Integrating Circular Economy Principles into Green Economics: A Systematic Review and Future Research Agenda

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ABSTRACT

The rapid pace of environmental degradation, the depletion of natural resources, and unsustainable production patterns have made it clear that we need a shift toward regenerative, resource-efficient economies. Even though policymakers around the world have started paying attention to this issue, the integration of Circular Economy (CE) principles into Green Economics (GE) is still fragmented and not fully developed. This study addresses that gap by systematically reviewing recent research, using Scopus AI-assisted analysis (March 2026) to uncover how CE and GE intersect, the main emerging trends, and directions for future research. By analysing peer-reviewed publications across economic, technological, and environmental dimensions, this study finds that CE integration strengthens sustainability by improving resource efficiency, turning waste into value, and fostering low-carbon innovations. Long-standing themes such as waste management and circular supply chains show that circular practices are becoming well-established, while newer trends like urban circular economies and bioeconomy models reveal how CE is expanding into cities, agriculture, and bio-based industries. Emerging intersections between CE and green finance or renewable energy supply chains are creating exciting opportunities for research at the crossroads of economics, sustainability, and technology. The study also highlights the importance of technology and policy in driving CE adoption. Tools like IoT, AI, blockchain, and Industry 4.0 technologies enable more efficient and traceable circular systems, while incentives like green taxes and subsidies encourage businesses to implement circular practices. From a theoretical standpoint, this research helps position circularity as a multidimensional concept in sustainable economic thinking. Practically, it offers actionable guidance for policymakers, businesses, and researchers to align CE strategies with the United Nations Sustainable Development Goals (SDGs). Finally, the study identifies quantitative analyses and cross-industry comparisons as promising paths for future research to better understand and implement circular approaches for sustainable growth.

Keywords: Circular Economy (CE), Green Economics (GE), Sustainable Development Goals (SDGs), Technological Innovation, Green Finance

INTRODUCTION

Sustainable globalisation has brought attention to the pressing need to reconsider conventional economic systems, which mostly adhere to linear "take-make-dispose" paradigms. These traditional methods have resulted in resource depletion, environmental deterioration, and excessive waste, endangering long-term economic stability as well as ecological balance (Thakur et al., 2025). A revolutionary framework for achieving resource efficiency, waste reduction, and regenerative growth is the Circular Economy (CE). Its

fundamental operational pillars—reduce, reuse, recycle, and renew—offer practical methods for shifting economies and industries toward sustainability (Jones et al., 2020).

By combining social welfare, environmental protection, and economic expansion, green economics (GE) enhances CE. The United Nations Sustainable Development Goals (SDGs), especially SDG 12 (responsible consumption and production) and SDG 13 (climate action), can be achieved with the help of CE and GE. CE and GE are frequently viewed as distinct paradigms despite having similar goals. While CE concentrates on operational processes at the industrial and sectoral levels, GE deals with sustainability at the macro level, including ecological value, green policies, and environmental investment. Cross-disciplinary communication is hampered by this division, especially in poor nations where green innovation and industrial transformation are still in their infancy (Loza Adaui, 2024). Applications of CE in particular industries have been investigated recently:

- Green manufacturing and industrial symbiosis (Dennison et al., 2024; Mohsin et al., 2024)
- Circular supply chains in agribusiness (Khan & Mahajan, 2025)
- Technological enablers for circularity across EU economies (Georgescu et al., 2025)

Nevertheless, most research is sector-specific and lacks a comprehensive synthesis that links GE macroeconomic theories with CE operational concepts. Additionally, the multidisciplinary connections between the two paradigms are only somewhat conceptually mapped. By performing a thorough analysis of CE integration within GE, this study fills in these gaps with the following goals:

1. Analyse the evolution and structure of the CE–GE research landscape.
2. Develop a conceptual map highlighting intersections between CE and GE.
3. Identify topic experts and influential works shaping the field.
4. Uncover emerging research themes and gaps to guide future inquiry and policy development.

This review offers a comprehensive picture of sustainable economic transformation by combining theoretical and practical insights, providing researchers, companies, and policymakers with practical advice for operationalising CE concepts within GE frameworks. This paper's remaining sections are organised as follows: The methodology is explained in Section II, the results are presented in Section III, there is debate in Section IV, future research is outlined in Section V, and implications for theory, policy, and practice are concluded in Section VI.

METHODOLOGY

The integration of Circular Economy (CE) with Green Economics (GE) is investigated in this work using a systematic literature review (SLR) technique. The fragmented and interdisciplinary nature of CE–GE research makes the SLR approach especially suitable, allowing for a thorough and organised synthesis of current information. The review adheres to the PRISMA 2020 framework to guarantee methodological rigour, transparency, and replicability. This study stresses a researcher-led synthesis that combines established techniques with critical interpretation, in contrast to merely automated evaluations.

Search Strategy and Data Source

The Scopus database, which was chosen for its broad coverage of excellent peer-reviewed literature across environmental and economic fields, was used to conduct the literature search on March 4, 2026. Studies discussing CE-GE integration in titles, abstracts, and keywords were the focus of the search.

The following search string was applied:

("circular economy" OR "closed loop" OR "resource efficiency" OR "sustainable production") AND ("green economics" OR "sustainable economics" OR "environmental economics" OR "eco-economics") AND ("integration" OR "synergy" OR "combination" OR "interconnection") AND ("sustainability" OR "renewable" OR "eco-friendly" OR "environmental") AND ("waste management" OR "recycling" OR "upcycling" OR "resource recovery")

To achieve the best possible balance between sensitivity and specificity, the search string was continually improved through pilot testing. 742 preliminary papers, including book chapters, conference proceedings, and peer-reviewed journal articles, were produced by this approach.

Inclusion and Exclusion Criteria

To ensure the quality and relevance of the review, studies were screened according to the following criteria:

Inclusion criteria:

- Peer-reviewed journal articles, conference papers, or book chapters
- Publications in English between 2000 and 2025
- Studies explicitly addressing the integration of CE and GE

Exclusion criteria:

- Studies focusing solely on CE or GE without integration
- Non-scholarly outputs (e.g., editorials, reports, notes)
- Duplicate records or studies with unclear methodology

These criteria ensured that the final dataset consisted of rigorous and directly relevant contributions to CE–GE integration.

Screening Procedure

The PRISMA protocol was followed in four stages:

1. Identification: 742 records retrieved from Scopus
2. Screening: Titles and abstracts reviewed to remove irrelevant studies
3. Eligibility: Full text articles assessed against inclusion/exclusion criteria
4. Inclusion: A final sample of 126 publications retained for analysis

The screening procedure adhered to precise standards, and cases that were unclear were reassessed prior to final inclusion in order to improve uniformity and reduce selection bias.

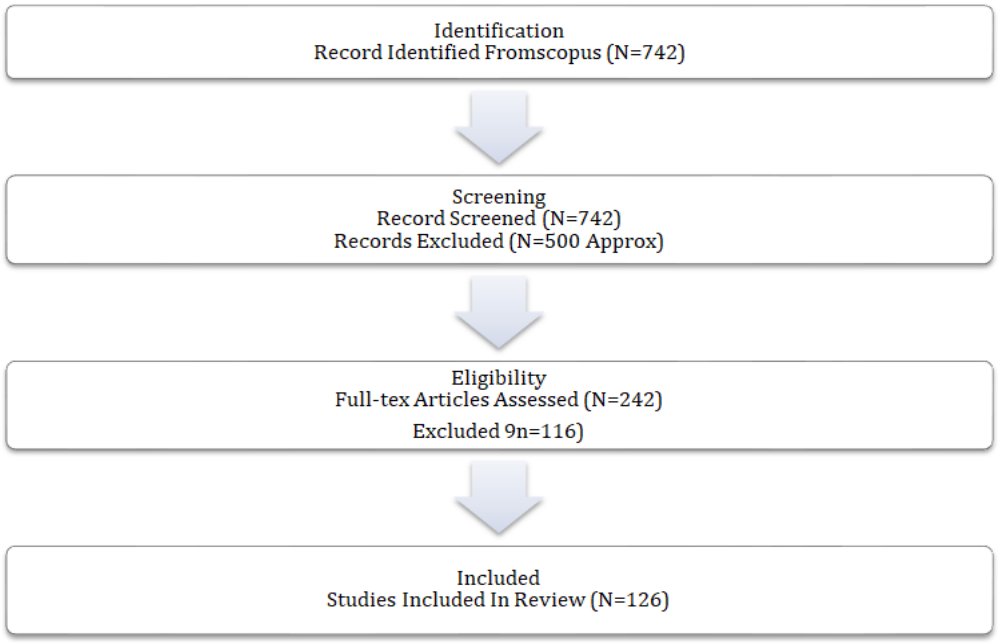

Figure 1: PRISMA Flow Diagram of Study Selection Process

Quality Assessment

Each study was subjected to a qualitative quality assessment based on the following criteria:

- Conceptual clarity and theoretical contribution
- Methodological rigor
- Relevance to CE–GE integration
- Empirical or policy significance

The overall quality of the study was evaluated using a qualitative evaluation system (low, medium, high). To ensure the robustness and credibility of the review dataset, only studies that satisfied medium to high quality levels were kept.

Analytical Approach and Role of Scopus AI

The analysis employed a combination of inductive and deductive thematic synthesis to systematically interpret the selected literature. The process involved three stages:

- Open coding: Identification of recurring concepts
- Axial coding: Establishing relationships between CE and GE dimensions
- Selective coding: Developing higher-order themes

This method found research gaps (poor empirical integration, absence of unified frameworks), divergences (operational vs. macroeconomic focus), and convergences (sustainability, low carbon transitions). Rather than being the main force behind the study, Scopus AI served as a support tool for topic visualisation and validation.

Conceptual Framework Development

Based on the thematic synthesis, a Green Circular Economy (GCE) framework was developed. The framework was constructed iteratively by integrating identified themes and aligning:

- CE operational mechanisms (e.g., recycling, resource recovery, circular production)
- GE systemic principles (e.g., ecological sustainability, policy integration, economic transformation)

This integrative approach resulted in a holistic conceptual model linking production systems, policy structures, and sustainability outcomes, thereby providing a comprehensive perspective on CE–GE integration.

RESULTS AND DISCUSSION

The examination of the chosen literature shows that a systemic and fundamental shift in how economies approach sustainability is reflected in the incorporation of Circular Economy (CE) ideas into Green Economics (GE). In order to accomplish GE goals, such as low-carbon development, sustainable production, and ecological restoration, the review shows that CE–GE integration represents a shift toward regenerative, resource-efficient economies, where CE principles reduce, reuse, recycle, renew, and regenerate (Loza Adaui, 2024).

Enablers in technology and policy are essential to this integration. While policy tools like green taxation, subsidies, and regulatory incentives promote adoption across sectors, technologies like digital twins, IoT, AI, and blockchain improve traceability, efficiency, and predictive maintenance in circular supply chains (Georgescu et al., 2025; Dennison et al., 2024). Despite these developments, obstacles still exist, such as high implementation costs, a lack of technical capability, fragmented regulations, and cultural resistance, especially in underdeveloped nations (Khan & Mahajan, 2025).

A thorough grasp of CE–GE integration and its practical ramifications is provided by the results, which are organised into major areas: conceptual mapping, topic experts, summary and extended summary, and emerging themes.

Summary and Expanded Summary

A developed, multidisciplinary research environment is shown in the incorporation of CE principles into GE. Recent studies highlight system-wide sustainability transitions, regenerative practices, and circular business models, whereas earlier research concentrated on waste management, recycling, and resource recovery (Thakur et al., 2025; Plachkov, 2024). It is becoming more widely acknowledged that GE and CE are mutually reinforcing systems. GE's ecological and economic objectives, such as low carbon development, sustainable production, and ecological restoration, are supported by CE's operating concepts of reduce, reuse, recycle, renew, and regenerate (Loza Adaui, 2024). The results show that a Green Circular Economy (GCE) paradigm has emerged, combining GE principles with CE tactics to promote environmental stewardship and economic viability (Mohsin et al., 2024; Khan & Mahajan, 2025).

Enablers in terms of technology and policy are essential to this integration. Operational circularity is facilitated by digital tools, IoT, AI, blockchain, and Industry 4.0 breakthroughs; adoption across industries is driven by green laws, taxes, and subsidies. Widespread adoption is nevertheless hampered by issues such high prices, capacity constraints, regulatory fragmentation, and cultural resistance, particularly in emerging economies (Georgescu et al., 2025; Dennison et al., 2024).

Concept Map

Based on the theme synthesis of the chosen literature, a conceptual map was created to more clearly illustrate the linkages between Green Economics (GE) and Circular Economy (CE) ideas. This map illustrates how operational tactics, technical advancements, policy tools, and sustainability goals interact within a single framework, highlighting the important aspects, mechanisms, and results of CE–GE integration. The map clearly illustrates the structural and functional linkages supporting the Green Circular Economy by grouping various components into thematic clusters, highlighting the intricacy and coherence of the integrated approach.

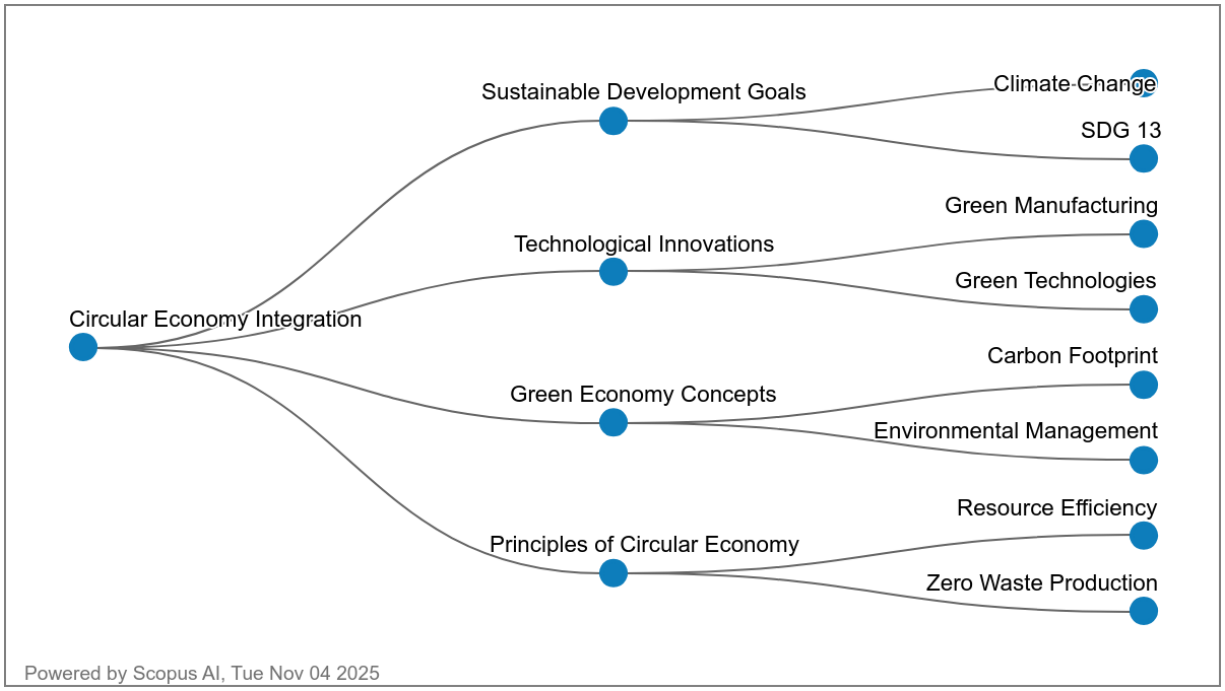

Figure 2: Conceptual Structure of Circular Economy Integration

The four thematic clusters are explained in detail as follows:

1. Sustainable Development Goals (SDGs):

The alignment of CE practices with global sustainability goals, especially climate action (SDG 13) and responsible consumption and production (SDG 12), is emphasised in this cluster. Circular supply chains, resource recovery, and trash reduction are examples of CE initiatives that directly support these objectives. CE practices support social and economic aspects of sustainability in addition to environmental stewardship by incorporating SDG-aligned concepts, which have quantifiable effects on development agendas and policy outcomes.

2. Technological Innovations:

Operational CE is made possible in large part by technology. This cluster improves the effectiveness, predictability, and transparency of circular processes by combining Industry 4.0 tools, IoT-enabled systems, AI-driven monitoring, and blockchain for traceability. These developments ensure that circular strategies are not only conceptually but practically practicable by enabling businesses and cities to undertake predictive maintenance, smart waste management, and optimised resource flows.

3. Green Economy Concepts:

The main goals of GE are low carbon transitions, resource efficiency, and ecological preservation, all of which are aided by CE integration. This cluster emphasises the systemic effects of circular practices, such as ecosystem regeneration, sustainable production, and environmental footprint reduction. This cluster illustrates how circularity upholds GE ideals, increases economic resilience, and protects natural capital by connecting operational CE techniques to macroeconomic and policy-level factors.

4. Principles of Circular Economy (CE):

This cluster emphasises the fundamental principles of CE at the operational level: resource circulation, waste minimisation, regenerative design, and the "reduce–reuse–recycle–renew" strategy. The technological, SDGs, and green economy objectives of the other clusters can be achieved through the use of these concepts. They offer an organised method for revamping supply chains, urban infrastructure, and production systems to maximise sustainability and reduce environmental impact.

Together, these clusters demonstrate that CE integration operates as a multidimensional framework bridging technological, policy, and ecological management. It provides both theoretical clarity and practical guidance for achieving regenerative, resilient, and sustainable economies, showing how CE can be systematically embedded into GE at multiple levels of implementation.

Topic Expert

The CE–GE research landscape has been significantly shaped by several influential scholars whose work bridges multiple disciplines, illustrating the complex and interdisciplinary nature of integrating circular principles into green economic frameworks. Key contributors include:

1. Nathalia N. Suchek:

Suchek's research focuses on the intersection of entrepreneurship and circular economy, highlighting how innovation networks, start-ups, and SMEs can act as catalysts for circular transformation. Her work emphasizes the importance of policy support and collaborative ecosystems, demonstrating that entrepreneurial initiatives are essential for scaling CE practices and translating theoretical concepts into operational, real-world solutions. By connecting innovation with regulatory and institutional support, Suchek provides insights into how businesses can adopt circular models while contributing to broader green economic objectives.

2. Jose Arturo Garza-Reyes:

Garza-Reyes has extensively explored the integration of CE principles with Industry 4.0 technologies. His studies examine how digital manufacturing, smart supply chains, and advanced data analytics can operationalize circular strategies within industrial contexts. He also emphasizes the role of policy frameworks in enabling low-carbon industrialization, showing that CE adoption is most effective when technological tools are paired with regulatory incentives. Garza-Reyes' work demonstrates how operational efficiency, environmental sustainability, and policy alignment can be harmonized to achieve systemic circularity.

3. Juan Manuel Maqueira:

Maqueira investigates the application of digital tools in circular supply chains and the organizational adaptations required to implement CE successfully. His research highlights the importance of capacity building, process redesign, and technology-enabled monitoring in ensuring that circular operations are integrated into existing industrial systems. By focusing on the organizational and operational dimensions, Maqueira provides a practical lens on how firms can transition from linear to circular models while maintaining economic viability and improving environmental outcomes.

Collective Contribution

Collectively, these academics highlight the interdisciplinary nature of CE-GE research, which connects technology, policy, innovation, entrepreneurship, and sustainable industrial practices. Their research shows that incorporating circular ideas into green economic frameworks necessitates both actual operational mechanisms and conceptual understanding. Their research provides a comprehensive viewpoint for academics, policymakers, and industry practitioners alike by highlighting the crucial necessity of combining organisational flexibility, supportive legislation, and technical advancements for successful CE adoption.

Emerging Themes

The review demonstrates that CE–GE integration represents a structural shift toward regenerative, resource-efficient economies. CE principles reduce, reuse, recycle, renew, and regeneration operate as mechanisms to achieve GE objectives, including low carbon development, sustainable production, and ecological restoration (Loza Adaui, 2024). The thematic analysis reveals three layers of research development: consistent, rising, and novel themes, reflecting both the maturity and the evolving frontiers of CE–GE scholarship.

Consistent Themes

Circular supply chains and waste management remain the foundational pillars of CE, representing the earliest and most extensively studied applications within green economic frameworks (Bukhari, 2024; Provenzano & Seminara, 2024). These themes focus on optimizing resource use, reducing environmental impact, and improving operational efficiency across industries. The work of scholars like Garza-Reyes connects these operational practices to Industry 4.0 technologies, showing how digital tools can track materials, improve recycling processes, and enhance transparency within supply chains. Consistent attention to these themes underscores their centrality in the CE–GE integration process, providing a strong operational backbone for broader sustainability transitions.

Rising Themes

Urban circular economy and circular bioeconomy are emerging as prominent research areas, highlighting the expansion of CE beyond traditional manufacturing contexts into cities and bio-based production systems (Eelager et al., 2025; Cervantes Puma et al., 2024). The urban circular economy focuses on creating "circular cities" where waste, energy, water, and mobility systems are efficiently managed and regenerated. Circular bioeconomy emphasizes the utilization of biological resources and renewable ecosystems to support sustainable production. Researchers like Suchek emphasize that entrepreneurial networks and policy incentives are key to realizing these rising themes, as innovation and institutional support enable scaling circular solutions in urban and bio-based contexts.

Novel Themes

Circular solar supply chains and circular economy green finance are two recently developed, multidisciplinary fields that connect circularity to financial innovation and the shift to renewable energy (Awad et al., 2025; Park & Ryosuke, 2025). These themes combine economic, technological, and environmental aspects: circular solar supply chains optimise material flows and cut waste in the solar energy industry, while green finance tools like sustainability inked bonds and circular investment funds are intended to support renewable energy projects. In order to successfully combine the operational and strategic aspects of circularity, Maqueira's work demonstrates how digital monitoring and organisational flexibility are crucial for putting these innovative ideas into practice.

Collective Insights:

Together, the consistent, rising, and novel themes illustrate that CE–GE integration is not merely conceptual but a practical, multidimensional framework. The themes map directly onto the Concept Map clusters (Figure 2):

- SDGs cluster aligns with all themes, highlighting CE's contribution to climate action, responsible consumption, and broader sustainability targets.
- Technological Innovations cluster links to consistent and novel themes, emphasizing Industry 4.0, AI, IoT, and digital tools that operationalize circular practices.
- Green Economy Concepts cluster underpins rising themes, showing how CE contributes to low-carbon transitions, urban sustainability, and bio-based economies.
- Principles of CE cluster forms the backbone of all themes, with operational strategies like waste minimization, resource circulation, and regeneration ensuring practical implementation.

By connecting these themes to both the Concept Map and key scholars' contributions, this review demonstrates that CE–GE research is dynamic, interdisciplinary, and evolving, offering a comprehensive roadmap for both academic inquiry and policy/practice applications.

CONCLUSION

The findings from this review demonstrate that the integration of Circular Economy (CE) principles into Green Economics (GE) represents more than a conceptual alignment it constitutes a structural and operational shift toward regenerative, resource efficient economies. CE principles reduce, reuse, recycle, renew, and regeneration serve as practical mechanisms to advance GE objectives, including low-carbon development, sustainable production, and ecological restoration (Loza Adaui, 2024).

The results underscore the mutually reinforcing nature of CE and GE. CE provides operational strategies for resource efficiency and circular production, while GE offers macro-level frameworks for ecological sustainability, policy integration, and economic transformation. This synergy enables a holistic approach to sustainability that spans industries, cities, and financial systems.

Technological and Policy Enablers

Industry 4.0 technologies including digital twins, IoT-enabled systems, AI, and blockchain emerge as critical enablers for circular operations, enhancing traceability, predictive maintenance, and operational efficiency. Policy instruments such as green taxation, subsidies, and regulatory frameworks further promote adoption across sectors (Georgescu et al., 2025; Dennison et al., 2024). Nevertheless, barriers remain, particularly high implementation costs, limited technical capacity, regulatory fragmentation, and cultural resistance issues that are especially significant in developing economies (Khan & Mahajan, 2025). Multi-stakeholder strategies, combining public policy, private sector engagement, and community participation, are therefore essential for inclusive CE adoption. Sector Specific Insights:

- Urban circular economy initiatives demonstrate the potential to transform cities into self-sustaining circular systems, optimizing waste, energy, water, and mobility networks.
- Industrial applications show CE's role in creating sustainable manufacturing systems, minimizing resource consumption while increasing operational efficiency.
- Bio-based and renewable energy systems highlight the relevance of circular bioeconomy and circular solar supply chains, linking CE with green finance and renewable transitions.

Emerging Research Frontiers:

The review of key scholars' contributions emphasizes the interdisciplinary nature of CE–GE research:

- Nathalia N. Suchek highlighted the importance of entrepreneurship, innovation networks, and policy support in enabling circular transitions.
- Jose Arturo Garza-Reyes explored CE integration with Industry 4.0 and sustainable supply chains, bridging operational practices and policy mechanisms.
- Juan Manuel Maqueira examined digital tools for circular supply chains and organizational adaptation, showing how technological innovations can accelerate adoption.

These contributions, alongside the emerging, rising, and consistent themes identified in the review, illustrate a dynamic research landscape where CE–GE integration is evolving from sector-specific studies to multi-level, system-wide strategies.

Conclusion

This study provides a comprehensive and systematic review of CE integration into GE, based on Scopus AI data from March 2026. The analysis combined conceptual mapping, expert contributions, and thematic

analysis to provide both theoretical clarity and practical guidance. Key insights include:

1. Evolution of CE: CE has progressed from a narrow focus on waste management to a multidimensional system embedded in economic, technological, and policy frameworks.

2. Thematic Maturity: Recurring, rising, and novel themes indicate a mature and interdisciplinary research landscape, bridging industrial, urban, bio-based, financial, and renewable energy systems.

3. Enablers and Barriers: Technological innovations and policy frameworks are critical enablers of CE–GE integration. Persistent barriers, especially for SMEs and developing economies, include costs, limited capacity, and regulatory inconsistencies.

4. Green Circular Economy Framework: The GCE framework provides a theoretical and operational roadmap, integrating ecological economics, sustainable production, and innovation systems to guide practical implementation.

5. Practical Implications: Policymakers, businesses, urban planners, and financial institutions can leverage CE–GE integration to achieve SDGs, foster green growth, and promote inclusive, regenerative economies.

Limitations and Future Research:

While this study provides comprehensive insights, it relies primarily on Scopus indexed literature and does not include quantitative bibliometric or network analysis. Future research should explore:

- Longitudinal bibliometric studies tracing CE–GE evolution over time
- Comparative sector-specific analyses to assess localization and scaling strategies
- Interdisciplinary research combining technological, financial, and behavioural perspectives to accelerate circular adoption

In conclusion, CE integration into GE represents a transformative, system-wide approach, offering both conceptual clarity and actionable pathways. By bridging operational strategies, technological innovation, and macroeconomic frameworks, CE–GE integration provides a roadmap for building resilient, regenerative, and sustainable economies capable of meeting the demands of the 21st century.

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