West Science Nature and Technology
Vol. 3, No. 03, September 2025, pp. 177~186

A Scientometric Review of Agroecology and its Role in Sustainable Food Systems

Loso Judijanto
IPOSS Jakarta

Article Info

Article history:

Received September, 2025
Revised September, 2025
Accepted September, 2025

Keywords:

Agroecology;
Sustainable Food Systems;
Scientometric Analysis;
VOSviewer

ABSTRACT

This study presents a scientometric review of the global research landscape on agroecology and its role in sustainable food systems, using data retrieved from the Scopus database and analyzed through VOSviewer. By examining co-authorship patterns, institutional collaborations, keyword co-occurrence, and thematic evolution, the study identifies key contributors, dominant research themes, and emerging trends within the field. Central concepts such as agroecology, sustainability, climate change, and food security form the core of scholarly discourse, reflecting the multidimensional nature of agroecology as both a scientific approach and a socio-political movement. The analysis highlights a growing shift in research focus—from traditional agronomic practices toward systemic issues like food sovereignty, adaptation, and justice-based food system transformation. This review contributes to a deeper understanding of how agroecology has evolved and provides strategic insights for researchers, policymakers, and practitioners engaged in advancing equitable and resilient food systems globally.

Corresponding Author:

Name: Loso Judijanto
Institution: IPOSS Jakarta
Email: losojudijantobumn@gmail.com

1. INTRODUCTION

In the face of intensifying climate change, biodiversity loss, and persistent global hunger, the future of food systems has emerged as one of the most pressing challenges of the 21st century. Traditional models of agricultural production, which prioritize yield maximization and industrial-scale efficiency, have revealed their vulnerabilities—from environmental degradation to social inequality [1], [2]. Amid these challenges, agroecology has gained increasing attention as a holistic and integrative approach that promises not only environmental sustainability but also socio-economic justice and food sovereignty. Defined broadly, agroecology is the application of ecological principles to the design and management of sustainable agroecosystems, merging scientific knowledge with local practices, traditional wisdom, and political engagement [3].

Agroecology is not merely a set of agricultural practices; it is a paradigm shift. Unlike conventional agriculture, which often depends on chemical inputs, monocultures, and fossil fuels, agroecology seeks to regenerate natural resources, increase resilience, and empower local communities [4]. The principles of agroecology emphasize

diversity, synergy, recycling, efficiency, and resilience—values that resonate strongly with the goals of sustainable development. In particular, agroecology supports several Sustainable Development Goals (SDGs), including zero hunger, responsible consumption and production, and climate action. As such, agroecology is increasingly being recognized by international institutions, such as the Food and Agriculture Organization (FAO), as a strategic pathway toward transforming food systems [5], [6].

Over the last two decades, agroecology has experienced an expanding footprint in academic research and policy dialogue. From grassroots movements in Latin America to institutional endorsements in Europe and Africa, the concept has evolved through a rich tapestry of scientific inquiry, local innovations, and socio-political advocacy [7]. This dynamic development is reflected in the growing body of literature surrounding agroecology, which includes studies on ecological farming techniques, policy frameworks, socio-cultural impacts, market integration, and transdisciplinary methodologies [8], [9]. However, this diverse and growing literature also presents a challenge: how can we systematically map, analyze, and interpret the evolving trends and knowledge structures of agroecology research in relation to sustainable food systems?

Scientometric analysis offers a powerful lens through which this challenge can be addressed. By examining publication trends, citation patterns, co-authorship networks, and thematic clusters, scientometrics enables researchers to understand the intellectual landscape of a research field. In the context of agroecology, scientometric tools can help reveal key contributors, influential works, collaborative networks, and emerging research frontiers [10]. This, in turn, can support evidence-based policy formulation, strategic research planning, and knowledge democratization—critical steps toward accelerating agroecological transitions in real-world food systems.

Moreover, understanding agroecology's role in sustainable food systems requires us to go beyond the biological and agronomic dimensions. It necessitates attention to social innovation, power relations, market structures, and governance mechanisms. The integration of agroecology into broader food systems transformation involves cross-cutting themes such as food justice, consumer behavior, indigenous knowledge systems, climate resilience, and circular economy. A scientometric review not only maps the volume of research but also reveals how these cross-disciplinary themes are connected, where the research gaps lie, and how future agendas can be shaped for greater systemic impact.

Despite the growing academic and institutional interest in agroecology, the literature remains fragmented across disciplines, regions, and methodological approaches. This fragmentation makes it difficult to obtain a comprehensive understanding of how agroecology is being conceptualized, researched, and applied in the context of sustainable food systems. There is currently a lack of consolidated insights into the evolution of the field, the leading contributors, and the thematic directions of research over time. Furthermore, the connections between agroecology and broader sustainability transitions are often implicit or underexplored in the literature. Without a systematic overview of these developments, researchers, practitioners, and policymakers may struggle to identify priorities, avoid duplication, and harness synergies across sectors. Thus, a comprehensive scientometric review is essential to map the knowledge landscape, highlight emerging trends, and guide future research and practice in this crucial domain. The objective of this study is to conduct a scientometric review of agroecology research with a specific focus on its role in sustainable food systems.

2. METHODS

This study adopts a scientometric approach using VOSviewer to explore the

intellectual and thematic landscape of agroecology research within the context of sustainable food systems. Scientometric analysis enables the systematic mapping of scientific output, collaboration patterns, and knowledge structures based on publication metadata. VOSviewer was selected as the sole analytical tool for its robust capability in visualizing bibliometric networks such as keyword co-occurrence, author collaboration, institutional linkages, and citation relationships. This tool is particularly effective for identifying clusters of related research topics and for tracking the evolution of emerging themes across time.

The data were sourced from the Scopus database, known for its wide coverage of peer-reviewed literature across disciplines. A comprehensive search strategy was formulated using the keywords: "agroecology," "sustainable food systems," "agroecological transition," and variations thereof. Boolean operators were used to combine terms, and filters were applied to restrict the results to journal articles and reviews published between 2000 and 2024, in English. The dataset was then downloaded in CSV and RIS formats, as required by VOSviewer. After cleaning the data, a final set of publications was prepared for analysis.

Once the data were imported into VOSviewer, several types of bibliometric analyses were performed. First, a co-authorship analysis was conducted to identify key authors and collaborative networks. Second, a co-occurrence analysis of keywords was used to detect major research themes and topic clusters. Third, citation analysis was performed to highlight influential publications and understand knowledge flow within the field. VOSviewer's clustering algorithm grouped related keywords and authors into visual maps, enabling intuitive interpretation of thematic structures.

3. RESULTS AND DISCUSSION

Co-Authorship Analysis

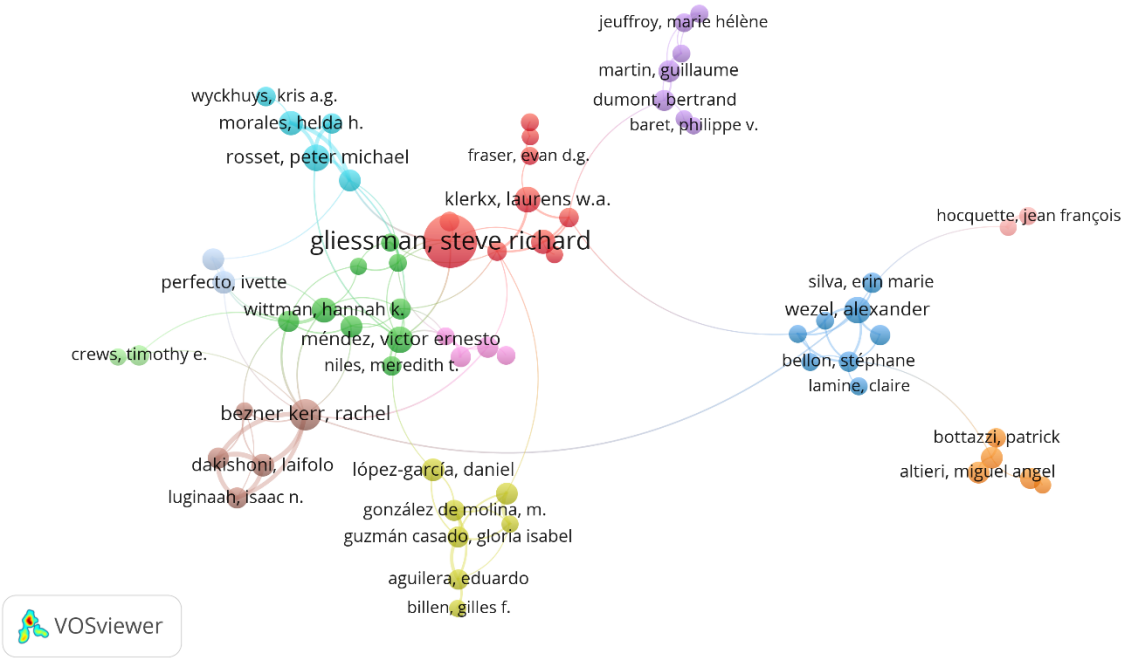

Figure 1. Author Visualization
Source: Data Analysis

The figure at the top indicates the co-authorship network among leading researchers of studies in agroecology and sustainable food systems. Each node represents an author, while the size of the node reflects the number of publications or

citation strength associated with each author. Lines (or links) between nodes denote co-authorship relations, with thicker lines representing stronger collaboration. Notably, Steve Richard Gliessman stands at the center of the largest cluster (red), representing his pivotal position as a key agroecology scholar. His collaborations encompass a number of other researchers such as Laurens Klerkx, Rachel Bezner Kerr, and Peter Michael Rosset, suggesting transdisciplinary and global span. There are also other clearly defined clusters, such as the blue cluster for Alexander Wezel and Claire Lamine, which could represent European research networks, and the orange cluster for Miguel Altieri and Patrick Bottazzi, traditionally associated with Latin American agroecological movements.

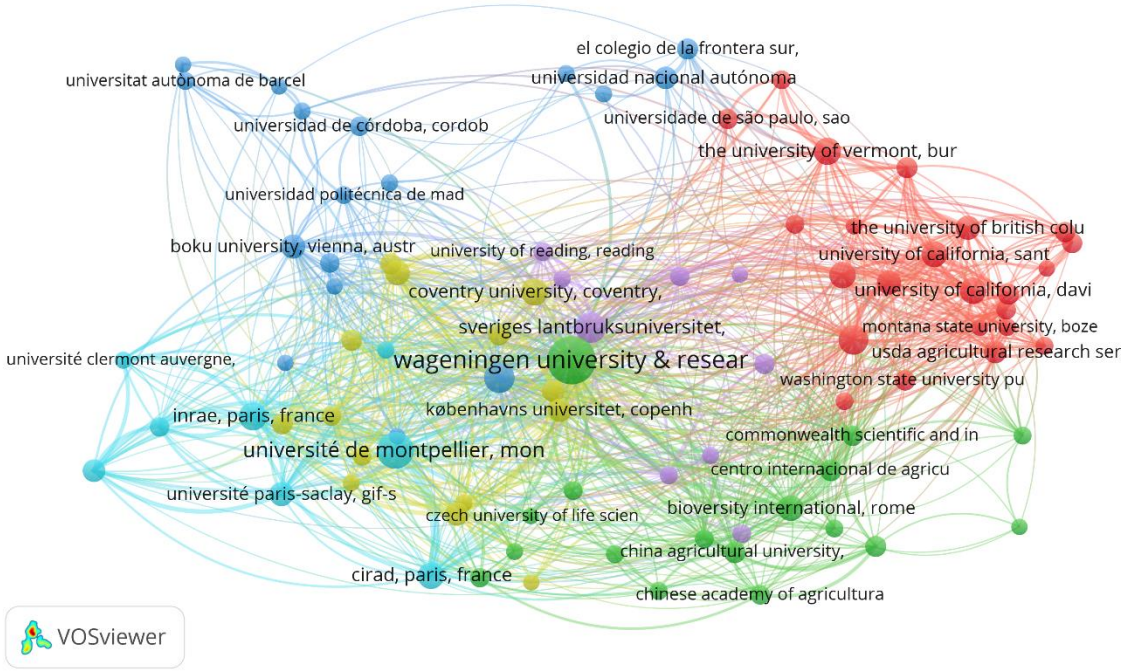

Figure 2. Affiliation Visualization
Source: Data Analysis

Figure 2 displays an institutional co-authorship network of research in agroecology and sustainable food systems. Nodes are research institutions or universities, and node size indicates the volume of scholarly output or citation impact. Lines signify collaboration among institutions, and thicker lines indicate more frequent joint publications. Wageningen University & Research is both the central and most connected node, which signifies its leading role as a worldwide hub for international Agroecology research collaboration. The red cluster includes key North American institutions The University of Vermont, University of California (Santa Cruz and Davis), and USDA Agricultural Research Service, revealing strong research networks within the U.S. The blue cluster includes Spanish and Latin American institutions such as Universidad de Córdoba and El Colegio de la Frontera Sur. The green cluster includes institutions such as China Agricultural University and Biodiversity International, indicating growing participation from Asia and international NGOs. Whereas the turquoise and yellow clusters depict European institutions such as Université de Montpellier, INRAE, and BOKU University Vienna, indicating intense intra-European collaboration.

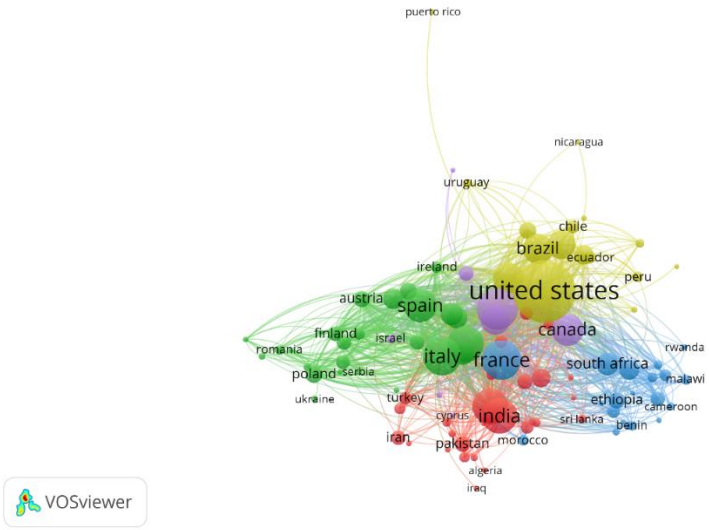

Figure 3. Country Visualization
Source: Data Analysis

Figure 3 shows a country-level co-authorship network of agroecology and sustainable food systems research, illustrating patterns of international collaboration. The nodes represent countries, the size of the nodes reflecting scholarly productivity or influence, and the lines co-authorship relationships—the thicker and more numerous the lines, the more extensive the collaboration. The United States is the most prominent and central actor, with widespread collaboration with countries on all continents. The European nations such as France, Italy, and Spain form a highly connected cluster, showing a strong regional cooperation basis. India is found taking a central position in its red cluster, showing its growing role in agroecology research, particularly in association with nations such as Pakistan, Iran, and Turkey. Conversely, Brazil is the leader of the Latin American network, which is associated with nations such as Chile, Ecuador, and Uruguay. African countries like South Africa, Ethiopia, and Cameroon are also participating, though with comparatively fewer but significant links, mostly with North America and Europe.

Keyword Co-Occurrence Analysis

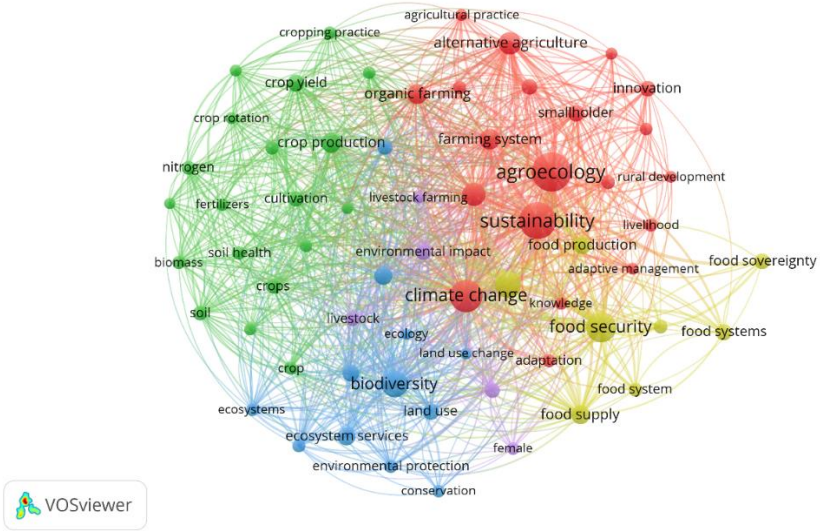

Figure 4. Network Visualization
Source: Data Analysis

Figure 4 is a keyword co-occurrence network from agroecology and sustainable food system literature. A node is a representation of a keyword, while the node size represents how often it occurs in the analyzed corpus. Connecting lines represent the strength of co-occurrence, with more frequent co-occurrences of two keywords being represented with thicker connecting lines. The map is colored into clusters that reflect thematic groups of highly related words. The map presents to us a fascinating glimpse into the conceptual structure and major themes underlying academic discourse in agroecology studies.

In the middle of the map are the most central and most co-occurring terms: "agroecology," "sustainability," "climate change," and "food security." These are the keywords that cross thematic boundaries as conceptual anchors, emphasizing their rootage status in agroecology research. That they are proximate to each other and to one another reflects an integrative research agenda that connects ecological resilience to food system transformation and climate mitigation. The central place of sustainability makes it a key outcome and planning strategy in agroecological change. The red cluster has its core themes being alternative agriculture, organic, smallholder, rural development, and innovation. This cluster embodies the socio-technical and systemic conception of agroecology with a concentration on how alternative forms of farming can enable rural livelihood improvement and systemic agricultural change. These terms highlight studies on transforming mainstream farming practice by the integration of social equity, innovation, and farmer-centered solutions—particularly in smallholder systems. It reflects particular interest in agroecology as a key to more socially equitable and equitable food systems. This compares to the green cluster that has more focus on agronomic and environmental issues, including keywords crop production, crop rotation, soil health, nitrogen, fertilizers, and cultivation.

This cluster is the biophysic nature of agroecology science, focus on maximizing yield, soil fertility, and ecological balance through sustainable farming practices. The strong interlink among these words shows how much of the scientific effort has been to maximize ecological relationships in the field toward both productivity and environmental stewardship. The blue and yellow clusters continue the span of themes. The blue cluster concentrates on ecological and conservation matters such as biodiversity, conservation, ecosystem services, and environmental protection. These are the key terms indicating a deep concern with ecological integrity and nature-based solutions within the agroecological system. The yellow cluster backed by food systems, food security, food sovereignty, and food supply is concerned with an influential policy and socio-political emphasis. It places agroecology in global discussions of equity, access to food, and democratic control of the food syste

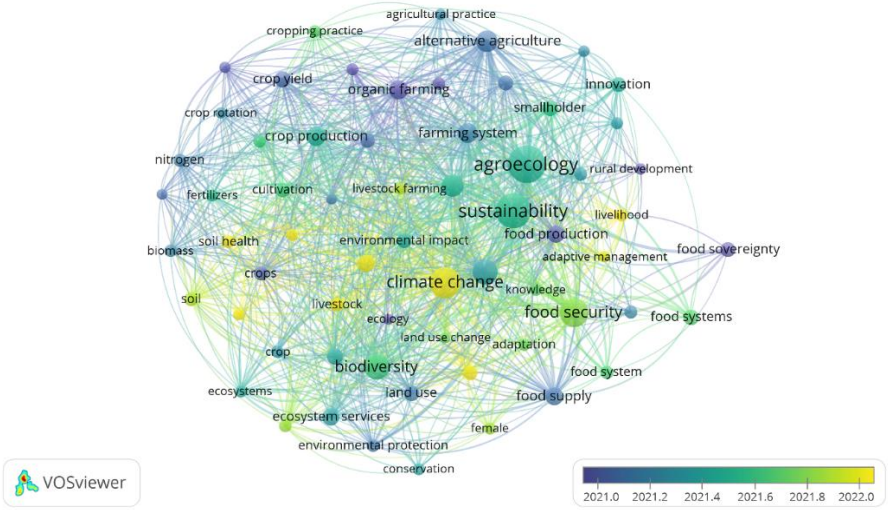

Figure 5. Overlay Visualization
Source: Data Analysis

Figure 5 is a temporal overlay of co-occurrence of keywords between agroecology and sustainable food systems literature published in 2021 and 2022. The color gradient, from dark blue (2021.0) to yellow (2022.0), represents the average year of publication when each keyword is most frequently occurring. Node size still denotes keyword frequency in the dataset, and the connecting lines denote co-occurrence relationships among terms. This map not only shows thematic connections but also displays rising and emergent trends according to recency. Keywords highlighted in bold, bright yellow, such as food sovereignty, climate change, food security, adaptive management, knowledge, and food production, are comparatively newer topics, demonstrating increased attention and research intensity surrounding them in the newest books (nearest to 2022). These are placed towards the map's center, indicating that they are heavily influenced by the central discourse of agroecology. Their increased significance implies a recent scholarly trend towards incorporating political, strategic, and rights-based aspects. In contrast, the terms organic farming, alternative agriculture, crop production, soil health, and fertilizers are blue-shaded towards cooler blues, reflecting earlier usage densities during the first half of the period. These are more deeply rooted themes in agroecological studies that laid the foundations for existing trends.

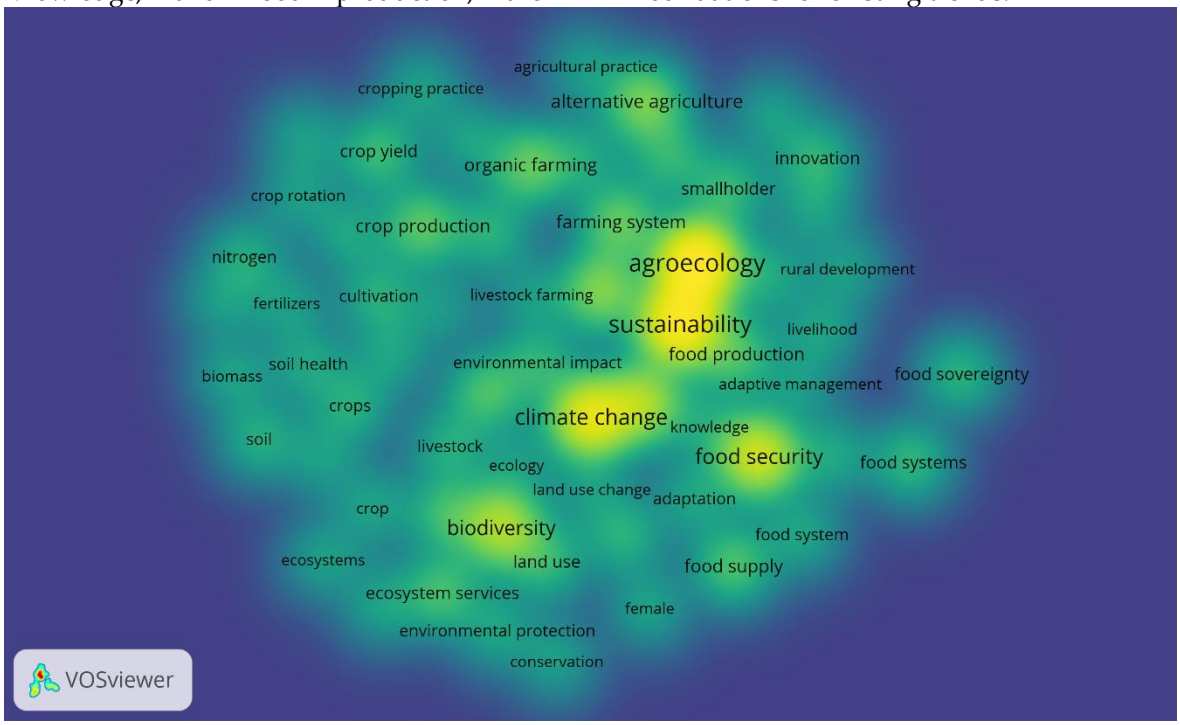

Figure 6. Density Visualization
Source: Data Analysis

Figure 6 presents the research theme frequency in agroecology and sustainable food systems by keyword frequency. The heatmap presented here has brighter yellow and green to indicate greater density of keywords and darker blue to indicate lower density or less frequent keywords. In the middle of the map, the most prominent keywords are agroecology, sustainability, climate change, and food security, which group in a light-colored region. This radiant core is indicative of these themes' functioning and emergence as integral aspects of agroecology research, suggesting that they serve as organic principles in shaping the scholarship. Thick but moderately dense rings surrounding this center consist of terms like organic farming, crop production, soil health, biodiversity, and ecosystem services, which reflect a long and acute focus on the

agronomic and ecological mechanisms through which sustainable agriculture operates. On the periphery, less dense but ultimately relevant topics such as food sovereignty, adaptive management, innovation, and female.

Citation Analysis

Table 1. Top Cited Literature

Citation	Author	Title
553	[1]	Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review
265	[11]	The future(s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents
228	[3]	Agroecology: The Ecology of Sustainable Food Systems, Third Edition
205	[12]	Dairy intensification: Drivers, impacts and alternatives
173	[13]	Characterizing diversity of food systems in view of sustainability transitions. A review
145	[14]	Challenges and potential pathways towards sustainable agriculture within the European Green Deal
140	[15]	Explaining the 'hungry farmer paradox': Smallholders and fair-trade cooperatives navigate seasonality and change in Nicaragua's corn and coffee markets
127	[16]	Development pathways toward “zero hunger”
89	[17]	Dietary contribution of Wild Edible Plants to women’s diets in the buffer zone around the Lama Forest, Benin – an underutilized potential
86	[18]	Agroecological Footprints Management for Sustainable Food System

Source: Scopus Database

Practical Implication

The findings of this scientometric analysis are valuable information for practitioners, researchers, and policymakers involved in the transition of food systems. In uncovering underlying themes like agroecology, sustainability, climate change, food security, and biodiversity as being central to the academic discussion, this analysis demonstrates how urgent it is to place ecological principles at the center of agricultural and food policy. Policymakers can use this evidence to promote agroecological practices as central means to achieving national food security goals with ecological integrity. Furthermore, the visualization of global research networks and institutional collaborations offers a foundation for establishing international partnerships, especially between the Global North and Global South, for knowledge sharing and co-developing context-specific solutions. These results would also be applied by NGOs and practitioners to align their field-level interventions with the most current trends in research so that community-based agricultural programs are evidence-based and internationally networked.

Theoretical Contribution

This study contributes to theoretical agroecology development by means of scientometric mapping of the complete knowledge structure and history of agroecology. Unlike traditional narrative overviews, this work employs co-authorship, keyword co-occurrence, institutional collaboration, and time-series analysis to show how agroecology has evolved from a limited agronomic methodology into a multidisciplinary paradigm involving environmental science, political ecology, development studies, and food system governance. The identification of thematic clusters includes the transdisciplinary character of the subject and its capacity to integrate biophysical, social, and policy dimensions. By visually depicting how research emphasis has progressed along the time axis from central ecological practices to broader systemic concerns such as climate adaptation and food justice, this research provides a dynamic theoretical lens through

which agroecology can be considered both scientific paradigm and transformational movement.

Limitation

For its merits, this study has its limitations.

First, the review is based solely on publications indexed in the Scopus database and does not capture relevant research published in local journals, grey literature, or non-English language publications, particularly from countries where agroecology is being implemented but is under-represented in mainstream academic publication. Second, VOSviewer's application focuses primarily on bibliometric and co-occurrence patterns that, while useful for mapping intellectual landscapes, do not capture the content depth, methodologies, or theoretical arguments of the texts. Certain conceptual nuances or socio-political critiques implicit in the literature may thus go undetected. Lastly, the time frame selected (2000–2024) provides a helpful historical perspective but may underestimate the most recent developments in 2025 and beyond. Follow-up studies could address these limitations by including full-text analysis, multi-database integration, and qualitative synthesis to enhance the understanding of agroecology's evolving role in sustainable food systems.

4. CONCLUSION

This scientometric study has mapped the evolving terrain of agroecology research and its central role in the formulation of sustainable food systems. Through co-authorship networks, institutional collaboration, keyword co-occurrence, and time trends as visualized using VOSviewer, the study shows that agroecology is increasingly realized as an inter- and transdisciplinary and revolutionary approach toward dealing with key global issues such as climate change, food security, loss of biodiversity, and rural development. Fundamental issues like sustainability, food sovereignty, and ecological resilience characterize the debate, an articulation of the shift from mainstream farming practices to system-based, justice-oriented alternatives. The study not only captures the intellectual maturity and worldwide extent of the topic but also offers practical lessons for policymakers, practitioners, and researchers who aim to extend agroecological transitions. By disclosing gaps in research and collaboration patterns, this article provides a foundation for future research as well as cross-sectoral collaboration, further cementing agroecology as a strategic strategy toward resilient and equitable food systems worldwide.

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