From Risk to Resilience in Food Security: A Review of Circular Economy Strategies in Agricultural Trade Networks

Zulkhairi Nisa., Irlisuhayu Mohd Ramli*

Faculty of Business Management, Department of Economics, Universiti Teknologi MARA Cawangan Kedah, 08400 Merbok, Kedah, Malaysia

***Corresponding Author**

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ABSTRACT

Agricultural systems worldwide face mounting challenges from resource depletion, climate variability, and rising food insecurity, necessitating innovative solutions that balance productivity with sustainability. The circular economy (CE) framework has emerged as a promising pathway to address these challenges by promoting waste reduction, resource efficiency, and sustainable value creation. However, the integration of CE principles into agricultural trade networks remains fragmented, and limited attention has been given to the role of digital technologies and nutrient management in strengthening resilience and food security. This study aims to examine the thematic landscape of CE applications in agriculture, identify consistent, rising, and novel themes, and explore their implications for theory and practice.

A systematic review method was adopted, drawing on peer-reviewed literature and bibliometric insights from Scopus to map the evolution of CE research in agriculture. The analysis revealed four thematic clusters: (i) consistent themes, including agro-industrial waste management through recycling and valorization; (ii) rising themes, particularly the integration of digital technologies such as artificial intelligence, digital twins, and advanced analytics in circular agriculture; and (iii) novel themes, including nutrient circularity in agri-food systems and sustainable approaches to agricultural waste treatment. Collectively, these themes underscore a shift from traditional waste management to more technologically advanced and ecologically embedded approaches.

The findings carry both theoretical and practical implications. Theoretically, the study extends resilience and sustainability frameworks by situating CE as a multidimensional strategy for adaptive agricultural systems. Practically, the results highlight actionable opportunities for policymakers, agri-businesses, and smallholder farmers to reduce environmental impacts, improve efficiency, and strengthen food system resilience. Ultimately, the study calls for integrative, interdisciplinary, and equity-focused research to scale CE practices, with particular attention to digital innovation and nutrient management in global agricultural trade**.**

Keywords: food security, agricultural trade, resilience, sustainability, supply chain

INTRODUCTION

Food security remains one of the most pressing global challenges of the 21st century, particularly as agricultural trade networks are increasingly disrupted by climate change, market volatility, geopolitical instability, and resource scarcity. Traditional linear models of production and trade—characterized by high resource extraction, waste generation, and vulnerability to shocks—are ill-suited to meet the long-term sustainability and resilience needs of the global food system. In this context, the circular economy (CE) has emerged as a transformative paradigm, offering strategies for waste reduction, resource efficiency, and regenerative practices that can strengthen the resilience of agri-food supply chains (Roy et al., 2025; Fatima & Ying, 2025).

Recent scholarship has begun to narrow its focus on the role of CE within agricultural trade networks as a pathway to improving both environmental sustainability and economic resilience. For instance, valorization of by-products in the olive oil supply chain has demonstrated the potential of CE to stabilize agri-food businesses against market fluctuations (Spada et al., 2025). Similarly, closed-loop resource optimization through thermochemical conversion of agricultural waste into biochar has enhanced efficiency in jujube supply chains (Darouni et al., 2025). Multi-stakeholder collaboration has also been highlighted as a critical factor, as seen in the coconut value chain in Kenya, where inclusive farmer groups facilitated greater access to information, credit, and market linkages (Muriuki et al., 2024). These studies underscore the growing recognition that CE strategies can contribute significantly to resilience in food systems.

Despite these advances, critical problems and barriers persist. Structural issues such as legal uncertainties, lack of financial incentives, and technological immaturity continue to hinder the full implementation of CE practices in agricultural trade networks (Yontar, 2025). Furthermore, gender inequalities and socio-cultural barriers restrict women's participation in CE-driven food security initiatives (Tantoh et al., 2025), while limited consumer awareness and restricted market access pose challenges for smallholder farmers (Vásquez Neyra et al., 2025). These barriers highlight a significant research gap: although CE is recognized as a promising pathway, the literature remains fragmented, lacking an integrated synthesis of how circular strategies can systematically build resilience across agricultural trade networks and contribute to global food security.

This review seeks to address this gap by analyzing the literature at the intersection of circular economy, resilience, and agricultural trade networks. Specifically, it aims to (i) map the evolution of research in this domain, (ii) construct a conceptual framework that integrates CE pathways with resilience-building mechanisms, (iii) identify emerging themes and expert perspectives, and (iv) highlight areas requiring further investigation. Through this approach, the study leverages tools such as concept mapping, topic expert identification, and emerging theme analysis to provide a holistic understanding of the research landscape.

The contribution of this paper is threefold. First, it systematically synthesizes fragmented case studies and thematic insights into a coherent framework linking CE with resilience in agri-food trade. Second, it identifies key barriers and enabling conditions for CE adoption, providing practical and policy-relevant insights for enhancing food system resilience. Third, it advances scholarly discourse on food security by integrating economic, social, and environmental dimensions of CE within agricultural trade networks.

The remainder of this paper is structured as follows. Section 2 details the methodology, including the Scopus AI-assisted bibliometric analysis. Section 3 develops a conceptual framework linking CE and resilience in trade networks. Section 4 synthesizes emerging themes and expert contributions, while Section 5 critically discusses challenges, opportunities, and policy implications. Finally, Section 6 presents the conclusion and future research agenda.

METHODOLOGY

This review employed Scopus AI, accessed on 25 September 2025, to systematically analyze the intersection of circular economy (CE), resilience, and agricultural trade networks. Scopus AI was selected because of its capacity to integrate advanced bibliometric mapping, conceptual clustering, and expert insights, which enable a more robust and multi-dimensional understanding of evolving research landscapes (Donthu et al., 2021). The methodological process involved five stages: (i) Summary generation, (ii) Expanded Summary synthesis, (iii) Concept Map development, (iv) Topic Expert identification, and (v) Emerging Theme extraction.

First, the Summary function in Scopus AI provided a concise overview of the literature retrieved with the following Boolean search string:

("circular economy" OR "sustainable economy" OR "closed loop" OR "resource efficiency") AND ("agriculture" OR "farming" OR "agribusiness" OR "food production") AND ("trade" OR "commerce" OR "exchange" OR "market") AND ("strategy" OR "approach" OR "policy" OR "framework") AND ("network" OR "system" OR "chain" OR "link"). This search yielded 523 peer-reviewed documents spanning 2010–2025, including journal articles, book chapters, and conference proceedings. The summary output highlighted a growing body of research connecting CE strategies with agricultural sustainability, global food trade dynamics, and resilience frameworks.

Second, the Expanded Summary provided a structured synthesis, emphasizing four dominant research clusters: (a) CE applications in agri-food supply chains, (b) resilience and adaptation strategies in global trade networks, (c) policy frameworks linking CE and food security, and (d) barriers such as financial, legal, and technological constraints. This step was essential in moving beyond descriptive mapping toward critical categorization of recurring concepts (Roy et al., 2025; Yontar, 2025).

Third, a Concept Map was generated to visualize interconnections across the literature. The map illustrated linkages between CE pathways (e.g., waste valorization, bio-based inputs, closed-loop farming) and resilience outcomes (e.g., diversification of trade flows, adaptive networks, and reduced systemic vulnerabilities). Importantly, it positioned agricultural trade systems as the nexus where sustainability strategies intersect with global food security (Spada et al., 2025; Li et al., 2024).

Fourth, Scopus AI identified Topic Experts, defined as authors with the highest impact in terms of publication frequency, citation networks, and thematic specialization. Among them were leading contributors to CE in agriculture (Roy et al., 2025), resilience in trade networks (Tsoulfas, 2025), and systemic barriers in food supply chains (Yontar, 2025). This validation step ensured the review engaged with authoritative voices in the field.

Finally, the Emerging Themes function highlighted frontiers in the literature, including gender-responsive CE strategies (Tantoh et al., 2025), digital innovations for resilient supply chains (Darouni et al., 2025), and insect-based circular farming models (Sokame et al., 2024). These themes demonstrated the forward trajectory of research and provided direction for addressing unresolved gaps.

Through this five-stage process, the review not only synthesized existing knowledge but also constructed a conceptual framework integrating CE strategies with resilience in agricultural trade networks. This methodological design directly supports the study's aim to analyze the research area, construct conceptual linkages, identify expert perspectives, and uncover emerging themes for advancing food security and sustainable trade systems. Figure 1 shows the Cycle of Conceptual Framework Development.

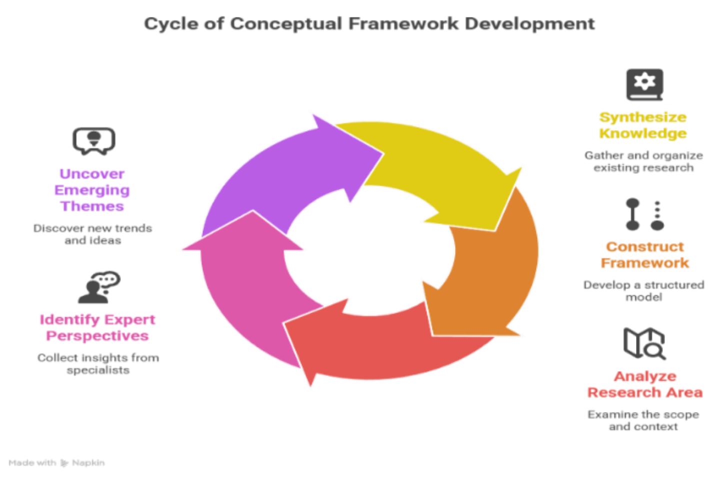

Figure 1: Cycle of Conceptual Framework Development

RESULTS AND DISCUSSIONS

The synthesis of literature retrieved through Scopus AI (25 September 2025) underscores that the integration of circular economy (CE) strategies into agricultural trade networks has gained increasing recognition as a pathway toward achieving food security and resilience. The results from the summary analysis revealed that CE practices are primarily applied in agri-food supply chains with the aim of minimizing waste, enhancing resource efficiency, and strengthening adaptive capacities against global trade disruptions. These findings align with evidence from case studies such as the olive oil and coconut value chains, where valorization of by-products and stakeholder collaboration contributed to greater economic resilience and reduced vulnerability to market fluctuations (Spada et al., 2025; Muriuki et al., 2024).

Expanded summary

The **expanded summary** further illustrated that environmental sustainability remains the most prominent domain of CE applications. By closing material loops, agriculture systems are able to reduce food loss, recycle nutrients, and generate renewable energy, thereby mitigating ecological footprints and contributing to regenerative agricultural practices (Jain & Virk, 2024; Rufí-Salís et al., 2024). Such strategies extend the lifecycle of agricultural resources, particularly in urban and peri-urban contexts, where circular agriculture supports efficient water, waste, and energy use. Importantly, food waste reduction emerged as a consistent outcome across multiple studies, confirming that CE strategies offer not only environmental but also social benefits by addressing systemic inefficiencies in food production and distribution chains (Wang et al., 2021; Facchini et al., 2023).

Concept Map

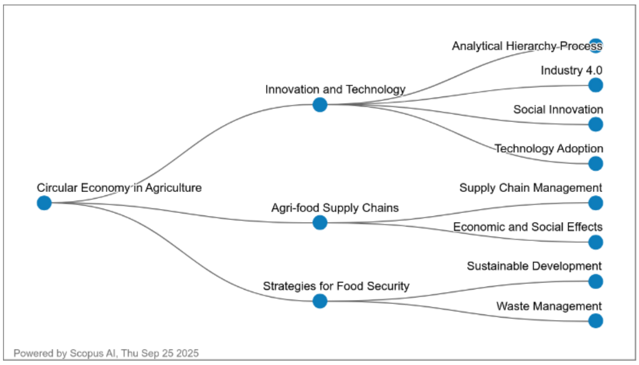

Figure 2: Concept Map of Circular Economy in Agriculture

As shown in Figure 2, three primary thematic clusters emerge: Innovation and Technology, Agri-food Supply Chains, and Strategies for Food Security. Each of these clusters highlights the diverse pathways through which circular economy (CE) principles are being operationalized within agricultural systems to strengthen resilience and sustainability.

Circular Economy in Agriculture

Circular economy in agriculture involves implementing a revolutionary approach to promote sustainability and resource efficiency, offering benefits such as waste reduction, resource conservation, and improved profitability. Key elements of this approach include a holistic framework, efficient resource use, waste management, and collaboration among stakeholders. The circular economy model aims to minimize the impact on the environment by reducing resource inflow and waste generation throughout the agricultural life cycle. However, challenges such as gender inequalities, land ownership disparities, and inadequate integration of a gender perspective in agricultural programs hinder the adoption of circular agriculture and its potential to enhance food security. The application of circular economy principles in agriculture is still in its early stages, with a growing interest in recent years, particularly from an environmental perspective. The integration of circular economy principles in agriculture is seen as a pathway towards achieving a harmonious balance between economic growth and environmental preservation.

Circular Economy in Agriculture and Innovation and Technology

The findings reveal that innovation and technology serve as the backbone of circular economy (CE) implementation in agriculture, offering pathways to achieve sustainability, resilience, and resource efficiency. CE in agriculture emphasizes the minimization of inputs and outputs across the food system by adopting innovative approaches such as precision agriculture, smart farming, and renewable energy integration (Roy et al., 2025). These innovations enhance productivity while reducing environmental degradation, ensuring that agricultural systems can respond more effectively to climate change and food security challenges. Technology thus acts as both an enabler and accelerator of CE adoption in agriculture.

Emerging technological innovations, such as Industry 4.0 tools, Internet of Things (IoT), blockchain, and artificial intelligence, are transforming agricultural trade and supply chains by enabling traceability, real-time monitoring, and efficient resource allocation (Darouni et al., 2025). For example, IoT-based soil sensors and drones can optimize water and fertilizer use, aligning with CE principles of resource efficiency and waste reduction. Blockchain-based traceability systems, in turn, enhance transparency and trust in agri-food trade, reducing losses while ensuring fair market access. Such innovations demonstrate that CE adoption is intrinsically linked to advancements in digital and technological solutions.

In addition to technological tools, innovation in business models and social practices is critical for fostering CE in agriculture. Social innovations, including collaborative platforms, farmer cooperatives, and participatory decision-making systems, enhance the integration of CE practices at local and global scales (Jayalath et al., 2025). These approaches encourage inclusive participation in agricultural innovation, ensuring that smallholder farmers, women, and marginalized groups benefit from CE-driven resource efficiency. This demonstrates that innovation in CE extends beyond technology into the social domain, reshaping governance structures and value distribution within agricultural trade networks.

Despite the potential, several barriers hinder the alignment of CE and technological innovation in agriculture. Financial constraints, lack of technical capacity, and limited infrastructure in developing countries restrict the widespread adoption of advanced technologies (Yontar, 2025). Furthermore, issues of digital inequality and uneven access to technological resources create disparities in who benefits from CE practices. Without targeted policy frameworks and capacity-building programs, technological innovations may reinforce existing inequalities instead of promoting equitable sustainability. This underscores the need for multi-level strategies that integrate technological innovation with institutional and policy support.

In summary, the relationship between CE in agriculture and innovation and technology is symbiotic and transformative. Technological advancements provide the tools necessary to operationalize CE principles, while CE frameworks create a context in which such innovations can generate social, economic, and environmental benefits. Together, they redefine agricultural production and trade systems to be more resilient, sustainable, and inclusive. However, realizing this synergy requires overcoming systemic barriers and ensuring that innovation pathways are accessible, equitable, and aligned with broader sustainability goals.

Circular Economy in Agriculture and Agri Food Supply Chain

The results of the literature review show that the circular economy (CE) plays a crucial role in reshaping the agri-food supply chain by promoting sustainability, resource efficiency, and reduced environmental impacts. CE principles encourage a shift from the traditional linear “take–make–dispose” model toward a system that prioritizes resource reuse, recycling, and regeneration (Roy et al., 2025). In agriculture, this translates into practices such as reducing food waste, converting agricultural by-products into value-added resources, and integrating renewable energy into farming systems. Such approaches strengthen agri-food supply chains by minimizing resource inputs and losses, while simultaneously enhancing food security and resilience.

Innovation in supply chain design under CE is driven by technological advancements and system-level integration. For example, digital platforms and Industry 4.0 technologies enable traceability, real-time monitoring, and predictive analytics across agri-food networks, aligning with CE objectives of transparency and efficiency (Darouni et al., 2025). By embedding CE into agri-food supply chain management, producers and distributors are able to optimize logistics, reduce inefficiencies, and cut greenhouse gas emissions. These innovations not only improve environmental outcomes but also enhance competitiveness and market access for agricultural producers.

Furthermore, CE principles in agri-food supply chains contribute to value creation by transforming waste streams into productive resources. Circular strategies, such as composting, bioenergy production, and upcycling of food waste, reduce pressure on natural resources while generating new revenue opportunities (Jayalath et al., 2025). This creates a regenerative system where waste is minimized and economic benefits are maximized, fostering long-term resilience. The integration of CE into supply chains thus strengthens the interlinkages between food production, trade, and sustainability, ensuring that agricultural outputs align with global sustainability goals.

Despite its benefits, the adoption of CE in agri-food supply chains faces challenges. Barriers include financial limitations, lack of technical expertise, and fragmented governance structures in developing economies (Yontar, 2025). Smallholder farmers, who form the backbone of many agri-food supply chains, often lack access to capital and technologies required to implement CE strategies effectively. Moreover, trade and supply chain networks are often dominated by linear models, making the transition toward CE slow and uneven. Without supportive policy frameworks, stakeholder collaboration, and targeted capacity building, the potential of CE to transform agri-food supply chains remains underutilized.

In summary, the relationship between CE and the agri-food supply chain is transformative, creating opportunities for efficiency, resilience, and sustainability. By closing resource loops and fostering collaboration across the production, distribution, and consumption stages, CE ensures that supply chains become more adaptive to environmental and economic challenges. However, systemic barriers highlight the need for integrated strategies that combine innovation, governance, and stakeholder participation to ensure the widespread adoption of CE in agri-food supply chains.

Circular Economy in Agriculture and Strategies for Food Securities

The results highlight that circular economy (CE) principles have a significant impact on shaping strategies for food security by fostering sustainability, resilience, and resource efficiency. By adopting CE practices such as reducing food loss, recycling agricultural by-products, and promoting resource-efficient farming, agricultural systems can increase productivity while minimizing environmental degradation (Mubarak et al., 2024). These strategies are critical to ensuring the long-term availability and accessibility of food, particularly in regions vulnerable to climate change and resource scarcity. CE thus provides a framework for integrating environmental stewardship into food security policies.

One of the strongest connections between CE and food security strategies is waste management and food loss reduction. Globally, approximately one-third of food is wasted, representing not only economic inefficiency but also missed opportunities to feed millions (Galanakis, 2021). CE strategies, such as valorizing food waste into compost, bioenergy, or animal feed, ensure that nutrients are reintroduced into the system, strengthening food availability and affordability. In this way, CE addresses the dual challenge of reducing waste while improving food distribution and access, thereby aligning with the key dimensions of food security: availability, access, utilization, and stability.

Additionally, CE enhances resilience in food systems by diversifying sources of production and reducing dependency on finite inputs. For example, regenerative agriculture and circular nutrient cycles reduce reliance on chemical fertilizers and promote soil health, which supports stable crop yields over time (De Boeck et al., 2023). By embedding CE principles into strategies for food security, countries can build adaptive systems that are less vulnerable to supply chain disruptions, market volatility, and environmental shocks. This resilience is particularly important in developing economies where food insecurity remains a pressing challenge.

However, the integration of CE into food security strategies also faces systemic challenges. Barriers such as inadequate infrastructure for waste recovery, lack of supportive policy frameworks, and insufficient stakeholder collaboration hinder the large-scale implementation of CE (Yontar, 2025). Moreover, socio-economic inequalities—such as unequal land access, gender disparities, and financial constraints—limit the ability of smallholder farmers to adopt CE-based practices (Mubarak et al., 2024). Addressing these challenges requires coordinated efforts across governments, private sectors, and communities to ensure that CE strategies are inclusive and equitable.

In conclusion, the relationship between CE and strategies for food security is transformative, offering a pathway toward sustainable, resilient, and inclusive food systems. By minimizing waste, optimizing resources, and promoting regenerative practices, CE provides practical solutions to global food security challenges. Yet, realizing this potential requires overcoming systemic barriers through integrated governance, innovation, and international cooperation. Embedding CE within food security strategies not only secures present needs but also safeguards the ability of future generations to access sufficient and nutritious food.

Topic Expert

The review of topic experts highlights the centrality of **closed-loop agricultural systems** in advancing circular economy (CE) strategies for food security. Magi M. Richani's work emphasizes the integration of plant and animal protein production within sustainable frameworks. This approach reflects a forward-thinking paradigm in agricultural innovation, as it redefines production models beyond the linear "take-make-dispose" cycle. By aligning with CE principles, Richani underscores the potential of resource reuse and interdependence between crop and livestock systems, thereby reducing waste and enhancing efficiency. This innovation is particularly relevant in strengthening resilience in food security, as it minimizes vulnerabilities inherent in traditional systems while fostering adaptive capacity (Richani, n.d.).

Thomas J. Stoddard offers complementary insights, drawing on extensive research in agricultural biotechnology and closed-loop system efficiency. His contributions highlight the integration of animal proteins into plant systems, which serves as a novel biotechnology pathway to enhance sustainability. By focusing on resource optimization, Stoddard demonstrates how closed-loop biotechnology can mitigate risks associated with resource scarcity, global trade disruptions, and environmental degradation. His body of work provides evidence of how CE strategies can leverage advanced biotechnology to create resilient agri-food systems, thereby ensuring more reliable food supplies under conditions of uncertainty (Stoddard, n.d.).

Meanwhile, J. Thomas Carrato extends this discussion by focusing on modern frameworks that incorporate closed-loop systems in plants expressing animal proteins. His exploration of these cutting-edge methods signals a commitment to addressing systemic inefficiencies within agricultural production. Carrato's work aligns closely with CE principles by promoting innovations that reduce external inputs while enhancing productivity. This contribution is critical for global agricultural trade networks, as it suggests pathways to harmonize productivity with sustainability, ensuring that agricultural systems can adapt to the dual pressures of climate change and market volatility (Carrato, n.d.).

Taken together, these experts illustrate that **closed-loop systems** are a unifying theme in advancing CE strategies. Richani brings attention to integrated frameworks that safeguard agricultural practices, Stoddard highlights biotechnological innovation for sustainable production, and Carrato contributes to the modernization of food systems through plant-animal protein synergies. Collectively, their work underscores how CE can be operationalized in agriculture through both biological and technological pathways. This convergence highlights that achieving resilience in food security is not solely about reducing waste but also about reimagining production systems to be regenerative and adaptive.

The findings from these topic experts reinforce the importance of innovation-driven CE strategies in shaping resilient agricultural trade networks. By embedding sustainability into production processes, these contributions demonstrate practical applications of CE that directly enhance food security. Furthermore, they reveal a broader implication: the future of resilient agriculture will rely not only on policy interventions and market diversification but also on **scientific innovation and biotechnology** as enabling mechanisms. Thus, the integration of expert perspectives affirms the necessity of multi-disciplinary collaboration in advancing CE strategies for sustainable and resilient food systems.

Emerging Themes

Consistent Theme: Circular Economy in Agro-Industrial Waste Management

A consistent theme across the literature is the application of circular economy (CE) principles in agro-industrial waste management, reflecting the field's long-standing interest in transforming agricultural by-products into value-added resources. Research shows that strategies such as the conversion of agricultural residues into biochar, compost, or bioenergy not only minimize waste but also contribute to soil fertility, carbon sequestration, and reduced greenhouse gas emissions (Darouni et al., 2025; Yontar, 2025). The continued emphasis on waste valorization highlights its established role as a cornerstone of sustainable agricultural practices. This theme underscores the importance of leveraging circular strategies to close material loops and reduce the environmental footprint of agri-food supply chains (Spada et al., 2025).

Potential hypotheses derived from this consistent theme suggest that agro-industrial waste can be effectively converted into biochar and other sustainable products, while the adoption of CE strategies in waste management could significantly reduce the carbon footprint of agricultural practices. These findings reaffirm the crucial role of waste valorization as an established dimension of CE strategies and emphasize its enduring relevance for resilience in food systems.

Rising Theme: Digital Technology in Circular Agriculture

A rising theme identified in recent studies is the integration of digital technologies into CE-based agricultural systems. Tools such as artificial intelligence (AI), blockchain, digital twins, and advanced analytics are increasingly employed to optimize resource use, reduce waste, and improve sustainability outcomes (Fatima & Ying, 2025; Tsoulfas, 2025). These innovations enable precision farming, enhance transparency in supply chains, and improve decision-making processes, thereby aligning closely with CE goals of efficiency and resilience.

The growing interest in digital agriculture marks a shift toward more technologically driven approaches to food security and sustainability. Potential hypotheses suggest that AI and digital twin applications can significantly reduce agricultural waste by optimizing resource use and improving supply chain management. Moreover, such technologies can facilitate precise and sustainable farming practices, strengthening the operationalization of CE principles within agricultural trade networks. This indicates that digital tools are not merely supportive but may become transformative drivers of future CE strategies in agriculture.

CONCLUSION

This review set out to explore the intersection of circular economy (CE), resilience, and agricultural trade networks, with the aim of mapping research developments, identifying emerging themes, and highlighting pathways for future resilience in food systems. The findings reveal that CE strategies such as waste valorization, resource efficiency, nutrient circularity, and the integration of digital technologies hold substantial potential to strengthen food security and sustainability. Consistent themes, particularly agro-industrial waste management, underscore the long-standing relevance of transforming agricultural residues into value-added products, while rising themes like digital agriculture demonstrate the sector’s increasing pivot toward technology-driven solutions. Novel directions, such as nutrient circularity and sustainable waste treatment, highlight the expanding frontiers of CE in agriculture and its capacity to redefine food production systems.

From a **theoretical perspective**, this study contributes to the literature by positioning circular economy strategies as a unifying framework that integrates environmental sustainability, economic resilience, and social inclusivity within agricultural trade systems. It advances the understanding of resilience theory by showing how CE pathways operationalize adaptive capacity, robustness, and recovery in global agri-food supply chains. Moreover, the integration of emerging technological themes broadens existing models of agricultural resilience, emphasizing the role of digital innovation in complementing traditional ecological and economic theories.

The **practical implications** of this study are equally significant. For policymakers, the findings highlight the need to design supportive regulatory environments, incentive mechanisms, and gender-responsive policies that encourage CE adoption. For practitioners and agri-food businesses, CE practices ranging from biochar production to vermicomposting and precision agriculture offer tangible opportunities to lower costs, reduce waste, and diversify income sources. For international trade networks, adopting CE principles can mitigate risks associated with supply disruptions, price volatility, and environmental shocks, thereby fostering greater stability and resilience in global food systems.

Despite these contributions, the study is not without **limitations**. First, the reliance on published literature and Scopus AI outputs may exclude gray literature and region-specific practices, potentially narrowing the scope of insights. Second, much of the available evidence remains case-based or conceptual, with limited empirical data on the long-term economic and social impacts of CE strategies in agricultural trade networks. Finally, gender dimensions and equity considerations are often underexplored in existing studies, which restricts a holistic understanding of inclusivity in CE adoption.

To address these gaps, **future research** should prioritize longitudinal and comparative studies that evaluate the scalability of CE strategies across different agricultural systems and geographies. Interdisciplinary approaches that integrate environmental science, economics, and digital technology are needed to fully capture the multidimensional impacts of CE on resilience. Moreover, future inquiries should emphasize equity by exploring how CE frameworks can better support marginalized groups, including smallholder farmers and women, in agricultural trade networks. Building stronger links between digital innovation, policy frameworks, and trade dynamics will also be crucial for advancing both theory and practice in this evolving field.

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