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RESEARCH PAPER

Circular Economy and Sustainability: A Comprehensive Analysis

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Abstract

The increasing recognition of the circular economy (CE) as a sustainable business model has spurred significant research and application across various industries. This study aims to provide a comprehensive analysis of the intersection between circular economy and sustainability, analyzing the evolving trends, key challenges, and opportunities within this domain. Through a content analysis of 112 scholarly articles published between 2022 and 2024, we delve into the fundamental components of CE and sustainability, examining their interdependencies and potential synergies. Our analysis reveals that the circular economy and sustainability are deeply interconnected, both striving for a more sustainable future. The circular economy focuses on extending the lifespan of products through strategies like design for the environment, eco-innovation, sharing economy, product lifecycle extension, recycling, upcycling, and bioeconomy. Sustainability, on the other hand, seeks a balance between environmental, social, and economic factors. Both concepts share common goals of resource efficiency, reduced pollution, social equity, and innovation. By working together, they can create a more resilient and equitable world, minimizing waste, conserving resources, and ensuring a healthier planet for future generations.

Keywords:
Circular Economy, Sustainability, Sustainable Business Models, Waste Reduction, Resource Efficiency

Introduction

Circular economy (CE) is defined as an important way to protect the environment and resources to achieve sustainable development; it can transform a traditional linear growing economy which depends on resource consumption into an economy that relies on the development of ecological resources circulation (Tiscini et al., 2022). circular economy can help countries use new, environmentally friendly technologies to minimize the use of virgin materials, design for recovery and use low-carbon materials. In this way, pollution can be significantly reduced (Hailemariam & Erdiaw-Kwasie, 2023). The circular economy (CE) aims to reduce processing by-product underutilization, increase reuse, and reduce pressure on natural resources and systems (Cooney et al., 2023). CE has attracted increasing research interest in the last few years. At the same time, environmental issues have progressively influenced business strategies, bringing new concerns and pressures to the design of sustainable business models (Triguero et al., 2022). The circular economy is gaining interest as a pathway to sustainable development

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among scholars, experts, and policymakers. The increased use of the CE construct started in recent years from the cradle-to-cradle movement in response to the lack of resources (Scarpellini, 2022). A circular economy is an economic model that associates production and consumption samples with sustainable development beliefs, improves resource efficiency and advances public well-being (Tapaninaho & Heikkinen, 2022).

Changing from a linear economy to a CE raises the need to measure the social impacts (Scarpellini, 2022). Changes in companies' organizational and business models become necessary to incorporate sustainability into business. It became necessary to overcome traditional design by implementing a sustainable design by forming and optimizing new business models to evolve into a circular economy (Tiscini et al., 2022). Due to the implementation of CE and its relationship with sustainability, it is investigated in many articles as an issue. The application of CE towards sustainability and vice versa has been studied in different organizations and companies; also, many papers have presented various models and frameworks for this issue. Therefore, a Comprehensive Analysis must provide a general view of sustainability and circular economy implementations. This can discover circular economy and sustainability models, identify which countries mostly investigate CE in their economy, manufacturing, and production, and guide the researchers in making the right choice and reaching the best result by applying sustainability in the scope of the circular economy. Different reviews have been provided for both titles based on the popularity of the circular economy and sustainability in the circular economy. Still, it needs to be investigated as a Comprehensive Analysis. In addition, this study is significant for classifying countries, journals, and models used in the field of circular economy (Bocklet et al., 2024).

In this paper, the area of interest in this emerging topic, the distribution of papers by journals and databases and the geographic distribution of papers are discovered. Furthermore, by analyzing the content of selected articles, findings are verified, and a conceptual framework is developed to guide further investigation into this topic. Sustainability and its application in circular economy has been studied as a literature in some papers, but this title is less investigated for 2020 to 2024 published papers. This study presented a Comprehensive Analysis of sustainability and circular economy in 2020 to 2024 papers and organized them based on journals and countries. The urgency of addressing the environmental, economic, and social difficulties created by the old linear economy drives the study into the circular economy (CE) and its promise for sustainability. With increased worries about resource depletion, environmental degradation, and climate change, it is becoming more clear that the linear 'take-make-dispose' paradigm is unsustainable. By investigating CE practices, this study hopes to discover how transitioning to a system that stresses resource efficiency, waste reduction, and the continuing use of materials might provide feasible answers to these critical concerns. Furthermore, understanding the mechanics and advantages of CE may help governments, companies, and communities build more sustainable and resilient economic systems. This study aims to add to the existing body of knowledge by integrating current results, identifying best practices, and emphasizing CE's potential to promote a sustainable future.

The rest of the paper is organized as follows: a background or literature review is presented in the next section for more investigation of keywords. Methods and descriptive analysis are performed in section three. A review of findings and models is displayed in section four. Finally, the conclusion is presented in the last section.

Background and Literature Review

New dimensions of product diversification and material use emerge through the industrial revolution. After World War II, the global economy accelerated, and waste management became increasingly problematic and important to regulate (Reike et al., 2018). These attempts have

lately been placed under the popular concept of circular economy (CE), which implies that any actor in an economic system should adjust its behaviour from linear to circular thinking (Nikolaou et al., 2021). Incorporating social and historical analyses into CE perspectives allows people to appreciate the broader politico-economic and cultural contexts of the CE. In researchers' view, this is an urgent task, given the many claims made in its name today (Corvellec et al., 2020).

In another part, the Report defines sustainable development (SD) as development that meets the current generation's needs without compromising future generations' ability to meet their own needs (Mensah, 2019). sustainability concerns promote the indefinite existence of human systems. In order to achieve that, a balance is required between the carrying capacity of the ecosystem and the human economic and social systems (Chang et al., 2017). Sustainable development or sustainability and its integration with the circular economy have emerged as a prominent topic due to their crucial relevance for researchers. In this section, additional details have been identified in the titles below to enhance understanding of CE and sustainability.

Circular Economy

The circular economy (CE) fundamentally differs from the traditional linear economy, which follows a 'take-make-dispose' model, leading to excessive waste and resource depletion. At its core, CE is an economic system aimed at eliminating waste and the continual use of resources, creating a closed-loop system where resource input, waste, emissions, and energy leakage are minimized. This concept is underpinned by several key principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems. By extending the lifecycle of products through design innovations that facilitate reuse, remanufacturing, and recycling, CE addresses environmental sustainability and offers economic and social benefits by fostering new business opportunities and reducing dependency on finite resources (Dantas et al., 2021).

To provide a structured understanding, several models and frameworks have been developed to guide the implementation of CE. The Ellen MacArthur Foundation Model emphasizes the importance of designing out waste, keeping products and materials in use, and regenerating natural systems. It advocates for systemic changes in product design, supply chain management, and consumer behaviour to support circularity. Another influential framework is the Cradle to Cradle (C2C) model proposed by McDonough and Braungart, which suggests designing products in a way that materials can be fully reclaimed or reused, either by returning to the biosphere or being used in high-quality, industrial processes. The Performance Economy model, introduced by Walter Stahel, shifts focus from selling products to providing services, thereby encouraging businesses to maintain the ownership of products and extend their lifespan through maintenance, upgrades, and reuse (Padilla-Rivera et al., 2020).

Regarding practical strategies, the CE encourages many approaches that companies and policymakers can adopt to transition from a linear to a circular model. Design for longevity and reusability involves creating durable, easy-to-repair, and upgradable products, reducing the need for frequent replacements. Resource efficiency and waste reduction focus on optimizing the use of materials and energy throughout the production process and implementing recycling and upcycling initiatives to manage waste. Innovating business models to embrace circularity includes leasing, sharing platforms, and product-as-a-service, which decouple economic growth from resource consumption. Effective policy and regulation are crucial to support CE practices, with governments implementing measures such as extended producer responsibility (EPR), tax incentives for sustainable practices, and stricter waste management regulations to drive the shift towards a circular economy. These comprehensive strategies underscore the multifaceted nature of CE and highlight the importance of a collaborative approach involving multiple stakeholders to achieve sustainable outcomes (Padilla-Rivera et al., 2020).

Corvallis, Stowell and Johansson (2021) examine the critiques of the circular economy and circular business models in a study. The argument is made that the circular economy is driven by an ideological agenda focused on technical and economic aspects, potentially leading to uncertain sustainability contributions and depoliticizing sustainable growth. By synthesizing these critiques, the paper challenges the notion that the circular economy is as promising as proponents suggest, suggesting that it is theoretically, practically, and ideologically questionable. The circular economy (CE) concept is characterized by various definitions and understandings that need coherence and consistency. the circular economy is often described as a combination of reduce, reuse and recycle activities, but there needs to be more emphasis on the need for a systemic shift. Additionally, the definitions frequently prioritize economic prosperity and environmental quality, with limited mention of social equity and future generations. The linkages between the circular economy concept and sustainable development should be explicitly articulated in many definitions. The circular economy concept is characterized by varying interpretations and a need for more consistency in defining its key components and objectives (Kirchherr et al., 2017). circular economy is described as a popular and influential idea promoted by the European Union, various national governments, and businesses worldwide. the circular economy revolves around the idea of extracting resources from nature, maximizing their value through multiple uses, and minimizing waste and emissions to create a more sustainable economic model (Korhonen et al., 2018).

The circular economy is an economic system representing a paradigm shift in how human society interacts with nature. It aims to prevent resource depletion, close energy and material loops, and facilitate sustainable development by recirculating resources and energy, minimizing resource demand, and recovering value from waste. The concept of CE includes four main components: 1) recirculation of resources and energy, minimization of resource demand, and recovery of value from waste, 2) a multi-level approach, 3) importance as a path to achieve sustainable development, and 4) its close relationship with societal innovation (Prieto-Sandoval et al., 2018). Critical enabling conditions must be identified and implemented to ensure the transition towards a successful circular economy. the success of the circular economy concept can be achieved through a combination of legislative support, innovative business models, company adaptation, consideration of economic growth implications, and continued research to inform decision-making and implementation strategies. By addressing these factors and conditions, the circular economy has the potential to thrive and contribute to a more sustainable and resource-efficient economic system (Geisendorf & Pietrulla, 2018). factors such as effective management, alignment of urban services with circular economy principles, cleaner production practices, urban-rural symbiosis, technological innovation, inclusive politics, and knowledge-sharing platforms can significantly impact the successful implementation of circular economy concepts in future cities. Addressing these factors can help cities transition towards a more sustainable and resource-efficient urban development model (Joensuu et al., 2020).

Transitioning to a circular economy maintains resource value, reduces waste, and promotes sustainability through 3Rs (reduce, reuse, recycle). This approach, endorsed by various sectors, aims for renewable energy and zero waste by enhancing resource efficiency and minimizing pollution. Embracing green chemistry principles and clean material cycles is crucial for environmental health. Collaboration between governments and private sectors is key to achieving Sustainable Development Goals (SDGs) and advancing circular economy principles (Khajuria et al., 2022). The inclusion of municipal waste generation significantly reduces TFP. This analysis aids EU stakeholders in waste management by highlighting effective waste reduction methods. Sustainability and CE benefit from SWM advancements (sustainable waste management). Linear programming methods estimate TFP and its components. These results can assist policymakers in improving production technology and SWM. The shift from a linear to a circular model is crucial for international politics. The interplay between CE and

sustainability offers policy alternatives (Halkos & Aslanidis, 2023). The conventional methods of recycling, including mechanical recycling and incineration, have been complemented by emerging technologies such as chemical recycling, photocatalysis, and electrocatalysis. These novel approaches offer the potential to transform plastic waste into valuable chemicals, fuels, and materials, contributing to a circular economy (Shi et al., 2024). co-constructing knowledge for political decision-making, developing the industry, creating local CE ecosystems and refining the business model. A CE is a relatively new way of organizing production and consumption and requires courage to rethink societal structures. Therefore, the CE was understood in close cooperation with stakeholders, especially industry and development organizations. CE operations can contribute to sustainability by creating multidimensional value with and for stakeholders and recognizing sustainability as a value in stakeholder relationships. If the business successfully creates local CE ecosystems, the value could be created for the case company, partners, customers, municipal stakeholders and sustainability (Tapaninaho & Heikkinen, 2022).

The circular economy permits the development of the circular supply chain and is responsible for environmentally friendly practices. Awareness of the circular economy has also seen a rising trend in the industry. However, given the significant changes in our natural habitat and ecosystems, stakeholders and government bodies should expand their operations to include circular economy-based concepts targeting the proper infrastructure, services, logistics, procurement, distribution and training skills. the circular economy-based reverse logistics model proposed by the product return and recovery protocol positively and significantly affects the company's financial performance and significantly mediates the relationship between sustainable resource commitment and its financial performance (Fernando et al., 2022). CE practices have resulted in better financial and ecological performance. More specifically, the strongest correlation between CE practices and performance is financial performance, followed by ecological performance. Further, the results indicate that the correlation between CE practice and performance is moderated by several factors (economic country, industry type, and firm size). CE practices have a stronger

positive impact on company commercial performance than noncommercial performance, because of the nature of CE practices (Yin et al., 2023).

Moreover, it is demonstrated that there is a significant relationship between innovation indicators and circular materials usage rates in most cases. The EU countries showed variations in the analyzed areas. Netherlands and Belgium excelled, while Denmark led in innovation. Romania has ranked low with declining indicators since 2010. Finland and Luxembourg saw a drop in material use. A link was found between material use and innovation. Romania, Portugal, Croatia, and Cyprus fared poorly. Policies that stimulate innovation will be essential for the transition to a CE, and their impact on the efficiency and competitiveness of European industries is expected to grow (Skare et al., 2024). The traceability of the production waste is essential, and it can be achieved through collaborations among manufacturers, buyers, government, consumers, and practitioners to ensure optimum utilization for achieving sustainability through a circular economy. the circular economy-led conceptual model will provide the factory management and relevant stakeholders with more comprehensive information to identify key strategies for managing materials waste and natural resources and to find scope for potential applications in different sectors, including agriculture, automobile, buildings, and incinerations, and to gain strategic advantages (Akter et al., 2022). The measurement of the level of circularity and the subsequent presentation of the results can be beneficial for the image of organizations, not only because it implies they present a strategy based on transparency towards society at large but also because it allows them to stand out as innovative companies committed to a more circular economy (Ibáñez-Forés et al., 2022).

Overall, the circular economy represents a paradigm shift towards a more sustainable and

regenerative economic model that aims to maximize resource efficiency, minimize waste, and promote innovation in production and consumption practices. By adopting circular economy principles, organizations can work towards achieving a more balanced and resilient economic system that considers environmental, social, and economic factors holistically (Khan & Haleem, 2021). The circular economy (grow-make-use-restore) aims to influence material and energy flows to increase environmental gains and avoid costs (Barros et al., 2020), and minimization of packaging, waste minimization, and sustainability collaboration activities can be attempted by decision-makers (Gedam et al., 2021; Lin, 2013).

Sustainable Development and Sustainability

Sustainable development and sustainability are integral to the concept of a CE, as both aim to balance economic growth, environmental protection, and social equity. Sustainable development, defined by the Brundtland Commission as meeting the needs of the present without compromising the ability of future generations to meet their own needs, aligns closely with CE principles. By promoting the efficient use of resources, reducing waste, and encouraging the reuse and recycling of materials, CE directly contributes to environmental sustainability. This includes reducing greenhouse gas emissions, conserving natural resources, and mitigating pollution, essential for maintaining ecological balance. Economic sustainability is supported by creating new business opportunities, cost savings from resource efficiency and the potential for innovation in product design and services. Social sustainability is enhanced by generating employment in new sectors, improving quality of life through healthier environments, and fostering community resilience. Thus, the CE not only aims to sustain economic activities by making them more efficient and less wasteful but also ensures that they support long-term environmental health and social well-being, embodying the holistic approach to sustainable development (Panchal et al., 2021).

Sustainability value is created by addressing societal-level aims, such as mitigating climate change and establishing a circular economy. It encompasses environmental, social, and economic factors, emphasizing holistic values tied to sustainability goals like carbon neutrality and socioeconomic well-being. National stakeholders, including the ministry and research organizations, prioritize sustainability value (Tapaninaho & Heikkinen, 2022). Adopting the circular economy that represents a new direction to create value and prosperity by elongating product lifespan and moving the waste from the end of the supply chain to the outset is very important (Jagaba et al., 2022). Sustainability can be understood as an idealized concept that represents the relationship between nature and society within specific reference systems. The meaning of sustainability is revealed through the reference made by statements to environmental, social, and economic purposes, goals, values, or objectives that human actions aim to achieve. Sustainability is characterized by aligning human actions with these purposes and goals, reflecting a teleological meaning of the concept. Sustainability is a concept that encompasses environmental, social, and economic goals and values, guiding human actions towards achieving a more sustainable and balanced relationship between nature and society. It involves a teleological perspective emphasizing the importance of working towards specific purposes and goals to create a more sustainable future for current and future generations (Salas-Zapata & Ortiz-Muñoz, 2019). Social, environmental, and financial dimensions are all part of a broader and integrated notion of sustainability, and their co-existence implies tensions and challenges that need to be addressed and managed in an attempt actually to implement sustainability. the concept of sustainability is broadly acknowledged as being multidimensional, its various dimensions have brought to light different discourses over time and have often been treated separately (Giovannoni & Fabietti, 2013).

Sustainability is described as a valuable overarching principle for global ecological ideals, particularly in the context of leaving a living planet for future generations. Particularly in the

context of changing environmental conditions and socio-ecological dynamics. Adapting to these challenges may require rethinking traditional approaches to sustainability and adopting more flexible and adaptive governance strategies to address the complexities of managing natural resources in a rapidly changing world (Benson & Craig, 2014). While the goal of the circular economy is to transition from a linear pattern of production and consumption to a circular system that maximizes the societal value of products, materials, and resources, it is essential to measure the sustainability impacts of these strategies against their linear counterparts to avoid unintended externalities. ensuring that circular strategies maximize social, economic, and environmental performance over time while avoiding unintended externalities. It requires a critical review of methods and the selection of appropriate quantitative approaches to assess the sustainability impacts of transitioning to a circular economy (Walzberg et al., 2021).

Smart technologies have a certain impact on environmental sustainability in the supply chain, improving CE efforts. To minimize the impacts of future disruptions, supply chain players can employ several strategies, including regionalization of the supply chain, diversification of the supply network, and acceleration of the use of smart technologies and CE practices to improve supply chain resilience and sustainability through visibility, connectivity, precision, and control in real-time. The digitalization and circular economy principles can help to develop agility and collaboration, localization, diversification, visibility and transparency (Cherrafi et al., 2022). Both industry and academia must collaborate to create a digital-savvy workforce that benefits sustainable businesses. Organizations can use technology for decision-making, gaining trust and sustainability. Managers should strategize to adapt to digitalization by training employees and improving structure. Government support is crucial for financial aid and policy formulation, favouring sustainability and CE principles. Strategic orientation is critical for adopting CE principles (Dwivedi & Paul, 2022).

The discussion delves into the evolving understanding of sustainability and the criteria a definition or conceptual model of sustainability should meet. These criteria include accounting for the complexity of socio-ecological systems (SESs), addressing intergenerational and intragenerational equity, and recognizing the hierarchical organization of nature. The analysis highlights that SESs can only be described as trending towards sustainability or unsustainability due to their inherent variability and uncertainty. It emphasizes the importance of applying sustainability concepts within specific geographic contexts rather than in abstract terms (Ruggerio, 2021).

Applying social LCA (life cycle assessment) to sustainability and circular economy focuses on the impact of sustainable practices on stakeholders. Exploring waste conversion into reusable resources through stakeholder collaboration and logistic chains is crucial. Comparative studies on sustainability can inform a normative framework. Developing circular business models and promoting stakeholder collaboration are key. Strategies like prefabrication, material selection, and waste management can enhance sustainability (Centobelli et al., 2023). The concepts of sustainable production and consumption, along with the integration of new technologies, should comprehensively support multiple dimensions of sustainability. This includes the development of SBMs, sustainable supply chains, sustainable circular production systems, and product design, among other aspects (Skare et al., 2024).

Circular Economy and Sustainability

Economically, the CE contributes to sustainability by fostering innovation, creating new business opportunities, and enhancing resource efficiency. Companies can benefit from cost savings through more efficient use of materials while opening new markets for refurbished or remanufactured goods. The shift towards service-based models, such as leasing and product-as-a-service, decouples economic growth from resource consumption, allowing for continued

prosperity without the corresponding environmental degradation. Moreover, the CE can enhance supply chain resilience by reducing dependency on scarce resources and mitigating the risks associated with volatile raw material markets. Social sustainability is also a critical component of the CE. The CE can generate employment opportunities and support community development by promoting local production and repair industries. It encourages a culture of sharing and collaboration, leading to stronger social ties and a greater sense of community. Additionally, by reducing pollution and conserving natural resources, the CE contributes to healthier living environments, improving the quality of life for current and future generations. Thus, the CE aligns with sustainability principles and operationalizes them through practical strategies and innovative business models that promote long-term environmental health, economic viability, and social well-being.

There are lots of papers that study circular economy and its connection with sustainability. As mentioned above, the impact of CE practices on corporate performance is significant and positive. CE practices have a stronger positive impact on company commercial performance, and companies will receive progressive commercial outcomes from their circular supply chain efforts (Yin et al., 2023). The concepts of sustainable production and consumption, along with the integration of new technologies, should comprehensively support multiple dimensions of sustainability. Therefore, it is crucial to understand the approaches to the most critical dimensions of sustainable production and consumption and examine the influence of innovative and technological potential on them. CE policies in individual countries play a significant role and are a key component of climate policies (Skare et al., 2024). Sustainability reports may play an important role as a supporting tool in the transition of organizations towards more circular economy models since their content can help to measure, monitor and communicate the organizations' transition and to establish goals in the short/medium term (Ibáñez-Forés et al., 2022).

Circular economy and sustainability have been examined in various industries and perspectives. For instance, many studies combine sustainability and its application in circular economy in the era of Industry 4.0 (Bai et al., 2022; de Mattos Nascimento et al., 2024; Hallioui et al., 2022; Kumar et al., 2024; Kurniawan et al., 2022; Liu et al., 2023; Lu et al., 2024; Patyal et al., 2022; Piscicelli, 2023; Schoeggl et al., 2023; Tang et al., 2022; Viles et al., 2022; Xin et al., 2022). The implementation of digital technologies (DTs) in companies to facilitate the transition to a circular economy is studied. While there is a consensus on the potential benefits of DTs in enabling circular economy practices, empirical insights on how these technologies are utilized across industries are limited. IoT technology is the most widely implemented, followed by big data analytics, AI, and blockchain. However, using these technologies in sustainability management is still in its early stages, with many applications being in pilot phases (Schoeggl et al., 2023). The principles governing Sustainable Production in Circular Economy and Industry 4.0 are refined. Through a Delphi Panel with experts, ten principles were identified, emphasizing the importance of prioritizing employees' well-being, enhancing management commitment to sustainability, measuring and optimizing sustainable processes, and boosting the use of sustainable technologies and the interdependence of these principles and their role in establishing an ideal context for Sustainable Production are highlighted. Additionally, positively contributing to the community can help promote value-chain stakeholder collaboration, a relationship not previously explored in the literature. Overall, the proposed principles provide clarity for researchers and offer strategies for manufacturing companies to transition towards more sustainable production practices (Viles et al., 2022).

To shift from linear to circular economy, sustainable perspectives were applied, for instance, on sustainable plastic treatment chemical upcycling, encompassing processes like pyrolysis and catalytic conversion, showing promise in breaking down plastics into monomers or higher-value products. Using renewable energy sources, photocatalysis and electrocatalysis offer new

pathways for plastic degradation and upcycling. While these technologies show potential, challenges such as low product selectivity, conversion efficiency, and scalability must be addressed through further research and development. Overall, these novel approaches hold promise in aligning with the principles of a circular economy by transforming plastic waste into valuable resources (Shi et al., 2024). The social sustainability of the circular economy is studied to explore the feasibility and methods of measuring in Finland at national and sub-national levels using secondary data. The complexity of connecting CE development to social outcomes and the need for tailored indicators and citizen surveys were highlighted to capture socio-cultural changes and social impacts effectively. The importance of developing statistical classifications for economic sectors to track better the CE transition and the necessity for customized data collection methods to monitor public awareness, behaviour, and experiences related to the CE are identified (Pitkänen et al., 2023).

The rapid changes driven by population growth, migration, economic development, and climate change are reshaping urban infrastructure systems worldwide. Globalization and urbanization are leading to environmental impacts and increasing the demand for resources to sustain growth. These activities contribute to various environmental issues such as greenhouse gas emissions, urban heat island effect, ecosystem degradation, waste disposal, water pollution, stormwater runoff pollution, and competition for land use and resources. To account for urban sustainability transitions under the impact of climate change. Understanding the complex feedback systems and integrating the food, energy, water, and waste sectors within an urban food, energy, water, and waste nexus is essential for addressing the challenges posed by global changes and ensuring sustainable urban development (Valencia et al., 2022). The environmental impact of plastic pollution and the challenges associated with recycling in the EU are emphasized, where only 32.5% of plastic waste is currently recycled. Transitioning to a circular economy model can help prevent the generation of post-consumer plastic waste (Chawla et al., 2022).

To calculate the circularity index in an industrial cluster ecosystem as a metric for assessing sustainable Environmental, Social, and Governance (ESG) performance, an algorithm involves estimating the integral circularity index and circular gap of the industrial cluster ecosystem by analyzing four key projections: waste and emissions, consumption efficiency, resource efficiency, and investments in environmental protection (Babkin et al., 2023). The transition from a linear production model to a circular economy model in manufacturing can promote sustainability. While many companies embrace sustainable practices, the current linear production model must be more environmentally sustainable. The circular economy model offers an eco-friendly alternative that can benefit manufacturers financially and environmentally. An eco-efficiency indicator can propose to target the reduction of energy consumption and manufacturing waste, in addition to considering life cycle assessment and cost analysis. This indicator combines environmental performance, value performance, and cost of implementation metrics to assess the feasibility of adopting circular economy strategies (Nikolakis et al., 2024).

Circular economy and sustainability are two popular subjects for researchers. Several papers have studied various combinations of circular economy with other objects. In this study, these papers are organized by year, geographic region, and other significant information.

Methodology

To conduct a comprehensive analysis of the intersection between circular economy (CE) and sustainability, a systematic literature review was employed. This methodology involved four key steps, as shown in Figure 1:

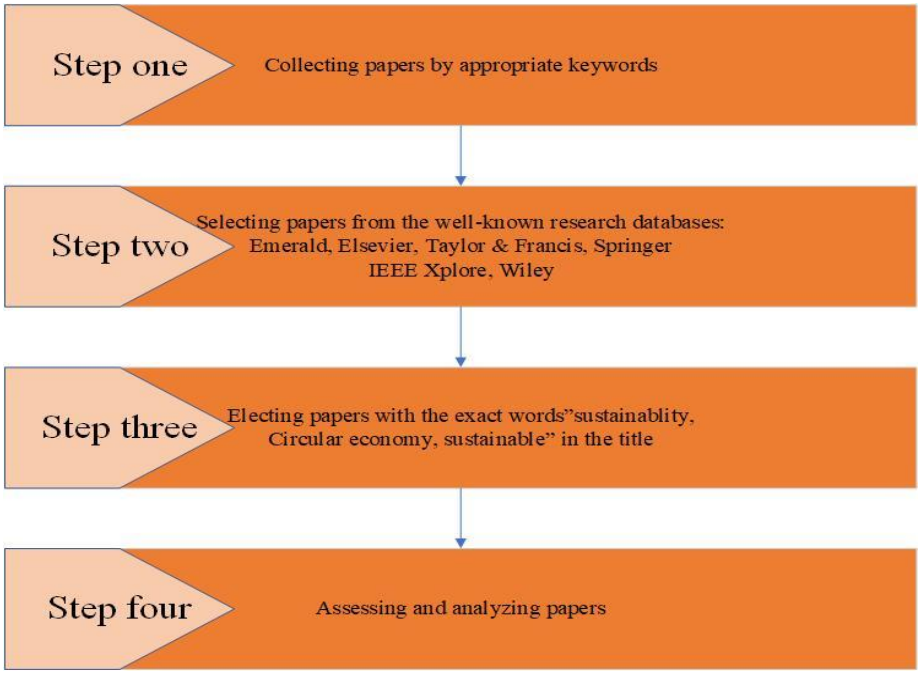

Figure 1. Research framework

Literature Search: A comprehensive search was conducted across multiple academic databases, including Google Scholar, JSTOR, ScienceDirect, and Web of Science. Keywords such as "circular economy," "sustainability," "resource efficiency," "waste reduction," "recycling," and "business models" were used to identify relevant articles.

Article Selection: The initial search yielded over 500 publications. To ensure relevance and quality, inclusion criteria were applied to select articles that directly addressed CE concepts, frameworks, and implementation methodologies. Duplicates, non-English articles, and papers that did not meet the inclusion criteria were excluded.

Data Extraction: Key information was extracted from the selected articles, including the research question, methodology, findings, and implications. This data was organized into a structured format to facilitate analysis.

Thematic Analysis: A thematic analysis was conducted to identify emerging trends, key challenges, and opportunities in the field of CE and sustainability. The analysis focused on the following research questions:

- Which countries are actively researching the intersection of CE and sustainability?
- What are the common case studies and applications of CE principles?
- What are the key themes and topics that are frequently explored in the literature?
- Finally, what are the most important future research areas in this field?

Results

One hundred twelve scholarly articles published between 2022 and 2024 were systematically reviewed to explore the intersection of the circular economy (CE) and sustainability. These papers were sourced from reputable academic databases and analyzed to identify key trends, challenges, and opportunities in the field.

Temporal Analysis

To understand the evolution of research on CE and sustainability over time, the papers were categorized by year of publication. As illustrated in Figure 2, a significant number of papers were published in 2022, followed by a slight decrease in 2023. While the number of publications declined further in 2024, there is still a strong foundation of research in this area.

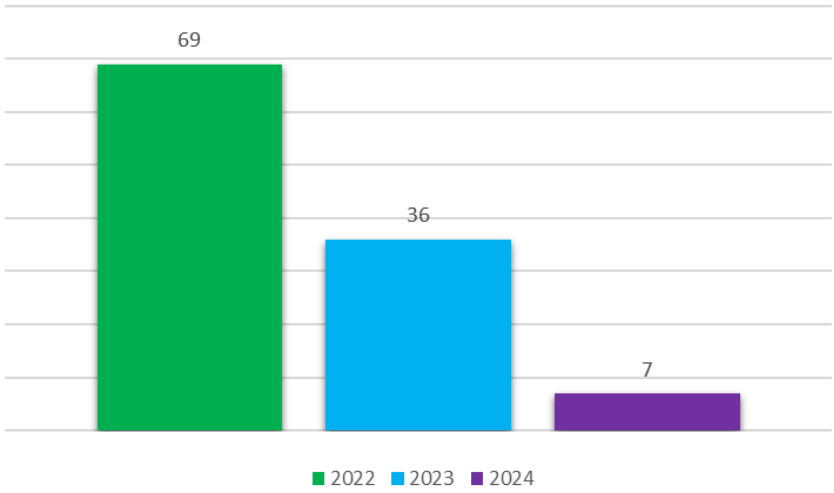

Figure 2. Annual chart

Geographical Analysis

Figure 3 provides a geographical overview of the countries where the reviewed papers originated. The analysis reveals a diverse range of countries actively engaged in CE and sustainability research. This global interest underscores the universal relevance of the circular economy and its potential to address pressing environmental and social challenges.

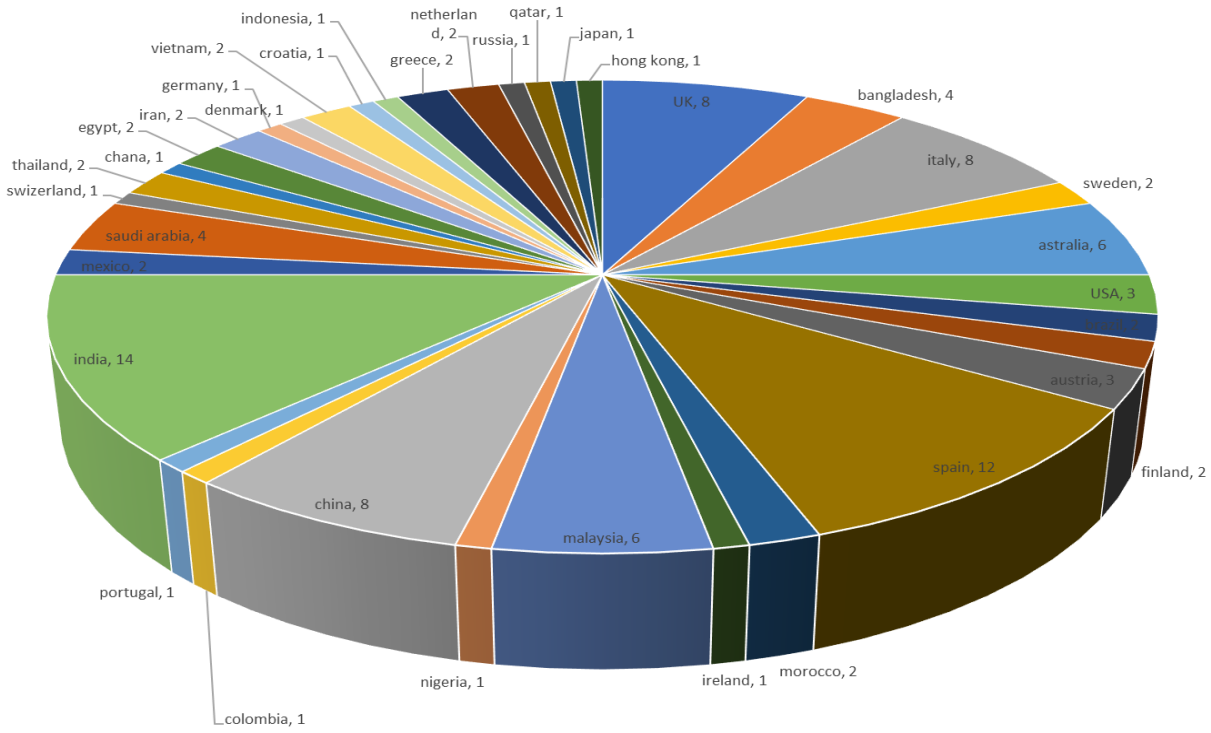

Figure 3. Geographical division

India emerged as a leading country in CE and sustainability research, with 14 papers contributing significantly to the field. This strong focus from India highlights its growing interest in sustainable development practices and the potential of the circular economy to address environmental and economic challenges.

Thematic Analysis

To delve deeper into the specific areas of research, a thematic analysis was conducted. The findings indicate that CE and sustainability are being explored in various contexts, including:

- Industrial Applications: CE principles are being applied to manufacturing, construction, and other industries to improve resource efficiency, reduce waste, and minimize environmental impact.
- Supply Chain Management: The integration of CE concepts into supply chain management can enhance sustainability, reduce costs, and improve risk management.
- Policy and Regulation: Governments and policymakers are increasingly recognizing the importance of CE and are developing policies and regulations to promote its adoption.
- Consumer Behavior: Understanding consumer attitudes and behaviors towards sustainable consumption is crucial for driving the transition to a circular economy.

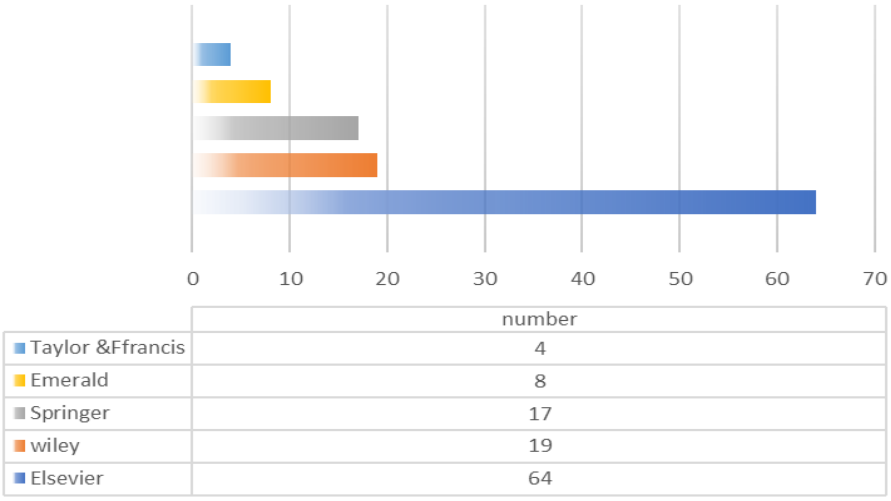

Figure 4. The number of documents based on the database

Journal Analysis

Elsevier journals were the most prominent publication venue for research on CE and sustainability, as illustrated in Figure 4. This suggests that Elsevier journals are recognized as leading platforms for disseminating knowledge and fostering discussions in this field. However, it is important to note that a diverse range of journals contributes to the body of knowledge on CE and sustainability. While Elsevier journals play a significant role, other journals, albeit with fewer publications, also offer valuable insights and perspectives.

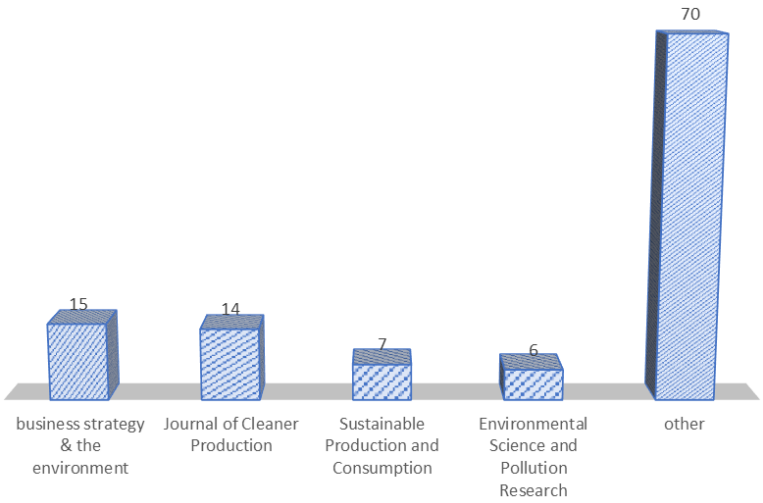

Figure 5. Number of documents based on journals

Statistical Analysis and Case Studies

Statistical analysis provides a quantitative approach to assessing the implementation of CE principles across different countries and industries. By examining key performance indicators,

such as waste generation, recycling rates, and material efficiency, researchers can identify trends, patterns, and areas for improvement.

For instance, Fura et al. (2020) employed descriptive statistics to evaluate the implementation of CE in EU member states. Their analysis revealed significant disparities between countries, with Nordic and Western European countries leading the way in terms of CE indicators. In contrast, Eastern European countries lagged behind, indicating a need for increased efforts to adopt circular economy practices.

Economic studies have also highlighted the potential benefits of CE. Rodriguez-Anton et al. (2019) estimated that a full-scale implementation of CE in Europe could generate substantial economic benefits, create jobs, and reduce greenhouse gas emissions.

Furthermore, the analysis of waste generation and management practices provides valuable insights into the challenges and opportunities for CE. Countries like Denmark and Estonia have historically been top producers of waste per capita. However, recent trends suggest a shift towards more sustainable waste management practices, as evidenced by the increasing adoption of recycling and waste reduction initiatives.

Case studies offer concrete examples of how CE principles can be applied in specific industries and regions. For example, Ibáñez-Forés et al. (2022) proposed a framework for measuring circularity levels based on corporate sustainability reports. By analyzing the information disclosed in these reports, organizations can identify opportunities to improve their circularity performance.

Another relevant case study focuses on the petroleum industry. Jagaba, Kutty et al. (2022) highlighted the potential of CE to address the environmental and economic challenges associated with petroleum industry sludge (PIS). By developing innovative treatment and recycling technologies, it is possible to recover valuable resources from PIS and minimize its negative impact on the environment.

The combination of statistical analysis and case studies provides a comprehensive understanding of the current state of CE implementation and its potential to drive sustainable development. By identifying best practices, addressing challenges, and promoting policy and regulatory frameworks that support CE, we can accelerate the transition to a more circular economy. The circular economy (CE) has gained significant traction in various industries, with a particular focus on sectors that generate substantial waste and environmental impact.

The plastic and electrical industries have been at the forefront of CE implementation. Researchers such as Kamal et al. (2022), Ofori & Opoku Mensah (2022), and Mirzaei & Shokouhyar (2023) have explored CE strategies for the electrical industry, including recycling, reuse, and energy recovery. Similarly, Chawla et al. (2022), Samitthiwetcharong et al. (2023), and Silva & Pålsson (2022) have investigated CE principles in the plastic and packaging industry, focusing on reducing waste, improving material efficiency, and promoting sustainable manufacturing practices.

The food and energy sectors are also increasingly adopting CE principles to address sustainability challenges. In the food industry, CE can help reduce food waste, optimize supply chains, and minimize environmental impact. Industry 4.0 technologies, such as AI and IoT, play a crucial role in enabling these improvements. For instance, Kumar et al. (2024) highlight the importance of AI in enhancing traceability, tracking, and quality monitoring in food supply chains.

The energy sector is undergoing a significant transformation driven by the need for clean and sustainable energy sources. AI-powered policy frameworks can help shape a more circular energy system by optimizing energy consumption, promoting renewable energy adoption, and facilitating the transition to a low-carbon economy. Danish & Senjyu (2023) propose an AI-driven policy framework to address energy policy transformation and align it with CE principles.

The construction industry, a major contributor to waste generation, can benefit significantly from CE practices. By adopting circular design principles, reusing materials, and promoting sustainable construction methods, the industry can reduce its environmental footprint. Ogunmakinde et al. (2022) emphasize the importance of aligning CE with the UN Sustainable Development Goals (SDGs) to address waste management challenges in the construction sector.

The fashion industry, known for its linear business model, is also exploring CE strategies to reduce waste and promote sustainability. D'Adamo, Lupi et al. (2022) highlight the potential of the second-hand market to facilitate a circular fashion economy. Additionally, Santolin et al. (2023) identify key enablers for SMEs to adopt CE practices post-pandemic, including digital technologies, green consumption, and circular entrepreneurship.

The circular economy offers a promising approach to addressing global environmental and social challenges. By applying CE principles across various industries, we can reduce waste, conserve resources, and create a more sustainable future, as can be seen from Table 1. Future research should continue to explore innovative CE solutions, assess their impact, and promote their adoption on a larger scale.

Table 1. Case studies in papers

No.	Reference	Strengths	Method	Industry under review	Findings
1	(Ibáñez-Forés et al., 2022)	Application of proposal of circularity indicators	Measure the level of circularity	foresty and paper sector	74% of the indicators can be measured using corporate sustainability reports
2	(Jagaba et al., 2022)	PIS treatment methods	A review	petroleum industry	CE can help the petroleum industry achieve self-cycle operation
3	(Kamal et al., 2022)	Using hypotheses testing	Confirmatory factor analysis	electrical and electronic equipment (SME)	specific type of return information and message framing positively affect Immediate Return Intention.
4	(Mendoza et al., 2022)	Analysis, classification and characterization of CBMs	circular business models	wind industry	general findings focus on renewable and low-carbon energy sectors
5	(Rodríguez-Espíndola et al., 2022)	Using the Goodness-of-fit of the SEM model	hypotheses testing	Mexican SMEs	highlighting the value of CE to mediate the relationship between technology implementation and sustainable-oriented innovation
6	(Silva & Pålsson, 2022)	Investigating the potential of sustainable supply chain and CE	A review	packaging industry	structuring the complexity and importance of strategically driven decisions in industrial packaging and their implications.
7	(Taghipour et al., 2022)	Using a management sustainability structure	using questionnaire-based surveys	steel recycling company	Understanding how this policy affects customer perceptions to continue advocating for the positive impact of policymaking on governments, industries, and customers
8	(Kumar et al., 2024)	the most prominent barriers to the adoption of I4.0 in SFSC were identified	using Rough-DEMATEL technique	food supply chain	identifying the most prominent barriers for adoption of I4.0 in SFSC

No.	Reference	Strengths	Method	Industry under review	Findings
9	(Ofori & Opoku Mensah, 2022)	study recommends that producers of electronic equipment must reconsider their role in sustainable waste management	used a quantitative approach	electronic	influencing perceived behavioural control, producer responsibility and facilitating conditions by sustainable waste management
10	(Singh et al., 2022)	the conversion of waste into biochar and its application in different regions have been discussed	-	Biochar	It highlights how biochar can be produced from different wastes and can be used in agriculture, wastewater treatment, anaerobic digestion and various other sectors, thereby proving its multidimensional role towards the protection of the environment and successfully building up a circular economy-based environmental management model
11	(D'Adamo et al., 2022)	simultaneously meet consumer and industry expectations in the management of second-hand garments within the value chain	review	fashion industry	The results emphasize that harvesting management and internal competition on low-cost collection are critical business drivers
12	(Shehata et al., 2022)	discussing the role of the Refused derived fuel in the achievement of the United Nations Sustainable Development Goals	-	refused derived fuel	evaluating solid wastes as alternative fuels concerning their sustainability and cheapness and proposing a set of indicators to increase the RDF contribution to sustainable development goals.
13	(Ogunmakinde et al., 2022)	Providing a framework that establishes a detailed relationship between the SDGs, construction of the CE to direct future sustainable development research	-	construction industry	In construction, waste management is integral to establishing long-term innovative solutions for developing multi-sectorial measures for waste prevention, eco-design, and materials reuse.
14	(Chawla et al., 2022)	discussing the environmental effects of post-consumer plastic wastes	pyrolysis, plasma gasification, photocatalytic degradation, and production of value-added products from polymer waste	plastic	utilizing CE as a solution for plastic production and its waste

No.	Reference	Strengths	Method	Industry under review	Findings
15	(Mirzaei & Shokouhyar, 2023)	Studying sustainable supply chain practices in the mobile industry	review	mobile phone companies	environmental practices in the basic and advanced categories have the most significant attention
16	(Luthra et al., 2022)	Investigating resources melioration and the circular economy	Review	mineral, mining and extraction sector	policymakers have to adopt resource circularity for extracted resources, minerals, and mining sectors, especially for emerging economies
17	(Lahane & Kant, 2022)	Investigating the novel concept of the circular supply chain	Pythagorean fuzzy analytic hierarchy process and Pythagorean fuzzy combinative distance-based assessment	manufacturing organization	practices based on 'government', 'management', and 'economy' initiatives play a significant role in the effective CSC adoption
18	(Larsen et al., 2022)	Integrating (LCA), (LCC), (S-LCA), (LCSA)	review	built environment	for CE to succeed, a comprehensive and circular view of buildings' life cycle phases is necessary to give closer attention to the service life phase and the reuse/recycle phase of buildings.
19	(Kamar Zaman & Yaacob, 2022)	discovering the potential of vermicompost as a sustainable strategy in the circular economy	review	vermicompost	The recycling of organic wastes to produce vermicompost can benefit both the consumers and the environment
20	(Hasheminasab et al., 2022)	Combining Sustainability and Circular Economy as two critical performance criteria in the context of building industry projects	Prospective Multiple Attribute Decision-making	building industry	ensuring sustainability and environmental resiliency by two mathematical approaches(ITARA,COCOSO) in building industry
21	(Zhang et al., 2022)	covering the source's potential environmental impacts and highlighting the importance of waste management strategies to provide the latest and updated knowledge	Review	e-waste, food waste	showing different approaches being set up and followed to manage and dispose of waste products
22	(Le et al., 2022)	examining the mechanism of how circular economy practices	Smart partial least square, structural equation modelling	food value chain	revealing how sustainable supply chain management mediates the link between circular economy practices and sustainable performance

No.	Reference	Strengths	Method	Industry under review	Findings
23	(Barón Dorado et al., 2022)	Implementing environmental management systems in CE	Studying 85 Spanish manufacturing	manufacturing organization	Results show that implementing an EMS has a positive effect as the companies analyzed adopted more CE practices.
24	(Silvestri et al., 2022)	Implementing CE and sustainability in argi-food	Review	argi-food sector	an integrated approach of indicators (environmental, social, and economic) offers the best solution to ensure an easier transition to sustainability
25	(Erdiaw-Kwasie et al., 2023)	examining the effects of institutional factors, contextual factors, and strategic factors on the adoption of a circular economy	simple random sampling	service organizations	CE adoption contributes to sustainable service provision via three channels: (1) service longevity, (2) service sharing, and (3) service ownership
26	(Nikolakis et al., 2024)	sustainable strategies and eco-efficiency indicators are proposed	quantified methodology that facilitates decision-making	manufacturing of glass bottles Trailing suspension arm manufacturing use case	extending an eco-efficiency indicator, check and compare that in two industry
27	(Schoeggl et al., 2023)	digital technologies can offer a wide range of potentials for implementing a circular economy	Descriptive analysis	CEOs of Austria's manufacturing	A strong positive correlation between the implementation of digital technologies in general and their use in a sustainability management context indicates synergies and spillover effects
28	(Al Rashid & Koç, 2023)	It is a guideline and a circular economy model for additive manufacturing of recycled polymers	Review	polymer product	delivering insight into different commodity polymers and their uses, challenges in polymer recycling, polymer recycling approaches, and a circular economy model for additive manufacturing of recycled polymers.
29	(Santolin et al., 2023)	Finding CE enablers	fuzzy TOPSIS methodology	COVID19	CE enablers have the most significant potential to contribute to a more circular and sustainable development post-pandemic.
30	(Haq & Alam, 2023)	Experiment circular fashion	-	apparel industry	presenting the shortest loop of the circular economy consisting of the stages of gathering, sorting, redesigning, re-cutting, and sewing process.

No.	Reference	Strengths	Method	Industry under review	Findings
31	(Danish & Senjyu, 2023).	Developing a competitive policy framework aligned with a circular economy	-	energy policy	providing a roadmap in the energy sector
32	(Moghayedi et al., 2024)	using green methods and technologies in supportive educational buildings in South Africa	Semistructured interviews	educational buildings	multiple green methods and technologies have been installed across various buildings to enhance the monitoring and management of water and energy consumption
33	(Olabi et al., 2023)	discussing the roles of microalgae in achieving the various SDGs	review	Microalgae	founding the microalgae contributed to all the 17th SDGs, where they directly contribute to 9th of the SDGs and indirectly contribute to the rest
34	(Butt et al., 2023)	re-imagine the production and distribution of goods and services for business models	40 semistructured interviews	logistic	revealing multiple ways by which reverse logistics contributes to a circular economy: for instance, reverse logistics enables firms to develop a circular product design; the combination of reverse flow with the forward flow consolidates the high volume of products, thus mitigating waste; use of innovative tools (robots, autonomous bikes) in reverse logistics increases the used products' return rate and thereby enhancing recycling; technological advances (e.g. big data and IoT) in reverse logistics help trace the product thus reducing waste
35	(Bin Abu Sofian et al., 2024)	Investigating properties, applications, and challenges of polyhydroxyalkanoates (PHAs), polylactic acid (PLA), alginate, carrageenan, and ulvan for bioplastics production presents	Review	sustainable materials	indicating the promise of algae-based bioplastics, IoT, and machine learning in fostering a more environmentally sustainable future. By harnessing these advanced technologies, optimization of bioplastic production is possible, potentially revolutionizing the materials industry and addressing existing challenges toward achieving a sustainable circular economy.

No.	Reference	Strengths	Method	Industry under review	Findings
36	(Abbasi et al., 2024)	exploring circular economy-based integrated farming systems	detailed analysis, Qualitative data	food industry	understanding the impact of varying parameters, such as egg production and parent chicken population, on the system's behaviour, exponential growth patterns in critical components, shedding light on the system's scalability potential, the significance of integrating forward and reverse linkages in achieving sustainability and minimizing waste throughout the value chain
37	(Khaw et al., 2023)	examining the impact of firms' decision-making, crisis management, and risk-taking behaviours on their sustainability and circular economy behaviours	dual-stage structural equation modelling, multi-criteria decision-making (MCDM)	energy industry	eco-innovation behaviour has a fully mediating role. For the MCDM methods, ranking energy companies according to the circular economy can support policymakers' decisions to renew contracts with leading companies in the ranking.
38	(Shehata et al., 2023)	focusing on reporting the current membrane-based technologies	-	Membrane-based water and wastewater	Membrane-based water/wastewater treatment technologies have numerous applications in water reuse, water treatment, wastewater remediation, desalination, the food industry, biofuel, and value-added materials production. The main challenges to the wide application of such technologies at large scale are the high initial cost, the high energy requirements, and membrane fouling.
39	(Chowdhury et al., 2023)	led to the concept of a zero-waste circular economy (CE)	Analytical Network Process	textile industry	The findings suggest that efficient monitoring and control of waste recovery are the most critical steps in adopting SWMS.
40	(Nandhini et al., 2023)	providing an understanding of the technology transition to attain carbon neutrality through the production of carbon-free energies such as hydrogen and bioenergy	review	bioenergy production	An innovative prototype to resolve emission issues other than CO2 was also addressed.

Key Trends in Circular Economy and Sustainability Research

A comprehensive analysis of the reviewed literature reveals several key trends that are

driving research and innovation in the field of circular economy and sustainability (Table 2):

Digitalization and Industry: The integration of digital technologies, such as IoT, AI, and big data, is revolutionizing CE practices. These technologies enable real-time monitoring, predictive maintenance, and optimized resource utilization.

Circular Supply Chain Management: The focus on circularity extends beyond individual organizations to the entire supply chain. By optimizing material flows, reducing waste, and promoting collaboration among supply chain partners, businesses can achieve significant environmental and economic benefits.

Circular Business Models: Innovative business models, such as product-service systems, sharing economy, and circular design, are emerging to drive the transition to a circular economy. These models shift the focus from product ownership to service provision and resource optimization.

Circular Construction and Infrastructure: The construction and infrastructure sectors are increasingly adopting CE principles to minimize waste, conserve resources, and enhance building performance. This involves strategies such as material reuse, modular construction, and life cycle assessments.

Circular Agriculture and Food Systems: Sustainable agriculture and food systems are crucial for ensuring food security and environmental sustainability. CE practices, such as organic farming, precision agriculture, and food waste reduction, can contribute to a more resilient and sustainable food system.

Policy and Governance: Effective policies and regulations are essential to facilitate the transition to a circular economy. Governments and policymakers play a crucial role in creating enabling environments, providing incentives, and promoting public awareness.

Table 2. Trends categorize

No.	References	Trends
1	(Lu et al., 2024), (Khajuria et al., 2022), (Liu et al., 2023), (Patyal et al., 2022), (Xin et al., 2022), (Viles et al., 2022), (Kumar et al., 2024), (Prajapati et al., 2022), (Kurniawan et al., 2022), (Bai et al., 2022), (Tang et al., 2022), (Hallioui et al., 2022), (Piscicelli, 2023), (Schoeggl et al., 2023), (Dwivedi et al., 2023), (de Mattos Nascimento et al., 2024), (Bin Abu Sofian et al., 2024)	Digitalization and Industry 4.0
2	(Negrete-Cardoso et al., 2022), (Tanveer et al., 2022), (Ofori & Opoku Mensah, 2022), (Shehata et al., 2022), (Ogunmakinde et al., 2022), (Chawla et al., 2022), (Kamar Zaman & Yaacob, 2022), (Valencia et al., 2022), (Zhang et al., 2022), (Shi et al., 2024), (Nikolakis et al., 2024), (Al Rashid & Koç, 2023), (Halkos & Aslanidis, 2023), (Chowdhury et al., 2023), (Samitthiwetcharong et al., 2023)	Waste management
3	(Silva & Pålsson, 2022), (Sonar et al., 2022), (Mirzaei & Shokouhyar, 2023), (Sudusinghe & Seuring, 2022), (Lahane & Kant, 2022), (Le, 2022), (Le et al., 2022)	Supply chain
4	(Rodríguez-Espíndola et al., 2022), (Takacs et al., 2022), (Agyabeng-Mensah et al., 2022), (Nudurupati et al., 2022), (Santolin et al., 2023), (Siddik et al., 2023)	Small and Medium Enterprises (SMEs)
5	(Jagaba et al., 2022), (Knäble et al., 2022), (Singh et al., 2022), (Luthra et al., 2022), (Barón Dorado et al., 2022), (Kara et al., 2022), (Fatimah et al., 2023), (Mukherjee et al., 2023), (Nandhini et al., 2023)	Economic and environmental concerns
6	(Dwivedi & Paul, 2022), (Hasheminasab et al., 2022), (Silvestri et al., 2022), (Khaw et al., 2023)	Decision-making models

Conclusion

While significant progress has been made in understanding and applying circular economy concepts, challenges persist. High initial costs, technological limitations, and resistance to change hinder full circular economy implementation. Future research should focus on developing accurate measurement tools, exploring the impact of digital technologies, and assessing the socioeconomic implications of the circular economy. A multidisciplinary

approach involving policymakers, businesses, and academics is essential to overcome these challenges and promote a more sustainable future. The intersection of the circular economy (CE) and sustainability is a critical area of research and practice. This study has provided a comprehensive analysis of the key trends, challenges, and opportunities within this domain. By understanding the interdependencies between the circular economy and sustainability, we can work towards a more sustainable and resilient future. However, significant challenges remain, including the high initial costs of implementing circular economy practices, technological limitations, and resistance to change. To overcome these challenges, policymakers, businesses, and researchers must collaborate to develop innovative solutions. Based on the findings, it can be concluded that future research should focus on several key areas, including:

Developing robust measurement tools: Accurate measurement and evaluation are essential for tracking progress and identifying effective strategies.

Exploring the impact of digital technologies: Leveraging digital technologies like IoT and blockchain can enhance the efficiency and transparency of circular economy practices.

Assessing the socioeconomic implications of the circular economy: Understanding the social and economic benefits of the circular economy is crucial for gaining broader support and ensuring equitable distribution of benefits.

It is important to acknowledge the limitations of this study. The analysis was based on a specific dataset of 112 scholarly articles published between 2022 and 2024. While this dataset provides a valuable snapshot of current research, it may not fully capture the breadth and depth of the field. Additionally, the study primarily focused on theoretical and conceptual aspects of the circular economy, with limited exploration of practical implementation challenges and case studies. By addressing these challenges and capitalizing on the opportunities presented by the circular economy, we can create a more sustainable and prosperous future for generations to come.

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