics in the context of sustainable development and waste management can be categorized into five main clusters, namely circular economy and business analysis, resource management and sustainability, environmental policy and economic learning, waste management and waste, and innovation and environmental management. This cluster categorization can be used as a reference for further research topics.

This research is still limited by the use of specific search keywords, such as "circular economy", "sustainable development", and "waste management". Although this is important to maintain the focus of the research, it also has the potential to overlook other studies with terms related to circular economy. Therefore, it is recommended for future research to broaden the scope of search keywords to increase the depth and relevance of the analysis.

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