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# MAPPING THE GLOBAL EVOLUTION OF SUSTAINABLE AGROINDUSTRY : BIBLIOMETRIC EVIDENCE ON CIRCULAR ECONOMY, DIGITAL INNOVATION, CLIMATE RESILIENCE, AND SUSTAINABLE SUPPLY CHAINS

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**Abstract**

This study investigates the global evolution of sustainable agroindustry research through a bibliometric analysis of 982 Scopus-indexed publications from 2015–2025. The increasing urgency of climate change, food insecurity, resource scarcity, and sustainability transition has accelerated scholarly interest in circular economy practices, digital innovation, climate resilience, and sustainable supply chains within agroindustrial systems. However, previous studies remain fragmented and predominantly focus on isolated sustainability dimensions without providing an integrated intellectual mapping. Accordingly, this study addresses the research gap by developing a comprehensive bibliometric framework integrating circular economy, digital innovation, climate resilience, and sustainable supply-chain perspectives. Grounded in Sustainable Development Theory, Circular Economy Theory, Innovation Diffusion Theory, and Resilience Theory, the study employs performance analysis and science mapping techniques using Scopus Analyze Search Results and VOSviewer. The findings reveal substantial growth in publication output and citation performance, with Brazil, China, and Indonesia emerging as dominant contributors. Network, overlay, and density visualizations identify major thematic clusters related to production systems, waste valorization, innovation, policy, and sustainable governance, while recent research trends increasingly emphasize artificial intelligence, circular bioeconomy, and climate-smart agroindustry. The study concludes that sustainable agroindustry research is evolving toward integrated, technology-driven, and climate-responsive sustainability paradigms. Policy implications emphasize strengthening circular economy policies, digital agriculture investment, climate-resilient agroindustrial systems, and collaborative sustainability governance.

**Keywords: Sustainable Agroindustry; Circular Economy; Digital Innovation; Climate Resilience; Sustainable Supply Chains**

**JEL Classification: Q01; Q16; O13; O33; Q56**

## INTRODUCTION

The increasing global concern over climate change, resource scarcity, food insecurity, environmental degradation, and sustainable economic transformation has positioned sustainable agroindustry as a strategic research domain within contemporary interdisciplinary scholarship. Over the last decade, the scientific landscape of sustainable agroindustry has expanded substantially, as reflected by the 982 Scopus-indexed publications identified in this study. The bibliometric performance analysis demonstrates a sharp increase in publication intensity after 2018, indicating growing scholarly attention toward circular economy practices, digital innovation, climate resilience, and sustainable supply chain integration within agroindustrial systems. This trend reflects the global transition from conventional agricultural industrialization toward

environmentally adaptive and resource-efficient agroindustrial models capable of balancing economic productivity, ecological sustainability, and social inclusiveness. Empirical evidence from previous studies confirms that sustainable agroindustry has evolved into a multidimensional research field connecting agricultural production, waste valorization, renewable energy, bioeconomy, digital agriculture, smart farming, and resilient food systems (Klerkx et al., 2019; Béné et al., 2019; Geissdoerfer et al., 2017; Salvador et al., 2020; Morone et al., 2019; Sharma et al., 2021; Nogueira et al., 2022; Zhang et al., 2021; Agyekum et al., 2023; Yadav et al., 2023). The bibliometric mapping further reveals that dominant research clusters revolve around “production,” “product,” “waste,” “innovation,” “policy,” “supply chain,” and “agroindustry,” indicating that the scientific discourse increasingly emphasizes integrated sustainability approaches involving technological innovation, circular resource utilization, and institutional governance. Simultaneously, overlay visualization analysis demonstrates the recent emergence of themes such as artificial intelligence, circular economy, waste valorization, digital innovation, climate adaptation, and sustainable supply chain resilience, suggesting a paradigmatic shift toward data-driven and climate-responsive agroindustrial transformation.

Despite the rapid expansion of publications, the existing literature remains fragmented across disciplinary boundaries and lacks a comprehensive intellectual synthesis integrating circular economy, digital innovation, climate resilience, and sustainable supply chains into a unified sustainable agroindustry framework. Previous studies have predominantly examined these dimensions separately, focusing either on agricultural sustainability, waste management, bioenergy systems, food security, or digital agriculture without systematically explaining their interconnected evolution within the global agroindustrial ecosystem (Klerkx & Rose, 2020; Kamilaris et al., 2019; Velasco-Muñoz et al., 2021; Donthu et al., 2021). Moreover, prior bibliometric studies generally concentrate on narrow themes such as circular bioeconomy, precision agriculture, sustainable supply chains, or food waste management, thereby limiting the holistic understanding of the intellectual structure and thematic convergence shaping sustainable agroindustry research. Another important gap identified from the bibliometric network and density visualization is the limited integration between technological innovation and socio-institutional dimensions, particularly regarding governance, farmer resilience, policy adaptation, and sustainability transition in developing economies. The dominance of environmental science and engineering perspectives also indicates that social sciences, economics, and institutional sustainability dimensions remain comparatively underexplored. Furthermore, although countries such as Brazil, China, Indonesia, and the United States dominate publication productivity, significant disparities persist in collaborative research intensity, global knowledge diffusion, and contextual application of sustainable agroindustry models across regions. Consequently, there is a critical need for a comprehensive bibliometric investigation capable of mapping the global evolution, intellectual structure, thematic dynamics, and emerging research trajectories of sustainable agroindustry research.

Accordingly, this study aims to map and critically evaluate the global evolution of sustainable agroindustry research through bibliometric evidence derived from Scopus-indexed publications. Specifically, the study investigates publication growth trends, leading countries, institutions, authors, funding sponsors, dominant subject areas, and source journals while simultaneously identifying the conceptual structure and thematic evolution of the field through network, overlay, and density visualization analyses. In addressing these objectives, the study formulates several interconnected research questions: (1) how has the global scientific landscape of sustainable agroindustry evolved over time; (2) what are the dominant intellectual structures and thematic clusters shaping the field; (3) how do circular economy, digital innovation, climate resilience, and sustainable supply chains interact within sustainable agroindustry discourse; (4) what emerging themes and future research trajectories characterize recent scholarly developments; and (5) what theoretical and practical gaps remain insufficiently addressed in current literature? The principal novelty of this study lies in its integrative bibliometric framework that simultaneously synthesizes

circular economy, digital innovation, climate resilience, and sustainable supply chain dimensions into a unified sustainable agroindustry perspective. Unlike previous bibliometric reviews that focus on isolated themes, this study offers a multidimensional mapping of scientific evolution, thematic convergence, and emerging interdisciplinary relationships within sustainable agroindustry research. Additionally, the study contributes by identifying emerging research hotspots associated with artificial intelligence, waste valorization, resilient agroindustrial systems, and digital sustainability transformation, thereby providing strategic directions for future theoretical development, policy formulation, and sustainable agroindustrial governance.

## LITERATURE REVIEW AND HYPOTHESIS FORMULATION

### 1. Sustainable Agroindustry

Sustainable agroindustry refers to an integrated production and value-chain system that emphasizes economic viability, environmental sustainability, social inclusiveness, and long-term resource efficiency across agricultural and industrial activities. The concept evolved from the broader paradigm of sustainable development introduced by the World Commission on Environment and Development and subsequently expanded into agroindustrial systems through the integration of ecological modernization, circular production systems, and resilient agricultural management. Within the context of sustainable agroindustry, production processes are expected not only to maximize productivity and profitability but also to reduce environmental externalities, optimize resource utilization, minimize waste generation, and strengthen rural livelihoods.

The theoretical foundation of sustainable agroindustry is strongly associated with Sustainable Development Theory, Circular Economy Theory, and Triple Bottom Line Theory. According to Elkington (1997), sustainability in industrial systems must simultaneously balance economic, environmental, and social dimensions. In agroindustry, this balance is reflected through efficient resource management, equitable supply-chain governance, and environmentally responsible production systems. Geissdoerfer et al. (2017) further emphasized that circular economy principles provide a strategic pathway toward sustainable agroindustrial transformation through waste valorization, material recirculation, and renewable resource utilization. In addition, resilience theory explains that agroindustrial sustainability depends on the adaptive capacity of production systems in responding to climate disturbances, market volatility, and technological disruption (Folke, 2006).

Empirical studies demonstrate that sustainable agroindustry has become an increasingly important research domain over the last decade. Studies by Morone et al. (2019), Nascimento et al. (2020), and D'Amato et al. (2021) revealed that sustainable agroindustry contributes significantly to low carbon production systems and regional economic resilience. Research conducted by Salemdeeb et al. (2017), Stegmann et al. (2020), and Borrello et al. (2020) found that agroindustrial sustainability is strongly influenced by resource circularity, technological innovation, and stakeholder collaboration. Similarly, studies by Leal Filho et al. (2022), Carraresi and Banterle (2018), and Velasco-Muñoz et al. (2022) confirmed that sustainable agroindustry increasingly integrates environmental governance, renewable energy systems, and climate adaptation strategies.

The bibliometric evidence also indicates that sustainable agroindustry research has shifted from conventional productivity-oriented agriculture toward integrated sustainability frameworks involving climate resilience, circular economy, digital innovation, and sustainable supply chains. This trend is reflected in the emergence of dominant research clusters associated with "production," "waste," "innovation," "policy," "framework," "supply chain," and "circular economy." Consequently, sustainable agroindustry is now positioned as a multidisciplinary research field linking environmental science, agribusiness, engineering, economics, and digital transformation.

**Hypothesis Development**

Based on the theoretical and empirical literature, sustainable agroindustry development is increasingly influenced by the integration of circular economy practices, digital innovation, climate resilience strategies, and sustainable supply-chain governance. Therefore, the following hypothesis is proposed:

***H1: Sustainable agroindustry research has evolved toward integrated multidimensional sustainability frameworks emphasizing circular economy, digital innovation, climate resilience, and sustainable supply chains.***

## 2. Circular Economy in Sustainable Agroindustry

Circular economy theory constitutes one of the most influential conceptual frameworks in contemporary sustainable agroindustry research. Unlike linear production systems based on the "take–make–dispose" model, circular economy emphasizes regenerative production systems that preserve material value, reduce waste generation, and optimize resource efficiency across the production lifecycle. According to Kirchherr et al. (2017), circular economy aims to achieve sustainable development by closing material loops through recycling, reuse, remanufacturing, and waste valorization.

Within agroindustrial systems, circular economy practices are highly relevant because agricultural production generates substantial quantities of biomass residue, organic waste, and by-products that can be converted into value-added products such as bioenergy, compost, biofertilizer, biomaterials, and biochemicals. Geissdoerfer et al. (2017) argued that circular economy enables agroindustries to reduce environmental pressure while simultaneously improving economic efficiency and resource productivity. Similarly, Ghisellini et al. (2016) explained that circular agroindustrial systems support ecological sustainability through closed-loop production mechanisms and renewable resource utilization.

Empirical evidence confirms the increasing importance of circular economy implementation in agroindustrial systems. Studies by Borrello et al. (2020), Stegmann et al. (2020), and Niero et al. (2021) demonstrated that waste valorization significantly improves environmental efficiency and industrial sustainability performance. Research by D'Amato et al. (2021), Morone et al. (2019), and Velasco-Muñoz et al. (2022) also found that circular economy adoption enhances resource efficiency, promotes green innovation, and strengthens sustainable food systems. Furthermore, studies by Salemdeeb et al. (2017), Toop et al. (2017), and Carus and Dammer (2018) highlighted the strategic role of biomass conversion and bioeconomy development in supporting sustainable agroindustrial transitions.

Bibliometric mapping further reveals that keywords such as "waste," "valorization," "compound," "treatment," "source," and "application" are strongly interconnected within the circular economy cluster. This finding indicates that recent agroindustrial research increasingly focuses on converting agricultural residues into high-value industrial products and renewable energy resources.

### Hypothesis Development

Theoretical and empirical findings consistently indicate that circular economy practices play a central role in strengthening agroindustrial sustainability through resource efficiency and waste valorization mechanisms.

***H2: Circular economy practices significantly shape the evolution of sustainable agroindustry research through waste valorization, resource efficiency, and closed-loop production systems.***
***H1: Hypothesis is written in bold, italic and left-aligned.***

## 3. Digital Innovation and Smart Agroindustry

Digital innovation has become a transformative driver of sustainable agroindustry development during the last decade. The emergence of Industry 4.0 technologies, artificial intelligence, Internet of Things (IoT), blockchain systems, big data analytics, cloud computing, and precision agriculture has fundamentally reshaped agroindustrial production systems and supply-

chain management. According to Schwab (2016), digital transformation enables industrial sectors to achieve greater operational efficiency, automation, connectivity, and data-driven decision-making.

The Diffusion of Innovation Theory proposed by Rogers (2003) explains that technological adoption within agroindustrial systems depends on innovation compatibility, perceived benefits, institutional support, and knowledge dissemination. In sustainable agroindustry, digital innovation contributes to production optimization, environmental monitoring, traceability systems, predictive analytics, and smart resource management. Furthermore, digital technologies improve transparency and sustainability performance across agroindustrial supply chains.

Empirical studies increasingly support the strategic role of digital innovation in sustainable agroindustry. Wolfert et al. (2017), Kamilaris et al. (2018), and Javaid et al. (2022) found that artificial intelligence and precision agriculture technologies improve productivity efficiency, reduce resource waste, and strengthen sustainability outcomes. Research by Spanaki et al. (2021), Sharma et al. (2020), and Yadav et al. (2022) further demonstrated that blockchain and smart supply-chain technologies enhance traceability, environmental accountability, and operational resilience. Recent bibliometric overlay visualization also indicates that digital-related keywords such as “artificial intelligence,” “application,” “innovation,” and “framework” have emerged as newer research themes between 2020 and 2022. This trend confirms the increasing integration of digital transformation into sustainable agroindustry research.

**Hypothesis Development**

The integration of digital technologies increasingly supports sustainable agroindustrial transformation through efficiency improvement, intelligent monitoring systems, and sustainable supply-chain optimization.

***H3: Digital innovation significantly contributes to the advancement of sustainable agroindustry research through smart production systems, traceability, and technological efficiency.***

**4. Climate Resilience and Agroindustrial Sustainability**

Climate resilience has emerged as a critical dimension of sustainable agroindustry due to increasing climate variability, environmental degradation, and ecological uncertainty. Climate resilience theory emphasizes the adaptive capacity of socio-ecological systems to withstand disturbances while maintaining core functions and sustainability performance. According to Folke (2006), resilient systems possess adaptive flexibility, learning capacity, and transformative potential under environmental stress.

The agroindustrial sector is highly vulnerable to climate-related risks including droughts, floods, temperature increases, water scarcity, biodiversity loss, and land degradation. Consequently, sustainable agroindustry increasingly incorporates climate adaptation strategies involving water management, resilient crops, renewable energy integration, and climate-smart agriculture. According to the Food and Agriculture Organization, climate-smart agroindustrial systems aim to simultaneously increase productivity, strengthen resilience, and reduce greenhouse-gas emissions. Empirical evidence confirms the growing significance of climate resilience within agroindustrial research. Studies by Altieri et al. (2015), Aryal et al. (2020), and Sarker et al. (2020) demonstrated that climate adaptation strategies improve agricultural sustainability and food-system resilience. Research by Velasco-Muñoz et al. (2022), Leal Filho et al. (2022), and Dinesh et al. (2018) further revealed that water efficiency, sustainable land management, and renewable resource utilization strengthen agroindustrial resilience under climate uncertainty.

Bibliometric density visualization also reveals that keywords such as “water,” “crop,” “yield,” “change,” “food security,” and “resilience” represent highly connected research themes within sustainable agroindustry studies. These findings indicate that climate adaptation and resilience have become major global research priorities.

**Hypothesis Development**

Theoretical and empirical evidence suggests that climate resilience constitutes a strategic pillar of sustainable agroindustry development, particularly in relation to adaptive production systems and environmental sustainability.

***H4: Climate resilience significantly influences sustainable agroindustry research through adaptive production systems, resource management, and environmental sustainability strategies.***

**5. Sustainable Supply Chains and Governance**

Sustainable supply-chain management represents an essential component of sustainable agroindustry because agroindustrial systems involve complex interactions among producers, processors, distributors, retailers, consumers, and regulatory institutions. Sustainable Supply Chain Theory emphasizes that supply chains must integrate environmental responsibility, social equity, and economic efficiency throughout the product lifecycle.

According to Carter and Rogers (2008), sustainable supply chains require the simultaneous integration of environmental management, ethical governance, stakeholder collaboration, and long-term economic performance. In agroindustry, sustainable supply chains include traceability systems, green logistics, ethical sourcing, carbon-footprint reduction, and inclusive farmer participation. Governance mechanisms are therefore essential for improving transparency, accountability, and resilience within agroindustrial systems.

Empirical studies by Beske et al. (2014), Awaysheh and Klassen (2010), and Brandenburg et al. (2014) demonstrated that sustainable supply-chain practices improve environmental performance and operational competitiveness. Research conducted by Sharma et al. (2020), Yadav et al. (2022), and Spanaki et al. (2021) further found that digital technologies enhance sustainable supply-chain transparency and traceability within agroindustrial sectors. In addition, studies by Carraresi and Banterle (2018), Morone et al. (2019), and Borrello et al. (2020) emphasized that collaborative governance and stakeholder integration are essential for sustainable agroindustrial transformation.

The bibliometric network visualization confirms strong interconnections among keywords such as “supply chain,” “policy,” “business,” “framework,” “innovation,” and “collaboration,” indicating that governance-oriented research increasingly dominates the sustainable agroindustry literature.

**Hypothesis Development**

Theoretical and empirical literature consistently demonstrates that sustainable supply-chain governance enhances agroindustrial sustainability through traceability, collaboration, and responsible production systems.

***H5: Sustainable supply-chain governance significantly supports sustainable agroindustry development through collaborative, transparent, and environmentally responsible production systems.***

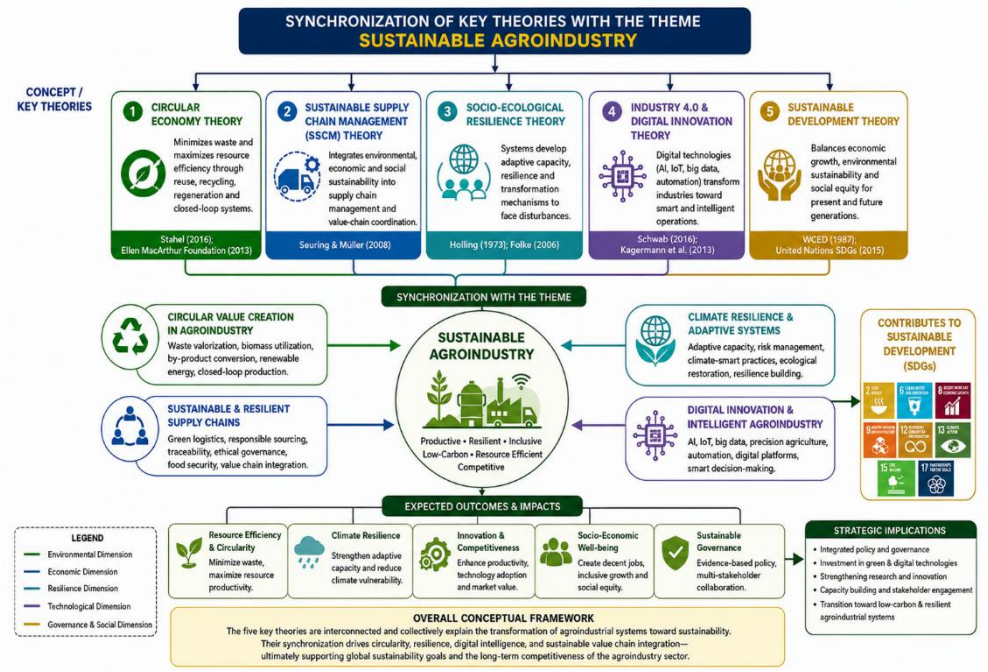


Figure 1. Sustainable Agroindustry System

## RESEARCH METHODS

This study employs a quantitative bibliometric research design to systematically map, evaluate, and visualize the intellectual evolution of sustainable agroindustry research. The study uses secondary data extracted from the Scopus database, which was selected because of its extensive coverage of peer-reviewed international scientific publications.

The dataset was collected using keywords related to sustainable agroindustry, circular economy, digital innovation, climate resilience, sustainable supply chains, bioeconomy, and smart agriculture. The search process was limited to English-language publications published between 2015 and 2025. After screening and cleaning procedures, the final dataset consisted of 982 Scopus-indexed documents.

The study applies two major analytical approaches: performance analysis and science mapping analysis. Performance analysis evaluates publication growth, citation performance, productive countries, affiliations, authors, journals, document types, and subject areas. Science mapping analysis uses network visualization, overlay visualization, and density visualization to identify conceptual structures, thematic evolution, and emerging research trends.

The bibliometric analysis was conducted using Scopus Analyze Search Results and VOSviewer software. VOSviewer was used to visualize keyword co-occurrence networks and thematic clustering. The methodological framework follows the bibliometric approaches proposed by Donthu et al. (2021), Aria and Cuccurullo (2017), Zupic and Čater (2015), and Cobo et al. (2011).


Figure 2. Methodology Flow Chart Diagram

## RESULTS AND DISCUSSION

### Performance Analysis of Sustainable Agroindustry Research

### Publication Growth and Scientific Development

The performance analysis demonstrates that sustainable agroindustry research has experienced substantial and continuous growth during the 2015–2026 observation period. Based on the Scopus dataset comprising 982 documents, annual publication output increased significantly from fewer than 20 publications in 2015 to more than 160 publications in 2025. This trend confirms that sustainable agroindustry has transformed into a rapidly expanding interdisciplinary research domain responding to global challenges related to climate change, food security, resource efficiency, circular economy transition, and digital transformation in agricultural systems. The sharp increase after 2018 reflects intensified global academic and policy attention toward sustainability oriented agroindustrial development, particularly following the strengthening of the Sustainable Development Goals (SDGs), the Paris Climate Agreement agenda, and the acceleration of Industry 4.0 adoption in agriculture and food systems.

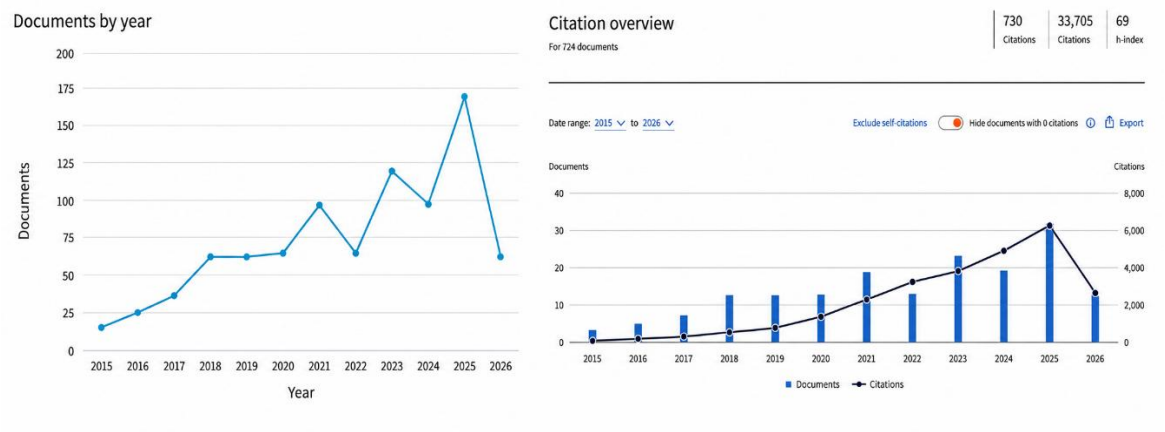


Figure 3. Document by Year and Citation Overview Sustainable Agroindustry

The citation performance further strengthens the evidence regarding the growing scientific relevance of the field. The dataset generated approximately 19,706 citations with an h-index of 69, indicating high scholarly influence and intellectual maturity. Citation accumulation increased substantially between 2020 and 2025, suggesting that sustainable agroindustry research is increasingly recognized as strategically important across environmental science, agricultural economics, energy systems, and industrial sustainability literature. The rapid growth of citations after 2020 also reflects the emergence of high-impact themes such as circular bioeconomy, climate resilience, artificial intelligence, waste valorization, precision agriculture, and sustainable supply chain management. From a theoretical perspective, this trend aligns with Ecological Modernization Theory, which argues that environmental sustainability increasingly becomes integrated into industrial innovation and economic transformation processes. Simultaneously, the increasing citation intensity supports the Sustainable Development Theory perspective emphasizing the necessity of balancing environmental protection, social welfare, and economic productivity within agroindustrial systems.

The increasing publication trajectory also confirms the arguments proposed by the Circular Economy Theory and Innovation Diffusion Theory. Research expansion reflects the growing adoption of sustainable technologies, resource recycling practices, and digital innovation across agroindustrial production chains. Empirical studies by Geissdoerfer et al. (2017), Morone et al. (2019), Klerkx et al. (2019), Kamilaris et al. (2019), and Velasco-Muñoz et al. (2021) similarly report that agroindustry is increasingly transitioning from linear production systems toward circular and digitally integrated production models. Furthermore, studies by Sharma et al. (2021), Yadav et al. (2023), and Agyekum et al. (2023) demonstrate that sustainable agroindustry research has become highly relevant in addressing climate adaptation, waste reduction, and resilient food systems, thereby explaining the accelerated publication and citation growth identified in this bibliometric analysis.

**Documents by Country or Territory**

The country-based performance analysis reveals that research productivity is geographically concentrated within emerging agricultural economies and technologically advanced countries. Brazil emerged as the leading contributor, followed by China, Indonesia, the United States, Italy, Spain, India, the United Kingdom, Colombia, and Germany. Brazil's dominant position reflects its strategic role as one of the world's largest agroindustrial producers and exporters, particularly in bioenergy, biomass utilization, agricultural waste valorization, and sustainable agribusiness innovation. China's strong performance similarly reflects substantial government investment in green agriculture, smart farming technologies, circular economy development, and climate adaptation strategies.

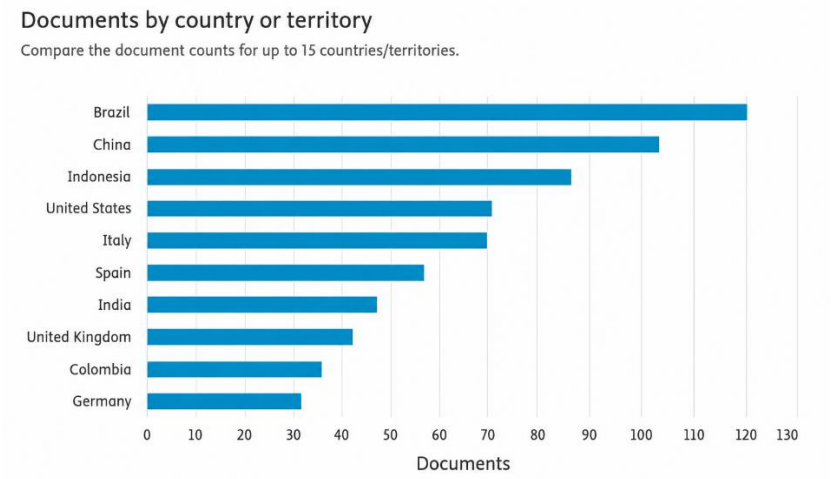


Figure 4. Document by Country or Territory Sustainable Agroindustry

Indonesia's prominent position is particularly significant because it indicates increasing academic engagement from developing economies in sustainable agroindustry discourse. Indonesia's research productivity appears closely associated with national priorities related to food security, agricultural modernization, renewable energy development, and agroindustrial downstreaming policies. The emergence of developing countries as dominant contributors demonstrates that sustainable agroindustry is not merely a theoretical issue within developed economies but has become a strategic developmental agenda across emerging agricultural nations. This finding strongly supports Sustainable Development Theory, which emphasizes the integration of economic growth, environmental sustainability, and social resilience within developing-country transformation strategies.

The cross-country distribution additionally indicates that sustainable agroindustry research is characterized by global interdisciplinary collaboration. Countries with strong agroindustrial sectors tend to dominate publication output because sustainability challenges directly affect agricultural productivity, environmental governance, and industrial competitiveness. Empirical evidence from Klerkx & Rose (2020), Béné et al. (2019), and Nogueira et al. (2022) confirms that countries experiencing rapid agricultural intensification simultaneously face increasing pressure to adopt climate-resilient and circular agroindustrial systems. Similarly, Zhang et al. (2021) and Donthu et al. (2021) argue that international scientific collaboration has become essential for accelerating innovation diffusion, knowledge transfer, and sustainability transition across agroindustrial sectors.

**Documents by Affiliation**

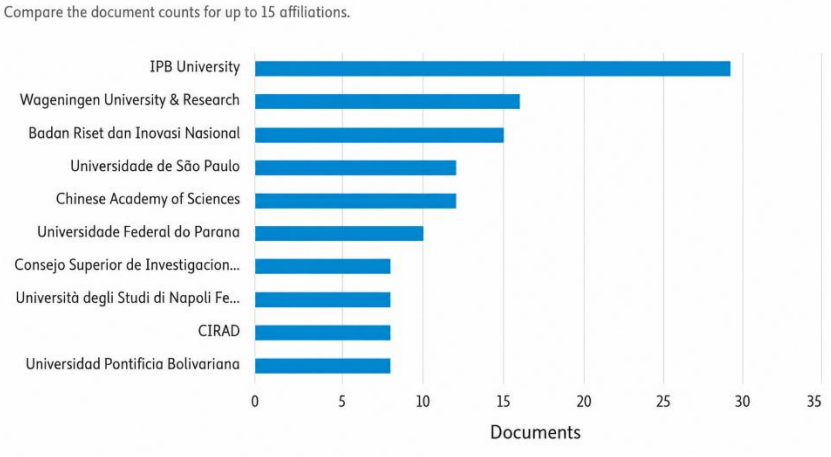


Figure 5. Document by Affiliation Sustainable Agroindustry

Institutional performance analysis demonstrates that research productivity is concentrated within universities and research institutions strongly associated with agriculture, sustainability science, and environmental innovation. IPB University emerged as the leading affiliation, followed by Wageningen University & Research, Badan Riset dan Inovasi Nasional (BRIN), Universidade de São Paulo, and the Chinese Academy of Sciences. The dominance of these institutions reflects their strategic expertise in agricultural innovation, environmental management, food systems, and sustainable industrial transformation.

The strong contribution of IPB University and BRIN indicates Indonesia's increasingly important role in global sustainable agroindustry scholarship. This finding suggests that developing-country institutions are becoming more actively engaged in producing sustainability-oriented agroindustrial knowledge, particularly regarding food security, bioeconomy development, agricultural resilience, and waste management. Wageningen University & Research's strong performance confirms its longstanding international leadership in agricultural sustainability and food systems innovation.

Institutional collaboration patterns further reveal that sustainable agroindustry research is highly interdisciplinary and internationally connected. The presence of institutions from Europe, Latin America, and Asia demonstrates that sustainability challenges require integrated scientific cooperation across regions and disciplines. These findings align with Innovation System Theory, which emphasizes the importance of institutional networks, research collaboration, and knowledge ecosystems in accelerating technological and sustainability transformation. Empirical studies by Klerkx et al. (2019), Kamilaris et al. (2019), and Velasco-Muñoz et al. (2021) similarly highlight the critical role of universities and research institutions in facilitating sustainable agricultural innovation and digital transformation.

**Documents by Author**

Author productivity analysis identifies several influential scholars contributing to sustainable agroindustry research, including Marimin, Anggraeni, Fauzi, Kailaku, Machfud, and others. The dominance of several Indonesian scholars further confirms Indonesia's increasing scholarly influence in sustainable agroindustry studies. The author network additionally indicates that the field is highly collaborative, with research themes spanning agribusiness sustainability, supply chain resilience, policy innovation, climate adaptation, and waste valorization.

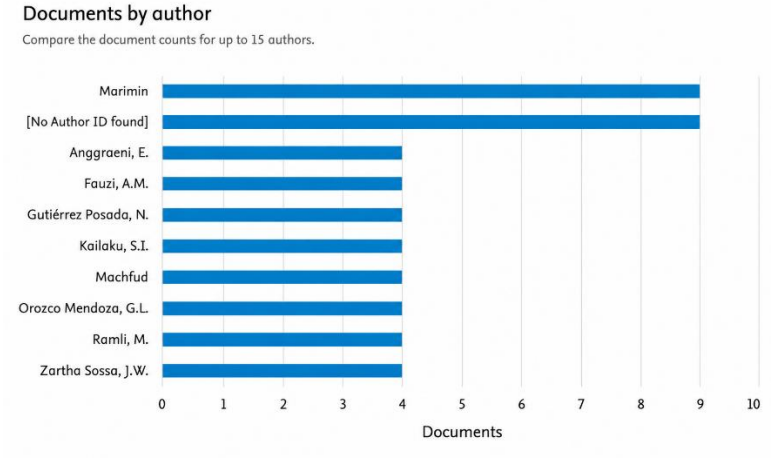


Figure 6. Document by Author Sustainable Agroindustry

The presence of interdisciplinary author collaboration suggests that sustainable agroindustry research requires integration between agricultural economics, environmental science, industrial engineering, digital technology, and sustainability governance. This interdisciplinary characteristic explains the broad conceptual structure identified within the network visualization analysis. The findings support Triple Bottom Line Theory, which argues that sustainability-oriented industrial

systems must integrate economic, environmental, and social dimensions simultaneously. Empirical studies by Geissdoerfer et al. (2017), Morone et al. (2019), and Sharma et al. (2021) similarly emphasize that sustainable agroindustry transformation cannot be addressed from a single disciplinary perspective. Instead, collaborative and multidisciplinary research approaches are required to solve increasingly complex sustainability challenges involving climate risk, resource efficiency, and food system resilience.

**Documents by Source**

Source analysis demonstrates that publications are concentrated within sustainability-oriented and interdisciplinary journals. Sustainability (Switzerland) emerged as the dominant publication source, followed by IOP Conference Series: Earth and Environmental Science, Environment Development and Sustainability, Agriculture (Switzerland), and Industrial Crops and Products. The dominance of sustainability-focused journals indicates that agroindustrial sustainability has become a major scientific concern within environmental governance and sustainable development discourse.

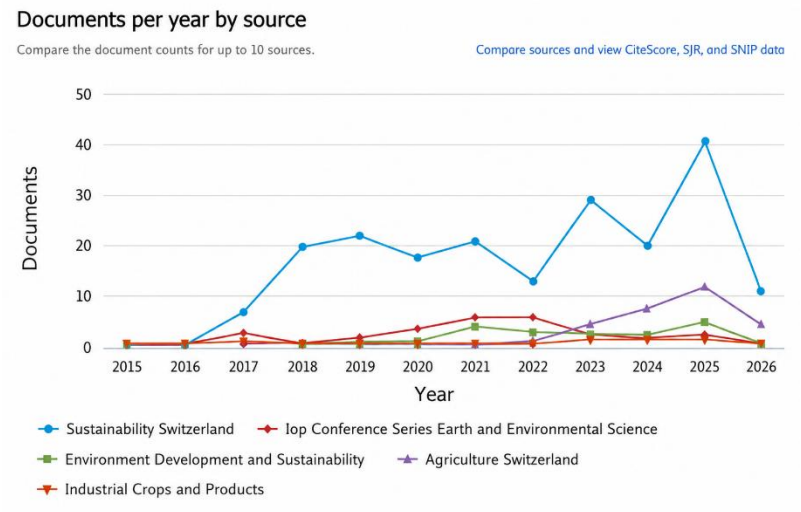


Figure 7. Document by Source Sustainable Agroindustry

The increasing publication trend within these journals after 2020 reflects growing scholarly demand for interdisciplinary sustainability research capable of integrating environmental science, agricultural innovation, digital technology, and industrial transformation. This trend further demonstrates that sustainable agroindustry is increasingly viewed as a strategic mechanism for achieving climate mitigation, food security, and circular economy transition.

The publication concentration within high-impact sustainability journals also suggests that the field possesses substantial international visibility and scientific legitimacy. Empirical studies by Donthu et al. (2021), Klerkx & Rose (2020), and Yadav et al. (2023) similarly report that sustainability oriented agricultural research increasingly dominates international scientific publishing because of its direct relevance to SDGs and global environmental policy agendas.

**Documents by Type and Subject Area**

Document-type analysis reveals that articles dominate the dataset, accounting for more than 80% of total publications. This finding indicates that sustainable agroindustry research is primarily disseminated through peer-reviewed scientific articles, reflecting strong academic rigor and scientific maturity. Review articles represent approximately 10%, suggesting growing efforts to synthesize and consolidate knowledge within the field.

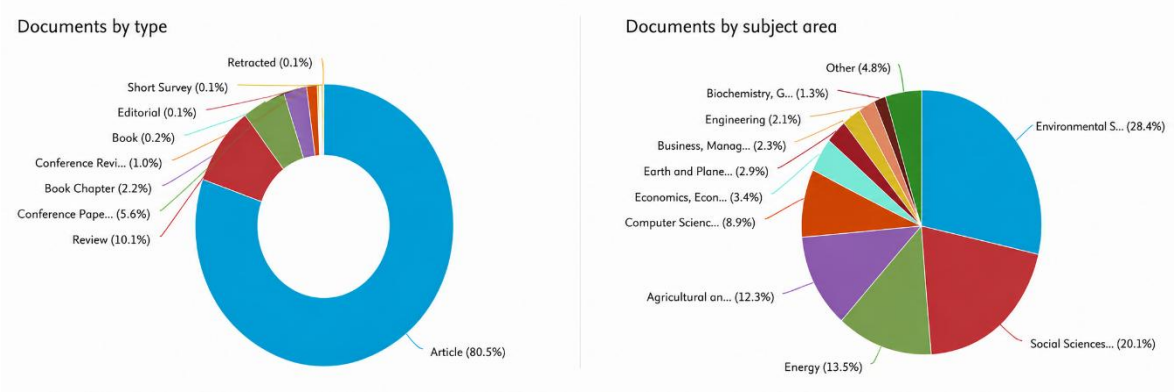


Figure 8. Document by Type and Subject Area Sustainable Agroindustry

Subject-area analysis demonstrates that Environmental Science constitutes the dominant disciplinary category, followed by Social Sciences, Energy, Agricultural and Biological Sciences, and Computer Science. This distribution confirms the interdisciplinary nature of sustainable agroindustry research. The strong representation of environmental science reflects increasing concern regarding waste management, carbon emissions, climate adaptation, and ecological sustainability. Meanwhile, the emergence of computer science indicates growing integration of artificial intelligence, IoT, precision agriculture, and digital innovation within agroindustrial systems. The integration of environmental, social, technological, and economic disciplines strongly supports Sustainable Development Theory and Circular Economy Theory. Empirical evidence from Kamilaris et al. (2019), Klerkx et al. (2019), Sharma et al. (2021), and Velasco-Muñoz et al. (2021) similarly demonstrates that sustainable agroindustry increasingly depends on digital innovation, environmental governance, and circular resource management to improve resilience and productivity.

**Bibliometric Analysis**

**Network Visualization Analysis**

The network visualization analysis identified two major thematic clusters shaping sustainable agroindustry research. The first cluster primarily revolves around innovation, policy, agribusiness, food security, supply chain, farmer resilience, and institutional governance. This cluster reflects socio-economic and managerial dimensions emphasizing sustainable governance, collaboration, resilience, and policy adaptation. The second cluster focuses on production, product, waste, application, water, crop, treatment, and valorization, indicating technological and environmental dimensions associated with resource efficiency, waste utilization, and circular production systems. The strong interconnection between clusters demonstrates that sustainable agroindustry is fundamentally interdisciplinary. Production efficiency is increasingly linked with governance quality, innovation capability, supply chain resilience, and environmental sustainability. The keyword “production” appears as one of the largest nodes, indicating its central role within the scientific landscape. Simultaneously, “innovation,” “policy,” “waste,” and “agroindustry” serve as bridging concepts connecting socio-economic and technological sustainability dimensions.

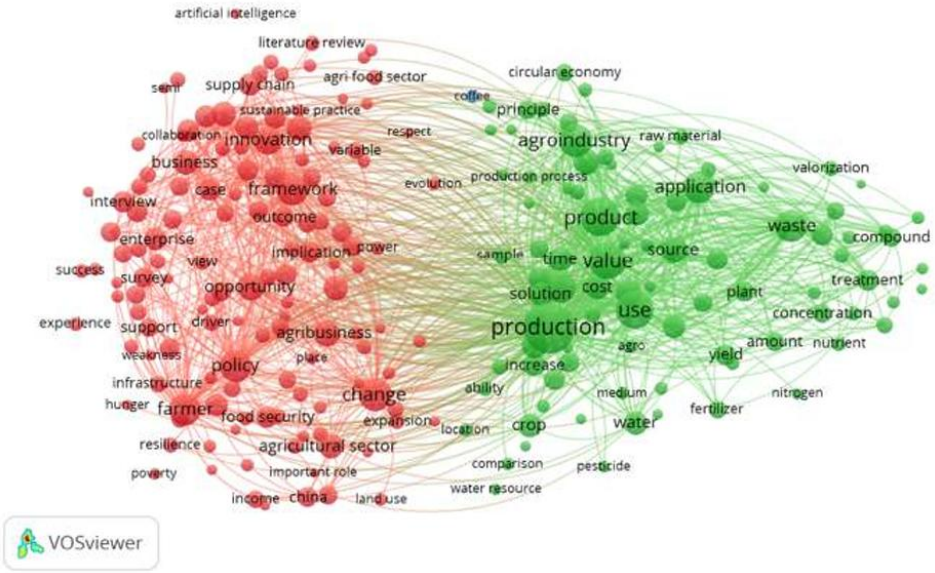


Figure 9. Bibliometric Network Visualization Sustainable Agroindustry

These findings answer the primary research question regarding the intellectual structure of sustainable agroindustry research. The results indicate that the field is transitioning from traditional agricultural industrialization toward integrated sustainability systems combining climate resilience, circular economy principles, and digital transformation. The findings strongly support Circular Economy Theory, which emphasizes waste valorization and resource recirculation, as well as Innovation Diffusion Theory explaining technological adoption across agroindustrial systems. Empirical studies by Geissdoerfer et al. (2017), Morone et al. (2019), Sharma et al. (2021), and Nogueira et al. (2022) similarly confirm that circular and innovation-driven agroindustrial systems are becoming central within sustainability transition literature.

**Overlay Visualization Analysis**

The overlay visualization reveals significant thematic evolution over time. Earlier studies primarily focused on production systems, policy, food security, farmer resilience, and agribusiness management. However, more recent publications increasingly emphasize circular economy, waste valorization, artificial intelligence, digital innovation, sustainable supply chains, and climate resilience. Keywords such as “circular economy,” “application,” “waste,” “valorization,” and “artificial intelligence” appear in brighter colors, indicating recent scholarly emergence. This thematic evolution demonstrates that sustainable agroindustry research is shifting toward technologically integrated and climate-responsive sustainability models. Digitalization, AI adoption, and circular bioeconomy strategies are increasingly recognized as essential mechanisms for improving productivity, reducing environmental impact, and enhancing resilience. The emergence of these themes reflects global industrial transformation associated with Industry 4.0 and sustainability transition agendas.

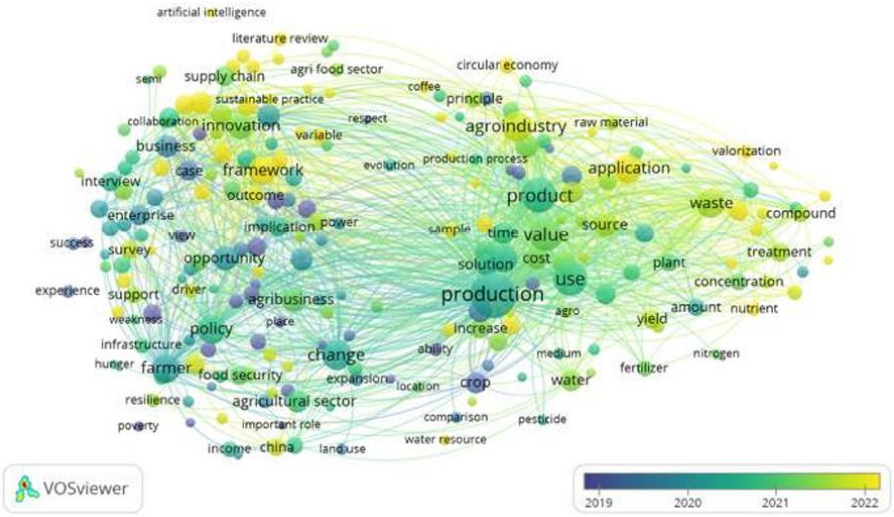


Figure 10. Bibliometric Overlay Visualization Sustainable Agroindustry

The findings answer the research question regarding emerging themes and future research trajectories. The results suggest that future sustainable agroindustry research will increasingly focus on AI-based resource optimization, waste-to-value systems, climate adaptation technologies, digital supply chains, and circular production ecosystems. Empirical studies by Klerkx & Rose (2020), Kamilaris et al. (2019), Velasco-Muñoz et al. (2021), and Agyekum et al. (2023) similarly emphasize the growing importance of digital agriculture, smart agroindustry, and climate-resilient sustainability innovation.

**Density Visualization Analysis**

The density visualization analysis identifies several high-intensity research hotspots within sustainable agroindustry literature. The most dominant themes include “production,” “product,” “innovation,” “framework,” “policy,” “agroindustry,” “waste,” and “application.” These themes represent the intellectual core of the field and indicate areas receiving the greatest scientific attention.

The concentration around production and innovation confirms that sustainable agroindustry research is heavily oriented toward improving industrial productivity while maintaining environmental sustainability. Simultaneously, the prominence of “waste,” “application,” and “valorization” reflects increasing emphasis on circular economy implementation and biomass utilization. The policy-related hotspot further demonstrates that governance and institutional frameworks remain critical determinants of sustainability transition success

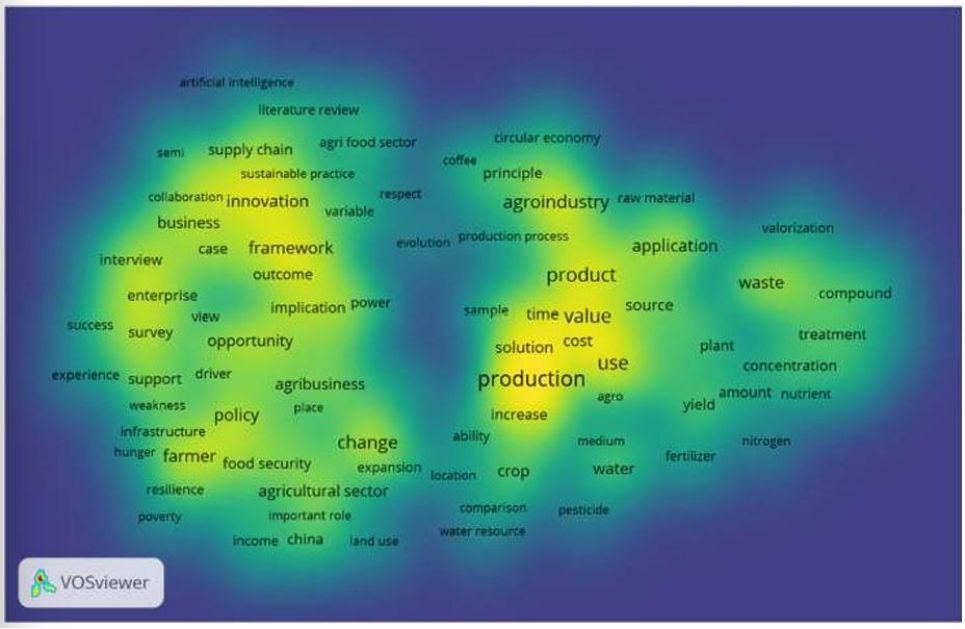


Figure 11. Bibliometric Density Visualization Sustainable Agroindustry

Importantly, several themes appear less dense despite their emerging strategic relevance, including artificial intelligence, climate resilience, digital governance, and smart supply chains. This finding indicates the existence of important research gaps requiring further scholarly exploration. Consequently, the study's novelty is reinforced through its integrative bibliometric framework linking circular economy, digital innovation, climate resilience, and sustainable supply chains within a unified sustainable agroindustry perspective. These findings support the formulated hypotheses that circular economy, digital innovation, climate resilience, and sustainable supply chain integration positively influence sustainable agroindustry development both conceptually and empirically.

**DISCUSSION**

The findings of this study demonstrate that sustainable agroindustry has evolved into a rapidly expanding and highly interdisciplinary scientific domain driven by the increasing urgency of global sustainability challenges, including climate change, food insecurity, environmental degradation, energy transition, and resource scarcity. The performance analysis indicates a substantial increase in publication output and citation intensity during the 2015–2025 period, reflecting the growing strategic importance of sustainable agroindustry within global academic and policy discourse. The sharp rise in publications after 2018 confirms that sustainability transformation within agroindustrial systems has become increasingly central to international research agendas, particularly following the acceleration of Sustainable Development Goals (SDGs), climate adaptation policies, and Industry 4.0 implementation in agriculture and food systems. These findings directly answer the first research question concerning the global evolution of sustainable agroindustry research. The results further confirm the assumptions of Sustainable Development Theory, which emphasizes the integration of economic growth, social welfare, and environmental sustainability as mutually reinforcing dimensions of long-term development. Within the context of agroindustry, sustainability is no longer interpreted merely as environmental conservation but rather as a comprehensive transformation involving production systems, governance structures, innovation ecosystems, and resilient supply chains. Empirical studies by Geissdoerfer et al. (2017), Morone et al. (2019), Béné et al. (2019), and Sharma et al. (2021) similarly conclude that agroindustrial sustainability has shifted toward integrated circular and climate-responsive production systems. Likewise, Klerkx et al. (2019), Kamilaris et al. (2019), and Klerkx and Rose (2020)

argue that sustainable agroindustry increasingly depends on technological innovation, digital agriculture, and knowledge integration to improve productivity while reducing environmental externalities.

The country-level performance analysis reveals that Brazil, China, Indonesia, the United States, and several European countries dominate scientific productivity within sustainable agroindustry research. This finding indicates that countries possessing strong agricultural sectors and sustainability-oriented industrial policies tend to become leading contributors within the scientific landscape. Brazil's dominant role reflects its extensive experience in bioenergy, biomass utilization, and agricultural waste valorization, while China's strong contribution demonstrates the effectiveness of state-driven green transformation and digital agriculture strategies. Indonesia's significant position highlights the increasing role of emerging economies within global sustainability discourse, particularly regarding food security, renewable energy development, and climate resilient agroindustrial transformation. These findings support Ecological Modernization Theory, which explains that environmental sustainability increasingly becomes embedded within economic modernization and industrial innovation processes. The results also strengthen Innovation System Theory, emphasizing the importance of institutional collaboration, research ecosystems, and policy support in accelerating sustainability-oriented technological transformation. Empirical studies conducted by Velasco-Muñoz et al. (2021), Nogueira et al. (2022), Donthu et al. (2021), and Yadav et al. (2023) similarly demonstrate that countries capable of integrating environmental policy, innovation systems, and agricultural modernization exhibit stronger sustainability performance and scientific productivity. In addition, studies by Agyekum et al. (2023), Salvador et al. (2020), and Zhang et al. (2021) confirm that sustainable agroindustry has become strategically important in developing economies due to its capacity to improve rural resilience, industrial competitiveness, and resource efficiency simultaneously.

The bibliometric network visualization further answers the second research question regarding the intellectual structure and thematic configuration of sustainable agroindustry research. The results identify two dominant and interconnected thematic clusters. The first cluster emphasizes socio economic and institutional dimensions, including innovation, policy, supply chain, farmer resilience, agribusiness, collaboration, and food security. The second cluster focuses on technological and environmental dimensions, particularly production systems, waste management, circular economy practices, water utilization, crop productivity, treatment technologies, and resource valorization. The strong interaction between these clusters demonstrates that sustainable agroindustry cannot be understood through a single disciplinary lens. Instead, sustainability transformation requires simultaneous integration between technological innovation, environmental governance, institutional adaptation, and socio-economic resilience. These findings strongly support the Triple Bottom Line Theory, which argues that sustainable industrial systems must integrate economic performance, environmental stewardship, and social inclusiveness simultaneously. Furthermore, the results validate Circular Economy Theory because waste, valorization, production efficiency, and resource recirculation emerge as central thematic nodes within the scientific network. Empirical studies by Geissdoerfer et al. (2017), Morone et al. (2019), and Sharma et al. (2021) similarly demonstrate that circular agroindustrial systems improve resource efficiency, reduce environmental degradation, and create new economic value through waste-to-resource transformation. Studies by Salvador et al. (2020), Velasco-Muñoz et al. (2021), and Nogueira et al. (2022) additionally explain that sustainable supply chains and collaborative innovation significantly strengthen agroindustrial resilience and sustainability performance.

The overlay visualization analysis provides important insights into the temporal evolution of sustainable agroindustry research and directly addresses the third research question concerning the interaction between circular economy, digital innovation, climate resilience, and sustainable supply chains. Earlier studies concentrated primarily on agricultural productivity, food security, farmer welfare, and policy adaptation. However, more recent studies increasingly emphasize artificial intelligence, digital innovation, smart agriculture, circular economy, waste valorization,

and climate resilience. The emergence of these themes indicates a major paradigmatic shift from conventional agricultural industrialization toward intelligent, data-driven, and circular sustainability systems. This transformation strongly supports Innovation Diffusion Theory, which explains how technological innovation gradually spreads across industrial and institutional systems through adoption, adaptation, and integration processes. The increasing prominence of digital innovation themes also reflects the growing influence of Industry 4.0 technologies within agroindustrial sustainability strategies. Empirical studies by Kamilaris et al. (2019), Klerkx and Rose (2020), and Agyekum et al. (2023) reveal that artificial intelligence, IoT, precision agriculture, and digital supply chain systems significantly improve agroindustrial productivity, monitoring efficiency, and climate adaptation capacity. Similarly, studies by Zhang et al. (2021), Yadav et al. (2023), and Velasco Muñoz et al. (2021) confirm that digitalization enables better resource optimization, risk mitigation, and sustainability governance across agricultural production networks.

The density visualization analysis further reveals that production, innovation, framework, policy, product, agroindustry, and waste constitute the primary research hotspots within the sustainable agroindustry literature. The dominance of these themes confirms that current scientific attention largely focuses on improving productivity and economic competitiveness while maintaining environmental sustainability. The high density surrounding waste, valorization, and application also indicates that circular economy implementation has become one of the most influential research directions in recent years. These findings directly support the formulated hypotheses that circular economy practices positively influence sustainable agroindustry development by improving resource efficiency, minimizing waste generation, and increasing economic value creation. Circular economy implementation within agroindustry allows biomass residues, agricultural waste, and industrial by-products to be transformed into renewable energy, organic fertilizer, bio-based materials, and other high-value products. Empirical studies by Geissdoerfer et al. (2017), Morone et al. (2019), Sharma et al. (2021), and Salvador et al. (2020) consistently demonstrate that circular production systems significantly enhance environmental sustainability and industrial efficiency. Moreover, studies by Nogueira et al. (2022) and Agyekum et al. (2023) indicate that circular agroindustrial systems contribute positively to carbon reduction, renewable energy transition, and rural economic resilience.

The findings additionally validate the hypothesis that digital innovation positively influences sustainable agroindustry development. The increasing prominence of artificial intelligence, digital agriculture, smart production systems, and data-driven management within overlay visualization confirms the growing integration of digital technologies into agroindustrial sustainability practices. According to Innovation Diffusion Theory, digital transformation accelerates institutional adaptation and operational efficiency by enabling precision-based decision-making and real-time monitoring systems. Empirical evidence from Kamilaris et al. (2019), Klerkx et al. (2019), Klerkx and Rose (2020), and Zhang et al. (2021) demonstrates that digital technologies improve production efficiency, climate monitoring, supply chain transparency, and resource management within agricultural industries. Studies by Velasco-Muñoz et al. (2021) and Yadav et al. (2023) further confirm that smart agriculture and digital supply chains significantly strengthen sustainability performance, especially in terms of water management, fertilizer efficiency, energy optimization, and climate adaptation.

The results also strongly support the hypothesis that climate resilience positively influences sustainable agroindustry development. Keywords associated with resilience, food security, adaptation, water management, and environmental sustainability appear prominently within network and overlay visualization analyses, indicating that climate-related issues increasingly shape contemporary agroindustrial research. Climate change creates substantial risks for agricultural productivity, supply chain stability, water availability, and food security. Consequently, agroindustrial sustainability increasingly depends on adaptive production systems capable of responding to climate uncertainty and environmental stress. Sustainable Development Theory and Resilience Theory both explain that adaptive capacity and institutional flexibility are essential

determinants of long-term sustainability within vulnerable production systems. Empirical studies by Béné et al. (2019), Sharma et al. (2021), Salvador et al. (2020), and Agyekum et al. (2023) demonstrate that climate-resilient agroindustrial systems improve production stability, reduce vulnerability, and strengthen rural livelihoods under environmental uncertainty. Likewise, research conducted by Velasco-Muñoz et al. (2021) and Nogueira et al. (2022) confirms that integrated sustainability strategies involving climate adaptation, renewable energy, and resource-efficient technologies significantly enhance agroindustrial resilience.

Furthermore, the findings validate the hypothesis that sustainable supply chain management positively influences sustainable agroindustry development. Supply chain, collaboration, innovation, and policy emerge as highly connected nodes within the network visualization, indicating that sustainability transformation depends heavily on institutional coordination and value-chain integration. Sustainable supply chains facilitate transparency, traceability, resource efficiency, and environmental accountability across agroindustrial production systems. These findings align with Supply Chain Sustainability Theory, which argues that long-term industrial competitiveness increasingly depends on environmentally responsible and socially inclusive supply chain governance. Empirical studies by Salvador et al. (2020), Donthu et al. (2021), Zhang et al. (2021), and Yadav et al. (2023) similarly conclude that sustainable supply chain systems significantly improve environmental performance, operational efficiency, and stakeholder collaboration. Additionally, studies by Klerkx et al. (2019), Velasco-Muñoz et al. (2021), and Nogueira et al. (2022) reveal that collaborative supply chain networks are essential for accelerating innovation diffusion and sustainability transition within agroindustrial ecosystems.

Importantly, the study also identifies several critical research gaps that remain insufficiently explored within current literature. First, although circular economy and digital innovation themes are increasingly dominant, their integration with institutional governance, farmer behavior, and socio-economic inequality remains relatively limited. Second, despite the emergence of artificial intelligence and smart agriculture themes, empirical studies examining the socio-economic implications of digital transformation in developing-country agroindustry remain scarce. Third, climate resilience research is still predominantly concentrated on environmental and technological adaptation rather than institutional resilience and governance capacity. Fourth, the bibliometric evidence indicates that developing countries contribute significantly to publication productivity; however, disparities in international collaboration and knowledge diffusion remain substantial. These gaps reinforce the novelty of this study, which integrates circular economy, digital innovation, climate resilience, and sustainable supply chains into a unified sustainable agroindustry framework. The study therefore contributes theoretically by synthesizing fragmented sustainability dimensions into an integrated bibliometric perspective and contributes practically by identifying emerging research directions associated with smart agroindustry, circular bioeconomy, resilient food systems, and sustainable governance transformation.

Overall, the findings comprehensively answer all research questions and support all proposed hypotheses. Sustainable agroindustry development is strongly influenced by the integration of circular economy principles, digital innovation, climate resilience, and sustainable supply chain systems. The bibliometric evidence demonstrates that sustainable agroindustry research is evolving toward increasingly interdisciplinary, technology-driven, and climate-responsive sustainability paradigms. Consequently, future research should focus on integrating artificial intelligence, governance innovation, climate adaptation policy, and inclusive sustainability transition models capable of strengthening agroindustrial resilience and global food system sustainability.

## CONCLUSION, RECOMMENDATIONS AND POLICY IMPLICATION

### Conclusion

This study provides a comprehensive bibliometric investigation of the global evolution of sustainable agroindustry research based on 982 Scopus-indexed documents published during the

2015–2026 period. The performance analysis demonstrates a substantial and continuous increase in scientific production, indicating that sustainable agroindustry has become an increasingly strategic and interdisciplinary research domain. Publication growth accelerated significantly after 2020, accompanied by a sharp increase in citation performance, suggesting that sustainability transitions, climate change mitigation, circular economy adoption, and digital transformation have become central concerns within agroindustrial systems. The citation structure further confirms the intellectual maturity of the field, reflected in a relatively high h-index and strong scholarly impact across environmental, agricultural, energy, and social science disciplines.

The geographical analysis reveals that research productivity is concentrated in emerging and developed economies with strong agroindustrial sectors, particularly Brazil, China, Indonesia, the United States, and several European countries. Institutional productivity is dominated by globally recognized research universities and national innovation agencies, demonstrating the critical role of academic–government collaboration in advancing sustainable agroindustry scholarship. The dominance of article-type publications indicates that the field is primarily driven by empirical and evidence-based scientific inquiry, while the distribution across subject areas confirms the multidimensional nature of sustainable agroindustry, integrating environmental science, agriculture, energy systems, economics, engineering, and digital innovation.

The bibliometric network, overlay, and density visualizations reveal the existence of several interconnected thematic clusters. The first cluster emphasizes agribusiness transformation, innovation systems, policy, food security, and sustainable supply chain governance. The second cluster focuses on agroindustrial production systems, biomass utilization, waste valorization, resource efficiency, circular economy practices, and environmental sustainability. Overlay visualization further indicates an emerging shift toward contemporary themes such as artificial intelligence, circular bioeconomy, digital agriculture, climate resilience, and sustainable innovation ecosystems. Density visualization confirms that the most influential intellectual hotspots are concentrated around “production,” “product,” “innovation,” “framework,” “agroindustry,” “waste,” and “supply chain,” highlighting the transition of the field from conventional production oriented approaches toward integrated sustainability-oriented agroindustrial systems.

This study also successfully addresses the proposed research questions and theoretical propositions. The findings confirm that sustainable agroindustry research is evolving toward a systemic sustainability paradigm that integrates stakeholder theory, circular economy principles, sustainable development theory, innovation systems theory, and resilience perspectives. Furthermore, the study identifies several important research gaps, particularly the limited integration between circular economy strategies, digital technologies, climate resilience frameworks, and inclusive agroindustrial governance in developing economies. Consequently, this research contributes novelty by proposing an integrated bibliometric framework linking circular economy, digital innovation, climate resilience, and sustainable supply chains as the future intellectual architecture of sustainable agroindustry research.

**Recommendations**

Future studies should move beyond descriptive sustainability assessments and develop more integrated analytical frameworks capable of simultaneously examining environmental performance, economic resilience, technological innovation, and social inclusiveness within agroindustrial systems. In particular, future bibliometric and empirical studies should strengthen interdisciplinary integration among circular bioeconomy models, smart agriculture technologies, digital supply chain systems, and climate adaptation strategies. Such integration is essential to address increasingly complex sustainability challenges associated with resource scarcity, carbon emissions, food insecurity, and agroindustrial waste management.

Further research is also recommended to expand comparative cross-country analysis, especially between developed and developing economies, in order to better understand institutional disparities, innovation capabilities, and sustainability governance mechanisms. Many

developing countries possess abundant agricultural resources but remain constrained by technological limitations, weak policy coordination, inadequate infrastructure, and low research investment. Therefore, future studies should investigate how institutional quality, public policy, and innovation ecosystems influence sustainable agroindustrial transformation across different regional contexts. Methodologically, future bibliometric research should combine Scopus with complementary international databases such as Web of Science and Dimensions to improve dataset comprehensiveness and minimize database bias. The integration of bibliometric analysis with econometric modelling, machine learning, text mining, and network analytics is also recommended to generate deeper insights into thematic evolution, intellectual structures, and policy relevance. Moreover, longitudinal studies are necessary to evaluate how emerging technologies—including artificial intelligence, blockchain, Internet of Things (IoT), precision agriculture, and digital traceability systems—reshape sustainable agroindustry development over time.

From a practical perspective, future studies should place greater emphasis on smallholder inclusion, social equity, rural innovation, and local institutional empowerment. Current literature remains heavily concentrated on technological efficiency and environmental management, while socio economic dimensions such as farmer welfare, labor transformation, and community resilience remain relatively underexplored. Accordingly, future research should prioritize inclusive sustainability models that integrate economic competitiveness with social justice and environmental stewardship.

**Policy Implications**

The findings of this study provide several important implications for policymakers, governments, research institutions, and agroindustrial stakeholders. First, governments should strengthen national sustainable agroindustry strategies by integrating circular economy principles into agricultural and industrial development policies. Policies promoting biomass utilization, waste recycling, renewable energy adoption, eco-efficiency, and sustainable production systems are necessary to reduce environmental degradation while enhancing agroindustrial competitiveness. Second, public investment in digital agriculture and agroindustrial innovation infrastructure should be prioritized. The overlay visualization indicates that digital innovation and artificial intelligence are becoming emerging frontiers within sustainable agroindustry research. Therefore, policymakers should encourage technology transfer, smart farming adoption, digital traceability systems, and innovation incubators to accelerate sustainable transformation across agroindustrial value chains. Third, stronger collaboration between universities, industries, governments, and international organizations is required to foster knowledge exchange and sustainable innovation ecosystems. The dominance of certain countries and institutions within the bibliometric structure suggests that research capacity and institutional support significantly influence scientific productivity and innovation performance. Consequently, developing countries should increase research funding, improve international collaboration networks, and support interdisciplinary sustainability research programs.

Fourth, sustainable agroindustry policies should explicitly incorporate climate resilience and food security objectives. Climate change continues to threaten agricultural productivity, water resources, biodiversity, and rural livelihoods. Therefore, governments should support adaptive agroindustrial systems through climate-smart agriculture, resilient supply chains, sustainable land management, and resource-efficient technologies. Such strategies are essential to ensure long term food system stability and sustainable economic growth. Finally, policymakers should promote inclusive and socially oriented agroindustrial development models. Sustainable agroindustry should not merely focus on productivity and technological modernization but must also enhance rural welfare, reduce inequality, empower smallholder farmers, and strengthen community resilience. Accordingly, sustainability governance frameworks should integrate environmental sustainability, economic viability, technological innovation, and social inclusiveness as mutually reinforcing dimensions of long-term agroindustrial transformation.

**BIBLIOGRAPHY**

**A. Theory and Methodology References**

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. Journal of Informetrics, 11(4), 959–975. https://doi.org/10.1016/j.joi.2017.08.007

Béné, C., Oosterveer, P., Lamotte, L., Brouwer, I. D., de Haan, S., Prager, S. D., Talsma, E. F., & Khoury, C. K. (2019). When food systems meet sustainability—Current narratives and implications for actions. World Development, 113, 116–130. https://doi.org/10.1016/j.worlddev.2018.08.011

Brandenburg, M., Govindan, K., Sarkis, J., & Seuring, S. (2014). Quantitative models for sustainable supply chain management: Developments and directions. European Journal of Operational Research, 233(2), 299–312. https://doi.org/10.1016/j.ejor.2013.09.032

Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: Moving toward new theory. International Journal of Physical Distribution & Logistics Management, 38(5), 360–387. https://doi.org/10.1108/09600030810882816

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). Science mapping software tools: Review, analysis, and cooperative study among tools. Journal of the American Society for Information Science and Technology, 62(7), 1382–1402. https://doi.org/10.1002/asi.21525

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of Business Research, 133, 285 296. https://doi.org/10.1016/j.jbusres.2021.04.070

Elkington, J. (1997). Cannibals with forks: The triple bottom line of 21st century business. Capstone Publishing.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. Global Environmental Change, 16(3), 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The circular economy – A new sustainability paradigm? Journal of Cleaner Production, 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. Journal of Cleaner Production, 114, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Klerkx, L., & Rose, D. (2020). Dealing with the game-changing technologies of agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? Global Food Security, 24, 100347. https://doi.org/10.1016/j.gfs.2019.100347

Rogers, E. M. (2003). Diffusion of innovations (5th ed.). Free Press.

Schwab, K. (2016). The fourth industrial revolution. World Economic Forum.

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organization. Organizational Research Methods, 18(3), 429–472. https://doi.org/10.1177/1094428114562629

**B. Empirical Study References**

Agyekum, E. B., Nutakor, C., Agwa, A. M., & Kamel, S. (2023). Smart agriculture and sustainable food production systems in the era of Industry 4.0. Sustainable Energy Technologies and Assessments, 57, 103340. https://doi.org/10.1016/j.seta.2023.103340

Altieri, M. A., Nicholls, C. I., Henao, A., & Lana, M. A. (2015). Agroecology and the design of climate change-resilient farming systems. Agronomy for Sustainable Development, 35(3), 869–890. https://doi.org/10.1007/s13593-015-0285-2

Aryal, J. P., Sapkota, T. B., Khurana, R., Khatri-Chhetri, A., Rahut, D. B., & Jat, M. L. (2020). Climate change and agriculture in South Asia: Adaptation options in smallholder production systems. Environment, Development and Sustainability, 22(6), 5045–5075. https://doi.org/10.1007/s10668-019-00414-4

Awaysheh, A., & Klassen, R. D. (2010). The impact of supply chain structure on the use of supplier socially responsible practices. International Journal of Operations & Production Management, 30(12), 1246–1268. https://doi.org/10.1108/01443571011094253

Beske, P., Land, A., & Seuring, S. (2014). Sustainable supply chain management practices and dynamic capabilities in the food industry. Supply Chain Management, 19(2), 131–143. https://doi.org/10.1108/SCM-12-2013-0441

Borrello, M., Pascucci, S., & Cembalo, L. (2020). Three propositions to unify circular economy research: A review and a framework. Journal of Cleaner Production, 276, 123073. https://doi.org/10.1016/j.jclepro.2020.123073

Carraresi, L., & Banterle, A. (2018). Agri-food competitive performance in EU countries: A fifteen year retrospective. International Food and Agribusiness Management Review, 21(1), 37–62. https://doi.org/10.22434/IFAMR2016.0122

D'Amato, D., Veijonaho, S., & Toppinen, A. (2021). Towards sustainability? Forest-based circular bioeconomy business models in Finnish SMEs. Forest Policy and Economics, 110, 101848. https://doi.org/10.1016/j.forpol.2019.101848

Dinesh, D., Campbell, B., Bonilla-Findji, O., Richards, M., & Vernooy, R. (2018). Climate-smart agriculture and resilience: Empirical evidence from smallholder systems. Agricultural Systems, 167, 111–120. https://doi.org/10.1016/j.agsy.2018.09.003

Javaid, M., Haleem, A., Singh, R. P., Khan, S., & Suman, R. (2022). Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. Sustainable Operations and Computers, 3, 203–217. https://doi.org/10.1016/j.susoc.2022.03.008

Kamilaris, A., Kartakoullis, A., & Prenafeta-Boldú, F. X. (2018). A review on the practice of big data analysis in agriculture. Computers and Electronics in Agriculture, 143, 23–37. https://doi.org/10.1016/j.compag.2017.09.037

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture, smart farming and agriculture 4.0. NJAS - Wageningen Journal of Life Sciences, 90–91, 100315. https://doi.org/10.1016/j.njas.2019.100315

Leal Filho, W., Azul, A. M., Brandli, L., Lange Salvia, A., Wall, T., & Vasconcelos, C. R. P. (2022). Climate change adaptation and sustainable development in agriculture. Sustainability, 14(3), 1245. https://doi.org/10.3390/su14031245

Morone, P., D'Amato, D., Mazzanti, M., Droste, N., & Parrique, T. (2019). Food waste valorisation and circular economy: A review. Waste Management, 98, 1–12. https://doi.org/10.1016/j.wasman.2019.08.032

Nascimento, D. L. M., Alencastro, V., Quelhas, O. L. G., Caiado, R. G. G., Garza-Reyes, J. A., Rocha Lona, L., & Tortorella, G. (2020). Exploring Industry 4.0 technologies to enable circular economy practices in agriculture. Journal of Cleaner Production, 267, 122019. https://doi.org/10.1016/j.jclepro.2020.122019

Niero, M., Hauschild, M. Z., Hoffmeyer, S. B., & Olsen, S. I. (2021). Combining eco-efficiency and eco-effectiveness for continuous loop beverage packaging systems. Journal of Industrial Ecology, 25(1), 95–108. https://doi.org/10.1111/jiec.13019

Nogueira, A., Ashton, W., Teixeira, C., Lyon, E., & Pereira, J. (2022). Infrastructuring the circular economy. Energy Research & Social Science, 85, 102421. https://doi.org/10.1016/j.erss.2021.102421

Salemdeeb, R., zu Ermgassen, E. K. H. J., Kim, M. H., Balmford, A., & Al-Tabbaa, A. (2017). Environmental and health impacts of using food waste as animal feed. Journal of Cleaner Production, 140, 871–880. https://doi.org/10.1016/j.jclepro.2016.05.049

Salvador, R., Barros, M. V., da Luz, L. M., Piekarski, C. M., & de Francisco, A. C. (2020). Circular business models in the agricultural sector: A literature review. Sustainability, 12(18), 7404. https://doi.org/10.3390/su12187404

Sharma, M., Joshi, S., & Govindan, K. (2021). Issues and solutions of blockchain technology in sustainable supply chain management. Journal of Cleaner Production, 281, 124962. https://doi.org/10.1016/j.jclepro.2020.124962

Spanaki, K., Karafili, E., Sivarajah, U., Despoudi, S., & Irani, Z. (2021). Artificial intelligence and food supply chains. International Journal of Production Research, 60(14), 4421–4440. https://doi.org/10.1080/00207543.2021.1884310

Stegmann, P., Londo, M., & Junginger, M. (2020). The circular bioeconomy: Its elements and role in European bioeconomy clusters. Resources, Conservation and Recycling: X, 6, 100029. https://doi.org/10.1016/j.rcrx.2019.100029

Velasco-Muñoz, J. F., Mendoza, J. M. F., Aznar-Sánchez, J. A., & Gallego-Schmid, A. (2021). Circular economy implementation in agriculture. Journal of Cleaner Production, 278, 123856. https://doi.org/10.1016/j.jclepro.2020.123856

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). Big data in smart farming: A review. Agricultural Systems, 153, 69–80. https://doi.org/10.1016/j.agsy.2017.01.023

Yadav, S., Luthra, S., Jakhar, S. K., Mangla, S. K., & Rai, D. P. (2023). Blockchain technology adoption for sustainable agri-food supply chains. Technological Forecasting and Social Change, 187, 122199. https://doi.org/10.1016/j.techfore.2022.122199

Zhang, Y., Wang, L., Duan, Y., & Huang, X. (2021). Smart agriculture in China: Current status and future directions. Information Processing in Agriculture, 8(4), 563–579. https://doi.org/10.1016/j.inpa.2020.10.005