The Evolution of Circular Economy Research Based on Bibliometric Analysis of International Publications 2010–2024

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Article Info	ABSTRACT
	The circular economy has emerged as a key concept in addressing global sustainability challenges, particularly those related to resource depletion, waste generation, and environmental degradation. This study aims to analyze the evolution of circular economy research based on international publications indexed in the Scopus database from 2010 to 2024. A bibliometric approach was employed to examine publication trends, collaboration networks, and thematic structures within the literature. Data were analyzed using VOSviewer to generate visualizations of co-authorship networks, keyword co-occurrence, and research density. The results indicate a significant increase in circular economy research over the past decade, reflecting growing academic and policy interest in sustainable production and consumption systems. Co-authorship analysis reveals the presence of several collaborative research clusters connected by influential authors who facilitate knowledge exchange across institutions and regions. Keyword co-occurrence analysis shows that circular economy research is strongly associated with themes such as sustainability, waste management, recycling, and life cycle analysis. In addition, technological topics including wastewater treatment, biomass utilization, and plastic recycling appear as important subthemes supporting circular resource flows. Density visualization further indicates that circular economy and sustainability remain the most dominant concepts within the field. Overall, the findings demonstrate that circular economy research has developed into an interdisciplinary domain integrating environmental science, industrial systems, and sustainability studies. This study provides a comprehensive overview of the intellectual structure of circular economy research and offers insights into emerging research directions for future studies.

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1. INTRODUCTION

In the past decade, the concept of the circular economy (CE) has transitioned from a marginal sustainability discourse to a central framework informing global research, policy, and industrial transformation. Rooted in ecological economics and industrial symbiosis, the circular economy aims to decouple economic growth from resource consumption by closing material loops, extending product lifecycles, and embedding regenerative processes across production systems [1], [2]. This shift gained traction as concerns over environmental degradation, resource scarcity, and systemic inefficiencies intensified, prompting scholars and

practitioners alike to explore alternative economic paradigms that prioritize sustainability over linear consumption models [3]. Accordingly, the growth of circular economy research reflects broader imperatives for societies to rethink the foundations of economic development in an era characterized by complex environmental crises.

Academic interest in the circular economy has expanded significantly since 2010, evidenced by a growing body of studies spanning multiple disciplines. Early research primarily focused on conceptual frameworks and theoretical alignments with sustainability, life cycle assessment, and systems thinking [4]. Over time, the field diversified into applied research, incorporating domains such as supply chain management, industrial ecology, innovation studies, and public policy [3]. With its interdisciplinary nature, CE research not only interrogates environmental and economic dimensions but also engages with social considerations, including employment, consumer behavior, and equitable resource access [5]. This broadening of scope has elevated circular economy from a niche academic construct to a multifaceted research field capable of generating both theoretical advancements and practical insights.

The acceleration of CE research is closely tied to global policy movements and international agendas that emphasize sustainable development. The United Nations' Sustainable Development Goals (SDGs), particularly SDG 12 on responsible consumption and production, have legitimized circular strategies as essential pathways for achieving environmental stewardship and economic resilience [6], [7]. Similarly, regional and national policy frameworks, such as the European Union's Circular Economy Action Plan, have further stimulated research by creating institutional expectations and funding mechanisms that encourage interdisciplinary inquiry [8]. As a result, research output in the circular economy has not only increased in volume but also in strategic relevance to decision-making

processes, signaling a convergence between academic exploration and policy imperatives.

Bibliometric studies have emerged as a valuable method for evaluating the growth, structure, and impact of scholarly fields, enabling researchers to systematically map trends, identify knowledge clusters, and assess international collaboration patterns [9]. In the context of circular economy research, bibliometric analysis offers an empirical lens through which to quantify evolution across years, reveal influential publications and authors, and discern thematic shifts over time. By analyzing citation networks, co-authorship patterns, and keyword co-occurrence, bibliometric tools provide insight into the intellectual architecture of CE research—insights that cannot be fully captured through traditional literature reviews (van Eck & Waltman, 2014). Consequently, bibliometric studies serve both as reflective assessments of academic maturity and as diagnostic instruments that guide future inquiry.

Despite the evident proliferation of circular economy scholarship, there remains a lack of comprehensive synthesis that spans an extended period and captures global trends. Many existing reviews focus on specific sectors, geographic regions, or conceptual frameworks, limiting their ability to portray the field's broader patterns and trajectories. Furthermore, as the research landscape evolves, new strands of inquiry—such as digital technologies in circular systems, circular business models, and socio-technical transitions—have emerged, suggesting the dynamic nature of CE research. A bibliometric assessment covering the period from 2010 to 2024 therefore becomes crucial for understanding not only historical developments but also emerging frontiers that define the next generation of circular economy scholarship.

Despite recognition of the circular economy's growing academic prominence, there is no unified, longitudinal analysis that comprehensively maps the evolution of CE research over the past 15 years. Existing bibliometric studies are often constrained by limited timeframes, regional datasets, or narrow disciplinary boundaries, which hinder

a holistic understanding of how research themes, global participation, and scholarly influence have unfolded internationally. This gap in longitudinal analysis creates uncertainty about the field's structural development, the interconnectedness of research actors, and the trajectory of foundational concepts. Without this macro-level perspective, stakeholders—including academics, policymakers, and industry leaders—lack evidence-based guidance on research priorities, collaborative opportunities, and strategic investments in advancing circular economy knowledge. The objective of this study is to provide a comprehensive bibliometric analysis of international publications on the circular economy from 2010 to 2024, in order to trace the field's evolution, identify key research themes, highlight influential authors and institutions, and reveal patterns of collaboration across countries and disciplines.

2. METHOD

This study employed a quantitative bibliometric research design to systematically analyze the evolution of circular economy (CE) scholarship published between 2010 and 2024. Bibliometric analysis is widely recognized as a robust methodological approach for mapping scientific knowledge structures, identifying research trends, and evaluating academic performance through publication and citation patterns [9]. The study focused exclusively on peer-reviewed international publications to ensure academic rigor and global representation. The time span

from 2010 to 2024 was selected to capture the period during which circular economy research transitioned from emerging discourse to a consolidated interdisciplinary field. This longitudinal scope enables the identification of developmental phases, shifts in thematic emphasis, and changes in collaborative structures over time.

Data were retrieved from Scopus. The search query used the keyword "circular economy" within titles, abstracts, and author keywords to ensure relevance and consistency. Inclusion criteria limited the dataset to journal articles and review papers published in English to maintain comparability and quality control. After data extraction, bibliographic information—including authors, affiliations, countries, publication years, keywords, abstracts, and citation counts—was exported in compatible formats for further analysis. A data cleaning process was conducted to remove duplicates, unify author and institutional names, and standardize keyword variations, thereby improving the reliability of network and trend analyses. The bibliometric analysis was conducted using VOSviewer to perform descriptive and network analyses [10]. The analytical procedures included science mapping techniques to examine co-authorship networks, co-citation relationships, and keyword co-occurrence patterns. Additionally, temporal analysis was applied to detect emerging topics and evolving research fronts across different sub-periods within the 2010–2024 timeframe.

3. RESULTS AND DISCUSSION

Co-Authorship Analysis

Figure 1. Author Visualization
Source: Data Analysis

Figure 1 illustrates the collaboration structure among researchers in circular economy studies between 2010 and 2024. The map reveals several distinct clusters representing groups of authors who frequently collaborate within the same research networks. The yellow cluster, centered around Osman, Ahmed I., appears to function as a key bridging node that connects multiple research groups, indicating that this author plays an important role in linking different collaboration communities within the field. From this central cluster, collaborative ties extend to other groups such as the green cluster involving Aghbashlo, Mortaza and Elsayed, Mahdy, the red cluster consisting of authors like Geng, Yong, Zhang, Lei, and Zeng, Xianlai, and the purple cluster including Chen, Lin and Wang, Yuzhong. In addition, a separate blue cluster features collaborations between Kurniawan, Tonni Agustiono, Zhang, Dongdong, and Othman, Mohd Hafiz Darfzan, indicating regional or thematic collaboration networks.

Keyword Co-Occurrence Analysis

Figure 2. Network Visualization
Source: Data Analysis

Figure 2 illustrates the thematic structure of circular economy research from 2010 to 2024. The visualization shows that "circular economy" is the most central and dominant keyword, strongly connected with related concepts such as sustainability, waste management, and recycling. The large size of the circular economy node indicates its high frequency in the literature, while the numerous links connecting it to other keywords demonstrate that the concept functions as the core framework integrating various sustainability-oriented research topics. This confirms that circular economy studies have evolved into a multidisciplinary field linking environmental management, industrial systems, and sustainable development. The red cluster represents research themes closely associated with sustainability and policy-oriented aspects of the circular economy. Keywords such as sustainability, life cycle, life cycle analysis, supply chains, manufacturing, green economy, and climate change indicate that many studies focus on evaluating the environmental impacts of production systems and developing sustainable industrial practices. This cluster also highlights the role of circular economy principles in addressing global environmental challenges, particularly through sustainable supply chains, renewable energy transitions, and climate mitigation strategies.

The green cluster reflects research related to environmental technologies and biological or chemical treatment processes for waste recovery and resource utilization. Keywords such as bioremediation, anaerobic digestion, wastewater treatment, biomass, valorization, and adsorption suggest that many studies explore technological innovations aimed at converting waste into valuable resources. These topics emphasize the technical dimension of circular economy research, particularly in environmental engineering and industrial biotechnology, where waste streams are transformed into energy, materials, or chemical products. The blue cluster focuses primarily on material recycling and polymer-related studies. Keywords including plastic recycling, plastic waste, polymer, elastomers, plastic, and tensile strength indicate strong research attention toward recycling technologies and material recovery, especially in the context of plastic waste management. This cluster reflects the growing concern about plastic pollution and highlights the importance of advanced material recycling technologies in implementing circular economy principles within manufacturing and industrial processes. The yellow cluster, which includes keywords such as recycling, waste management, and environmental sustainability, acts as a connecting theme between the technological and sustainability-oriented clusters. This suggests that waste management and recycling systems serve as the operational foundation of circular economy practices.
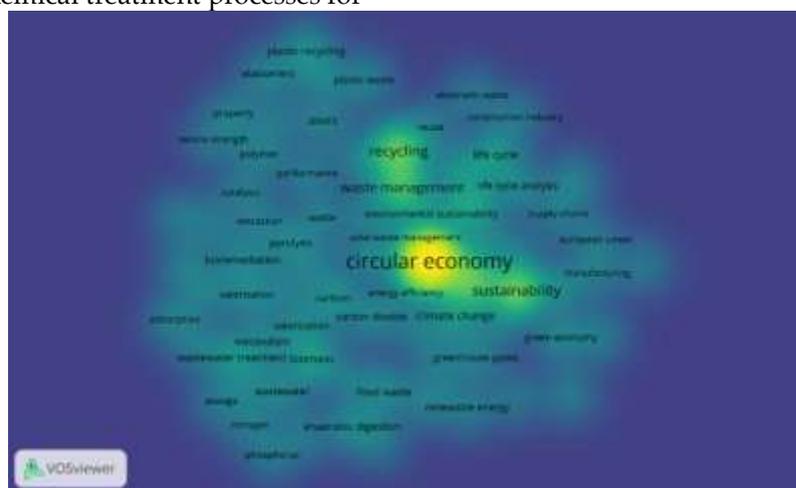

Figure 3. Density Visualization
Source: Data Analysis

Figure 3 illustrates the intensity of keyword occurrences in circular economy research between 2010 and 2024. The brightest area, shown in yellow around "circular economy," indicates that this concept is the most frequently studied and serves as the central focus of the research field. Closely surrounding this core term are related high-density keywords such as "sustainability," "waste management," and "recycling," suggesting that much of the academic literature emphasizes the relationship between circular economic practices and sustainable resource management. These keywords form the conceptual backbone of circular economy studies, highlighting how researchers focus on strategies that promote efficient resource use, reduce waste generation, and support sustainable development goals.

Beyond the central cluster, the density gradually decreases toward areas associated with more specialized topics such as plastic recycling, wastewater treatment, anaerobic digestion, renewable energy, bioremediation, and life cycle analysis. Although these topics appear with lower density, they represent important technological and sector-specific applications of circular economy principles. Their presence indicates that the research field is expanding into diverse areas such as environmental engineering, waste valorization, industrial processes, and climate mitigation strategies.

Citation Analysis

Table 1. Top Cited Literature

Citations	Authors and Year	Title
6,281	[11]	The Circular Economy – A new sustainability paradigm?
6,025	[4]	Conceptualizing the circular economy: An analysis of 114 definitions
4,883	[12]	A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems
3,028	[13]	Product design and business model strategies for a circular economy
2,901	[14]	Circular Economy: The Concept and its Limitations
2,417	[15]	The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context
2,154	[16]	Towards circular economy implementation: A comprehensive review in context of manufacturing industry
2,007	[17]	The circular economy
1,692	[18]	An engineered PET depolymerase to break down and recycle plastic bottles
1,672	[19]	Bioplastics for a circular economy

Source: Scopus

Discussion

The findings of this bibliometric analysis reveal a significant and continuous growth in circular economy research between 2010 and 2024. The increasing number of publications reflects the rising global attention toward sustainable development and resource efficiency. The concept of the circular economy has emerged as a critical framework for addressing environmental challenges associated with the traditional linear economic model. Governments, international organizations, and industries increasingly promote circular economy principles as strategies for reducing waste generation, improving resource productivity, and achieving climate mitigation targets. The rapid expansion of publications identified in this study suggests that the circular economy has evolved from a conceptual sustainability approach into a major interdisciplinary research domain that integrates

environmental science, industrial ecology, engineering, and business management.

The co-authorship analysis also demonstrates that circular economy research is supported by strong international collaboration networks. Several influential scholars act as bridges connecting different research clusters, indicating the presence of collaborative knowledge communities within the field. Such collaboration is essential because circular economy research often requires interdisciplinary expertise, including environmental engineering, material science, policy analysis, and industrial management. The presence of distinct clusters of researchers also suggests the development of specialized research groups focusing on particular themes such as waste valorization technologies, sustainable supply chains, or policy frameworks. This collaborative structure contributes to the diffusion of knowledge and accelerates the development of innovative solutions for implementing circular economy practices.

The keyword co-occurrence analysis further highlights the thematic structure of circular economy research. The dominance of keywords such as circular economy, sustainability, waste management, and recycling indicates that these topics form the core intellectual foundation of the field. These findings confirm that waste reduction and resource recovery remain central objectives of circular economy strategies. Many studies emphasize the importance of recycling systems, sustainable waste management practices, and life cycle assessment approaches to evaluate environmental impacts and resource efficiency. The close relationship between circular economy and sustainability also indicates that researchers frequently frame circular economy practices as tools for achieving broader sustainability goals, including climate change mitigation, greenhouse gas reduction, and responsible consumption and production.

In addition to sustainability-oriented themes, the analysis also reveals a strong presence of technological and engineering-related topics. Keywords such as anaerobic digestion, wastewater treatment, biomass utilization, and bioremediation illustrate the technological approaches used to transform waste streams into valuable resources. These findings highlight the role of environmental technologies in operationalizing circular economy principles. Technological innovation enables the recovery of materials and energy from waste while reducing environmental pollution. This technological dimension demonstrates that circular economy research is not only conceptual but also strongly oriented toward practical solutions for resource management and environmental protection.

Another important thematic area identified in this study is related to material recycling and industrial processes, particularly in the context of plastics and polymer materials. The presence of keywords such as plastic recycling, plastic waste, polymer, and tensile strength suggests that material science and recycling technologies represent an important research direction within circular economy studies. The growing focus on plastic waste management reflects increasing global concern about environmental pollution caused by single-use plastics. Researchers are therefore exploring advanced recycling technologies, material redesign, and circular production systems that allow plastics and other materials to remain within the economic cycle for longer periods. The density visualization analysis further confirms that circular economy research is strongly concentrated around several core concepts while also expanding into diverse specialized areas. The highest density appears around circular economy, sustainability, and waste management, indicating that these topics dominate the literature. However, surrounding areas include emerging topics such as renewable energy, climate change mitigation, and resource valorization. This pattern suggests that the field is evolving toward a broader sustainability transition framework that connects circular economy practices with energy systems, climate policies, and sustainable industrial development.

From a broader perspective, the results of this study highlight the

interdisciplinary nature of circular economy research. The integration of sustainability science, environmental engineering, industrial ecology, and business management reflects the complexity of implementing circular economy systems in real-world contexts. Addressing circular economy challenges requires collaboration between policymakers, industries, and academic institutions to develop both technological innovations and effective regulatory frameworks. Therefore, future research should focus not only on technological solutions but also on governance mechanisms, economic incentives, and behavioral changes that support circular production and consumption systems. Despite the rapid development of circular economy research, several research gaps remain. For example, there is still limited attention to social and economic dimensions of circular economy implementation, particularly in developing countries. Many studies focus primarily on technological and environmental aspects, while issues related to policy implementation, business model transformation, and consumer behavior remain underexplored. Future research could therefore examine how circular economy principles can be effectively integrated into regional development strategies, industrial ecosystems, and sustainable entrepreneurship models.

4. CONCLUSION

This bibliometric study highlights the evolution and growing importance of circular economy research in international publications between 2010 and 2024. The results demonstrate a significant increase in scholarly output, reflecting the rising global attention toward sustainable resource management and environmental sustainability. The analysis reveals that the concept of the circular economy is strongly interconnected with key themes such as sustainability, waste management, recycling, and life cycle assessment, indicating that these topics form the core intellectual structure of the field. Furthermore, the collaboration network shows that circular economy research is supported by international research communities and interdisciplinary partnerships that contribute to knowledge development and innovation. Overall, the findings confirm that circular economy research has become an increasingly dynamic and multidisciplinary field, with expanding applications in environmental technologies, industrial processes, and sustainability strategies, suggesting that future research will continue to play an important role in supporting the global transition toward more sustainable and resource-efficient economic systems.

REFERENCES

[1]   F. Alfazzi, "the Analysis of Challenges and Prospects Faced By Entrepreneurs To Ensure Sustainable Growth of Small and Medium Enterprises," *Acad. Rev.*, vol. 1, no. 58, pp. 175–186, 2023, doi: 10.32342/2074-5354-2023-1-58-13.

[2]   D. Viruega Sevilla, A. Francisco López, and P. M. Bello Bugallo, "The Role of a Hazardous Waste Intermediate Management Plant in the Circularity of Products," *Sustain.*, vol. 14, no. 3, 2022, doi: 10.3390/su14031241.

[3]   P. S. Sutar, G. Kolte, S. Yamini, and K. Mathiyazhagan, "Food supply chain resilience in the digital era: a bibliometric analysis and development of conceptual framework," *J. Bus. Ind. Mark.*, vol. 39, no. 9, pp. 1863–1893, 2024, doi: 10.1108/JBIM-10-2023-0587.

[4]   J. Kirchherr, D. Reike, and M. Hekkert, "Conceptualizing the circular economy: An analysis of 114 definitions," *Resour. Conserv. Recycl.*, vol. 127, pp. 221–232, 2017.

[5]   C. de Lauwere, M.-J. Smits, M. Dijkshoorn-Dekker, A. K. Brummelhuis, and N. Polman, "Understanding Circular and Nature-Inclusive Agricultural Business Models," *Circ. Econ. Sustain.*, pp. 1–32, 2024.

[6]   A. De Chiara, "What is a circular entrepreneur? Understanding entrepreneurs' experiences in order to support the circular economy," *Int. Entrep. Manag. J.*, vol. 21, no. 1, pp. 1–35, 2025.

[7]   M. Panait, E. Hysa, L. Raimi, A. Kruja, and A. Rodriguez, "Guest editorial: Circular economy and entrepreneurship in emerging economies: Opportunities and challenges," *J. Entrep. Emerg. Econ.*, vol. 14, no. 5, pp. 673–677, 2022.

[8]   V. Veleva and G. Bodkin, "Corporate-entrepreneur collaborations to advance a circular economy," *J. Clean. Prod.*, vol. 188, pp. 20–37, 2018.

[9]   N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: An overview and guidelines," *J. Bus. Res.*, vol. 133, pp. 285–296, 2021.

[10]   N. J. Van Eck and L. Waltman, "Visualizing bibliometric networks," in *Measuring scholarly impact: Methods and practice*, Springer, 2014, pp. 285–320.

[11]   M. Geissdoerfer, P. Savaget, N. M. P. Bocken, and E. J. Hultink, "The Circular Economy–A new sustainability paradigm?," *J. Clean. Prod.*, vol. 143, pp. 757–768, 2017.

[12]   P. Ghisellini, C. Cialani, and S. Ulgiati, "A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems," *J. Clean. Prod.*, vol. 114, pp. 11–32, 2016.

[13]   N. M. P. Bocken, I. De Pauw, C. Bakker, and B. Van Der Grinten, "Product design and business model strategies for a circular economy," *J. Ind. Prod. Eng.*, vol. 33, no. 5, pp. 308–320, 2016.

[14]   J. Korhonen, A. Honkasalo, and J. Seppälä, "Circular economy: the concept and its limitations," *Ecol. Econ.*, vol. 143, pp. 37–46, 2018.

[15]   A. Murray, K. Skene, and K. Haynes, "The circular economy: an interdisciplinary exploration of the concept and application in a global context," *J. Bus. ethics*, vol. 140, pp. 369–380, 2017.

[16]   M. Lieder and A. Rashid, "Towards circular economy implementation: a comprehensive review in context of manufacturing industry," *J. Clean. Prod.*, vol. 115, pp. 36–51, 2016.

[17]   W. R. Stahel, *The circular economy: A user's guide*. Routledge, 2019.

[18]   V. Tournier *et al.*, "An engineered PET depolymerase to break down and recycle plastic bottles," *Nature*, vol. 580, no. 7802, pp. 216–219, 2020.

[19]   J.-G. Rosenboom, R. Langer, and G. Traverso, "Bioplastics for a circular economy," *Nat. Rev. Mater.*, vol. 7, no. 2, pp. 117–137, 2022.