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Circular Business Models in Agriculture: A Bibliometric Assessment of Implementation and Economic Sustainability

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ABSTRACT

This study employs a bibliometric analysis to assess the implementation and economic sustainability of circular business models (CBMs) in agriculture. Using data exclusively from the Scopus database, the research analyzes citation trends, key publications, and thematic clusters through VOSviewer. The findings reveal that sustainability and agriculture are central themes, with strong interconnections to economic growth, environmental economics, and technological advancements. The study identifies three major research clusters: sustainability and business models, agriculture and environmental concerns, and food security and supply chain management. Additionally, temporal analysis indicates a shift from environmental sustainability towards integrated economic and technological solutions. While the co-authorship and country collaboration networks highlight expanding international research efforts, fragmentation persists, suggesting a need for stronger interdisciplinary cooperation. The study underscores the importance of circular economy approaches and innovation in fostering sustainable agricultural practices. These insights provide valuable guidance for policymakers, researchers, and practitioners in advancing the transition towards sustainable and economically viable agricultural systems.

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1. INTRODUCTION

The agricultural sector plays a pivotal role in ensuring food security and economic development worldwide. However, traditional agricultural systems are characterized by linear production models, where resources are extracted, used, and disposed of, leading to significant environmental degradation [1]. This model not only depletes natural resources but also exacerbates climate change, soil depletion, and water contamination. To address these issues, a shift toward circular business models (CBMs) in agriculture has been gaining traction. CBMs emphasize resource efficiency, waste minimization, and sustainable economic practices, which align with the principles of a circular economy (CE). By integrating these models, the agricultural sector can transition from a linear to a regenerative system that enhances both environmental and economic sustainability [2].

The concept of circular economy in agriculture has been widely discussed in academic and policy circles. A circular economy promotes closed-loop systems that reuse agricultural residues, optimize input utilization, and enhance ecosystem resilience [3]. For instance, organic farming, precision agriculture, and agroecology are some approaches that align with circular principles. These practices encourage nutrient cycling, reduce dependency on synthetic inputs, and improve soil health, making agriculture more resilient to climate change [4]. Furthermore, technological advancements such as bio-based fertilizers, waste-to-energy systems, and smart farming techniques contribute to the efficient implementation of circular strategies in agricultural enterprises [5].

Despite the recognized benefits of circular business models in agriculture, their implementation remains uneven across regions and farming systems. The adoption of CBMs depends on various factors, including policy support, access to technology, financial incentives, and stakeholder collaboration [6]. In some cases, small-scale farmers face significant challenges in adopting circular practices due to financial constraints and lack of technical expertise. Moreover, the lack of well-defined regulations and incentives to support CBM adoption further complicates the transition [7]. Addressing these challenges requires a comprehensive assessment of the economic viability and sustainability of these models.

Economic sustainability is a crucial aspect of circular business models in agriculture. While circular strategies can lead to long-term cost savings and increased efficiency, the initial investment and transition costs often deter farmers and agribusinesses from making the shift [8]. It is essential to evaluate the economic performance of CBMs to understand their feasibility and scalability in different agricultural settings. A bibliometric analysis of existing studies on CBMs in agriculture can provide valuable insights into the current trends, challenges, and economic outcomes associated with these models [9]. Such an analysis can also identify gaps in research and highlight areas where further investigation is needed to enhance the adoption of sustainable agricultural practices. Given the growing interest in circular business models and their economic implications, it is important to assess how these models are being implemented and what factors influence their success. A systematic review of the existing literature can shed light on the effectiveness of CBMs in enhancing resource efficiency, reducing environmental impact, and improving economic returns [10]. Additionally, understanding the key drivers and barriers to implementation can inform policymakers, practitioners, and researchers in designing effective strategies to promote circular agriculture.

Despite the increasing emphasis on sustainability in agriculture, there remains a gap in understanding the extent to which circular business models have been implemented and their economic viability. While numerous studies have explored individual aspects of circular economy practices, there is a lack of comprehensive bibliometric analyses that examine the broader trends, challenges, and economic outcomes of CBMs in agriculture. Without a clear understanding of these factors, policymakers and stakeholders may struggle to formulate strategies that facilitate the transition towards sustainable agricultural systems. Therefore, it is crucial to systematically assess the existing body of knowledge on circular business models in agriculture, particularly focusing on their implementation and economic sustainability. This study aims to conduct a bibliometric assessment of the implementation and economic sustainability of circular business models in agriculture.

2. LITERATURE REVIEW

2.1 *Concept of Circular Business Models in Agriculture*

Circular Business Models (CBMs) are gaining increasing attention as a sustainable alternative to traditional linear economic models in agriculture. These models emphasize the efficient use of resources, waste minimization, and value creation through recycling, reuse, and regeneration [11]. CBMs in agriculture integrate principles of the circular economy (CE) by closing nutrient cycles, reducing environmental footprints, and enhancing the economic viability of farming practices [12]. Unlike conventional farming systems that operate on a take-make-dispose principle, CBMs focus on extending the lifecycle of agricultural inputs, improving soil health, and ensuring long-term sustainability [13]. Several studies highlight the role of CBMs in fostering sustainability in agriculture. According to [14], implementing CBMs can lead to significant reductions in resource wastage and environmental degradation. For instance, practices such as organic farming, agroecology, and regenerative agriculture align with CBMs by promoting closed-loop systems and enhancing biodiversity. Additionally, the use of precision agriculture technologies, bio-based fertilizers, and waste-to-energy systems facilitates the transition toward circularity in agriculture [15].

2.2 *Implementation Strategies for Circular Business Models*

The implementation of CBMs in agriculture requires strategic approaches that consider economic, environmental, and social factors. One common strategy is the adoption of circular supply chains, which involve recycling agricultural by-products, using biodegradable inputs, and promoting sustainable farming techniques [16]. For example, livestock manure can be repurposed as organic fertilizer, reducing dependency on synthetic fertilizers and enhancing soil fertility [17]. Similarly, crop residues can be processed into bioenergy, contributing to renewable energy production and waste reduction [18].

Another critical approach is integrating technology to optimize circular agricultural practices. The use of digital tools, such as blockchain, artificial intelligence (AI), and Internet of Things (IoT), can enhance supply chain transparency and efficiency [19]. Precision agriculture technologies enable real-time monitoring of soil conditions, water usage, and crop health, ensuring optimal resource utilization and waste minimization [20]. These advancements support the implementation of CBMs by improving decision-making processes and fostering collaboration among stakeholders.

2.3 *Economic Sustainability of Circular Business Models*

Economic sustainability is a fundamental aspect of CBMs in agriculture, as financial feasibility determines the long-term success of these models. Research indicates that CBMs can generate economic benefits by reducing input costs, enhancing productivity, and creating new revenue streams [21]. For example, the adoption of circular practices such as composting, biogas production, and precision irrigation can lead to cost savings and increased farm efficiency. Furthermore, circular supply chains can open new market opportunities, such as selling organic produce at premium prices or participating in carbon credit programs [19].

However, the transition to CBMs presents economic challenges, particularly for small-scale farmers who may lack the financial resources and technical expertise required for implementation [4]. High initial investment costs, lack of incentives, and limited access to circular economy financing are some of the barriers to adoption. To address these challenges, policymakers and financial institutions must develop funding mechanisms, subsidies, and incentive programs that support farmers in transitioning to circular practices [8].

2.4 *Challenges in the Adoption of Circular Business Models*

Despite the potential benefits of CBMs, several barriers hinder their widespread adoption in agriculture. One major challenge is the lack of awareness and knowledge among farmers and agribusinesses regarding circular economy principles [11]. Many agricultural stakeholders continue to rely on conventional practices due to ingrained habits, resistance to change, and uncertainty about the economic benefits of circular approaches. Additionally, regulatory and policy frameworks play a crucial role in facilitating or hindering CBM adoption. Inconsistent policies, weak enforcement mechanisms, and the absence of clear guidelines for circular agriculture practices can create uncertainty for farmers and agribusinesses. Without supportive policies, farmers may struggle to access necessary resources, technologies, and financial support to implement CBMs effectively ([14]. Technological barriers also pose significant challenges to CBM adoption. While digital innovations and smart farming techniques offer potential solutions, their high costs and technical complexity can limit accessibility, particularly for small and medium-sized enterprises. Therefore, investments in research, training, and capacity-building programs are essential to equip farmers with the skills and knowledge required to integrate circular practices into their agricultural operations.

3. METHODS

This study employs a bibliometric analysis to assess the implementation and economic sustainability of circular business models in agriculture. Bibliometric analysis is a quantitative research method that systematically evaluates existing literature to identify trends, research patterns, influential publications, and knowledge gaps within a specific field (Zupic & Čater, 2015). Data for this study will be collected exclusively from the Scopus database, using relevant keywords and search criteria to ensure comprehensive coverage of circular business models in agriculture. The retrieved literature will be analyzed using the bibliometric software VOSviewer to generate visual maps, citation networks, and thematic clusters. By focusing on citation relationships and co-occurrence networks, this study aims to provide a structured overview of existing research trends and identify key contributors in the field.

4. RESULTS AND DISCUSSION

Table 1. Top Cited Research

Citations	Authors and year	Title
389	[22]	The nature and longevity of agricultural impacts on soil carbon and nutrients: A review
310	[23]	Factors influencing the adoption of precision agricultural technologies: A review for policy implications
206	[24]	The impact of Land Use/Land Cover Changes on land degradation dynamics: A Mediterranean case study
197	[25]	A system dynamics simulation model for sustainable water resources management and agricultural development in the Volta River Basin, Ghana
154	[1]	Critical success and risk factors for circular business models valorising agricultural waste and by-products
130	[26]	Potential mitigation of the environmental impacts of food systems through urban and peri-urban agriculture (UPA) – a life cycle assessment approach
118	[27]	Sustainability driven by agriculture through digital transformation
117	[28]	Decarbonizing the food and beverages industry: A critical and systematic review of developments, sociotechnical systems and policy options
107	[29]	Consolidating the current knowledge on urban agriculture in productive urban food systems: Learnings, gaps and outlook
106	[30]	Dramatic loss of agricultural land due to urban expansion threatens food security in the Nile Delta, Egypt

Source: Scopus, 2025

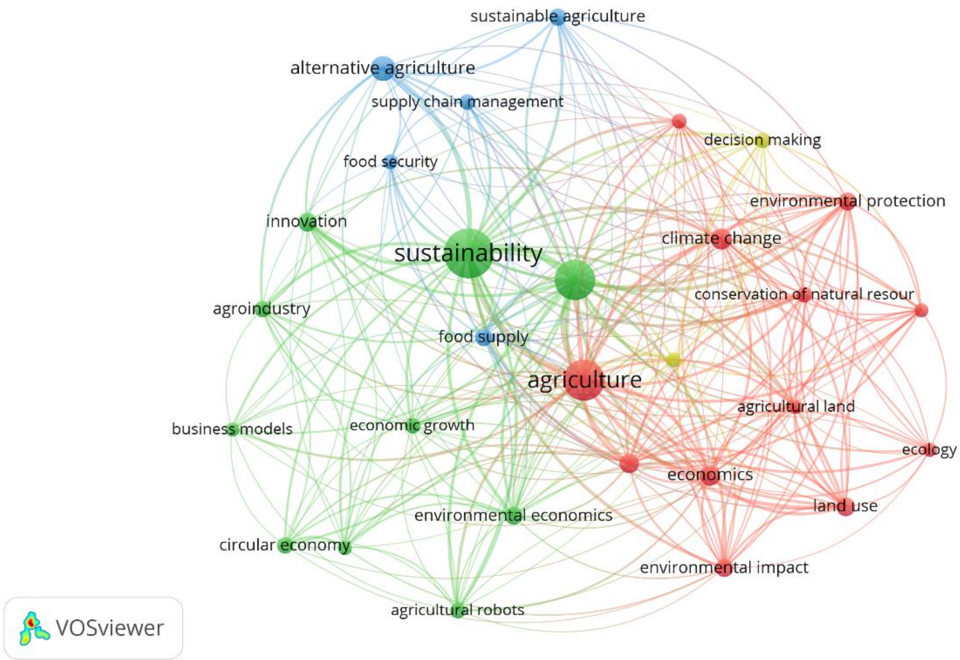

Figure 1. Network Visualization

Source: Data Analysis Result, 2025

This VOSviewer visualization represents a bibliometric network analysis of keywords related to agriculture, sustainability, and economics. The nodes (circles) represent keywords, and their size indicates frequency, meaning larger nodes are more frequently occurring terms in the dataset. The edges (connections between nodes) represent co-occurrences of terms in research articles, showing how closely related different concepts are. The colors indicate clusters, which group similar topics based on their relationships. This network provides insights into the main themes and interconnections within the research landscape on sustainability and agriculture.

The visualization presents three major clusters, each representing a distinct research focus. The green cluster focuses on sustainability, including keywords such as circular economy, economic growth, innovation, and business models. This indicates that research within this cluster emphasizes the economic and industrial aspects of sustainability in agriculture. The red cluster centers on agriculture and environmental concerns, including terms like land use, ecology, environmental impact, and agricultural land, suggesting that these studies primarily address environmental conservation, land management, and the ecological implications of agricultural activities. The blue cluster appears to focus on alternative agriculture and supply chain management, incorporating terms such as sustainable agriculture, food security, and supply chain management, indicating a research emphasis on food production systems and resilience.

The central position of "sustainability" and "agriculture" in the network suggests that they are the most frequently occurring and highly interconnected topics. The close ties between economic growth, environmental economics, and food supply indicate that sustainability in agriculture is not only an environmental concern but also an economic issue. The presence of agricultural robots in the sustainability cluster highlights the role of technology and automation in promoting sustainable farming practices. This suggests that agricultural innovations are increasingly being explored as solutions to environmental and economic challenges.

The red cluster emphasizes environmental issues such as climate change, conservation of natural resources, and environmental protection, indicating a significant research focus on the impact of agricultural practices on the environment. The interconnections between land use, ecology, and environmental impact suggest that research in this domain is concerned with balancing agricultural productivity with ecosystem conservation. This aligns with global efforts to develop environmentally responsible agricultural policies that minimize the negative impact of farming on biodiversity and natural resources.

The green cluster's focus on business models, circular economy, and innovation suggests that researchers are exploring sustainable agricultural practices that are economically viable. The presence of agricultural robots highlights the role of automation and artificial intelligence in enhancing agricultural sustainability. Additionally, the links between supply chain management, food security, and alternative agriculture in the blue cluster indicate a research emphasis on improving food distribution systems and ensuring resilience in agricultural supply chains.

This network visualization highlights the interdisciplinary nature of research on agriculture, sustainability, and economics. The strong interconnections between environmental, economic, and technological factors suggest that future research should adopt a holistic approach that integrates these domains. Policymakers can use these insights to develop sustainable agricultural policies that not only address climate change and land use but also promote economic growth and technological innovation. Additionally, the importance of food security and supply chain resilience in the blue cluster suggests that more research is needed to ensure global food systems remain stable amidst environmental and economic challenges.

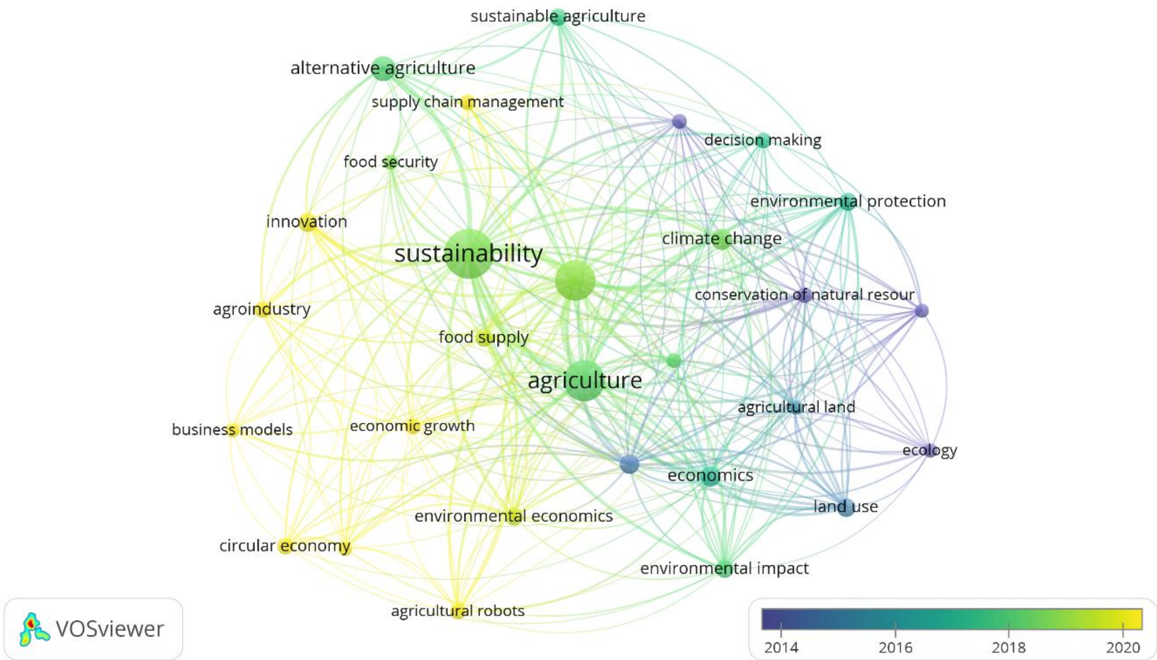

Figure 2. Overlay Visualization
Source: Data Analysis Result, 2025

This VOSviewer visualization represents a bibliometric analysis of keywords related to sustainability, agriculture, and economics, with an added temporal dimension (as shown in the color gradient from 2014 to 2020). The size of the nodes represents the frequency of occurrence of the keywords, while the lines between them indicate co-occurrence relationships. The color scale provides insights into how research trends have evolved over time, with older topics shown in blue (2014–2016) and more recent topics in yellow (2019–2020). This enables a dynamic understanding of research developments in sustainability and agriculture.

From the visualization, earlier research (blue and green nodes) focused on traditional environmental concerns such as land use, ecology, environmental protection, and conservation of natural resources. Over time, research has expanded to include economic perspectives, as seen in keywords like environmental economics, economic growth, and business models. The transition towards technological and innovation-driven sustainability is evident in the more recent terms (yellow nodes), such as circular economy, agricultural robots, and innovation, which have gained prominence in 2019–2020. This suggests a shift from purely environmental sustainability concerns to more integrated research that combines economic, technological, and environmental sustainability.

The visualization highlights that "sustainability" and "agriculture" remain central research themes throughout the analyzed period, acting as key connecting points between various domains. The recent emphasis on supply chain management, food security, and alternative agriculture suggests a growing focus on food systems resilience and sustainable production models. This evolving research trend underscores the increasing importance of integrating economic and technological advancements into sustainability discourse, reflecting a broader movement towards sustainable business models, innovation in agriculture, and circular economy approaches.

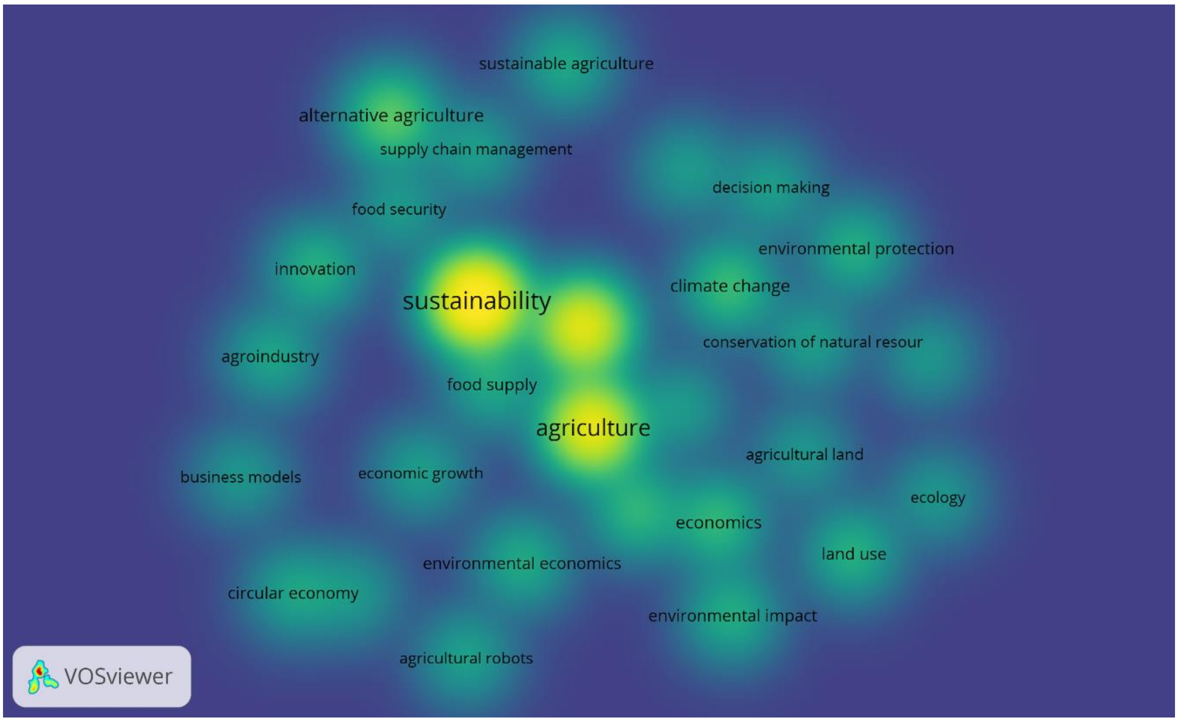

Figure 3. Density Visualization
Source: Data Analysis, 2025

This VOSviewer heatmap visualization represents the density of keyword occurrences related to sustainability, agriculture, and economics in bibliometric research. The yellow regions indicate areas with the highest concentration of keyword occurrences, suggesting that these topics have been extensively studied, while the green and blue regions represent less frequently occurring keywords. The most prominent keywords in the dataset are "sustainability" and "agriculture", which serve as central themes in the research field. Other highly occurring terms include "food supply," "economic growth," and "environmental economics," indicating strong scholarly interest in the economic and environmental aspects of sustainable agriculture.

The heatmap further reveals emerging and specialized research areas in sustainability and agriculture. Topics such as "circular economy," "innovation," and "agricultural robots" appear in green areas, suggesting that while they are gaining attention, they are not as dominant as sustainability-focused themes. On the environmental side, keywords like "climate change," "conservation of natural resources," and "environmental protection" are also visible but slightly less concentrated, indicating that they are important but not as frequently discussed as core sustainability and agricultural topics. The visualization highlights the need for further exploration of these emerging areas, particularly in technological innovations and sustainable economic models, to create a more holistic approach to addressing sustainability challenges in agriculture.

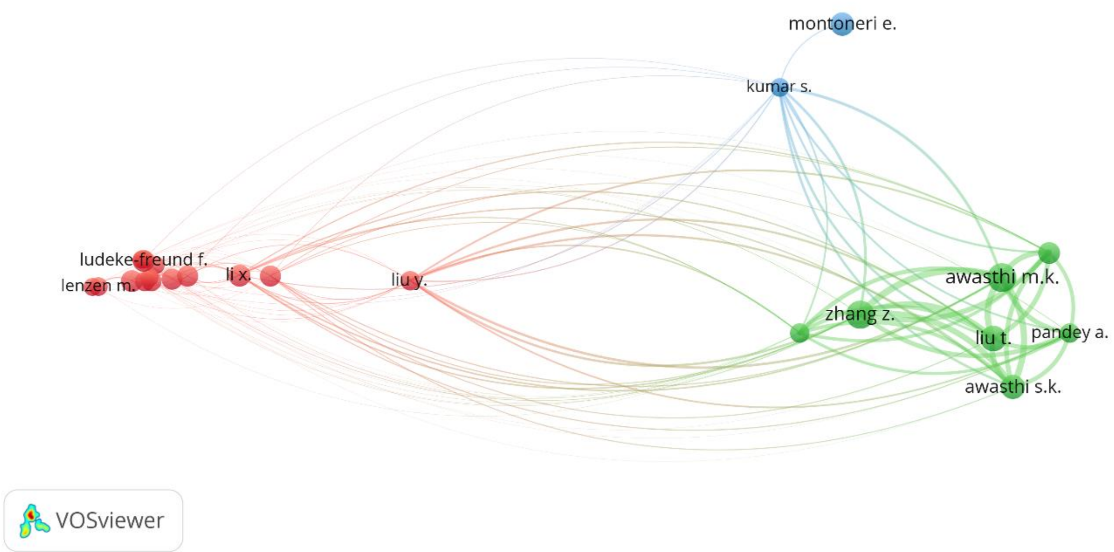

Figure 4. Author Collaboration Visualization
Source: Data Analysis, 2025

This VOSviewer co-authorship network visualization illustrates the collaboration patterns among researchers in the field. The nodes represent individual authors, with their size indicating the number of publications or citations, while the edges (connecting lines) indicate co-authorship relationships, with thicker lines suggesting stronger collaboration. The colors indicate different clusters of researchers who frequently collaborate. The visualization reveals three main research groups: the red cluster (authors such as Ludeke-Freund F. and Lenzen M.), which appears to focus on one area of study, the green cluster (authors such as Awasthi M.K., Liu T., and Zhang Z.), which has strong internal collaboration, and the blue cluster (authors such as Kumar S. and Montoneri E.), which has limited but significant interactions with other groups. The presence of weakly connected or isolated clusters suggests that research on this topic is somewhat fragmented, with distinct groups working independently rather than forming an integrated global research network.

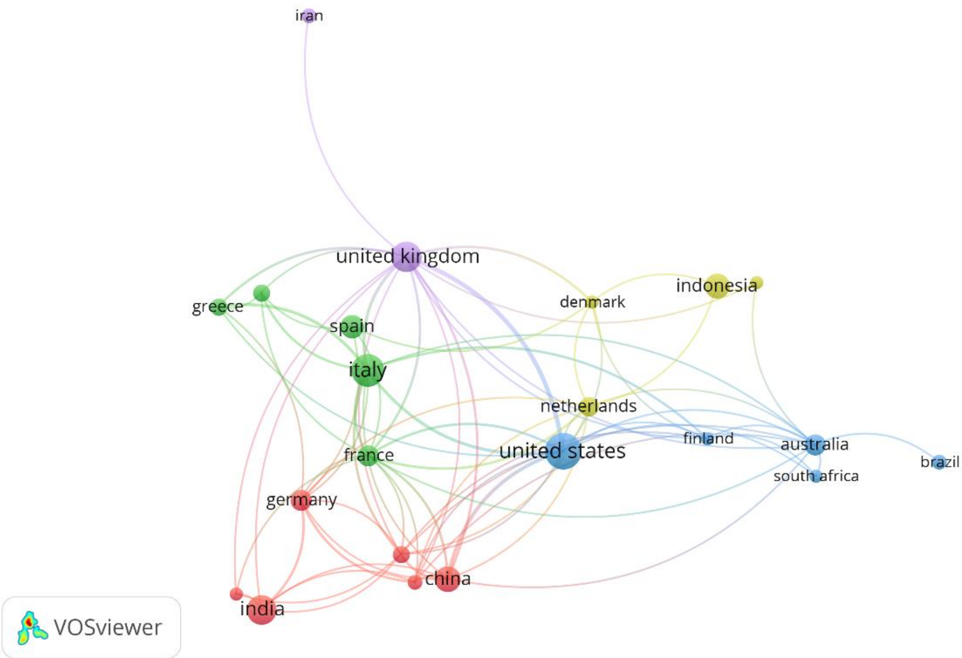

Figure 5. Author Collaboration Visualization

Source: Data Analysis, 2025

This VOSviewer co-authorship network visualization represents collaboration patterns between countries. Each node represents a country, with larger nodes indicating higher research contributions, while edges (connecting lines) represent international collaboration, with thicker lines suggesting stronger partnerships. The different colors indicate clusters of closely collaborating countries. The United States, United Kingdom, China, India, and Italy appear as key contributors with strong research collaborations, as indicated by their central positioning and numerous connections. The United States (blue cluster) has strong ties with Australia, South Africa, and Finland, whereas China and India (red cluster) maintain frequent collaborations with Germany and France. European countries like Italy, Spain, and Greece (green cluster) form another major collaborative hub. Notably, Iran (purple cluster) appears isolated, with limited international collaboration, suggesting regional or independent research efforts. This network indicates a globally interconnected research landscape, with some countries forming stronger regional collaborations, while others have broader international ties.

5. CONCLUSION

This bibliometric analysis of circular business models in agriculture has provided valuable insights into the research landscape, trends, and key contributors within the field. The study identified highly cited research that has shaped academic discourse on sustainability, agriculture, and economic viability. The network visualizations generated using VOSviewer reveal that sustainability and agriculture are central themes, with strong interconnections to economic growth, environmental economics, and technological advancements. The findings highlight the growing emphasis on circular economy approaches, innovative business models, and precision agricultural technologies as essential components of sustainable farming. However, challenges such as fragmented research collaboration, financial barriers, and policy inconsistencies hinder the widespread adoption of circular business models. The co-authorship and country collaboration networks suggest that while international research efforts are expanding, stronger interdisciplinary cooperation is needed to drive comprehensive solutions. Future studies should focus on bridging the knowledge gaps between economic, environmental, and technological aspects to ensure the successful implementation of circular business models in agriculture. These findings provide valuable guidance for policymakers, researchers, and practitioners in promoting sustainable agricultural practices that align with global sustainability goals.

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