EDITORA VERDE
Revista Verde
de Agroecologia e Desenvolvimento Sustentável
Green Journal of Agroecology and Sustainable Development
GVAA GRUPO VERDE DE AGROECOLOGIA E ABELHAS

Research Trend on Agroecology and Sustainable Development Goals: A Bibliometric Analysis

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ARTICLE
Recebido: 03-03-2025
Aprovado: 01-07-2025

Key words:
Agroecology
Scientometric analysis
Sustainable agriculture

ABSTRACT

The objective of this paper was to use bibliometric methods to analyze the publications of "Agroecology" topic research and citation topics of sustainable development goals (SDGs). Based on Web of Science database and using the bibliometric analysis method, this study analysed 3,865 articles and review types of papers on Agroecology topic research from 1979 to December 3, 2024, including 50 top papers classified as highly cited papers and one hot paper according to the Essential Science Indicators database. Papers mainly written in English (94.64%), were from 143 countries or regions and published in 758 journals and book series. The top five journals are Agroecology and Sustainable Food Systems, Sustainability, Frontiers in Sustainable Food Systems, Agriculture Ecosystems Environment, Agronomy for Sustainable Development. The top five countries and regions are USA, France, Brazil, England and Spain, each published more than 265 papers. With co-occurrence network visualization by VOSviewer, all keywords were separated into seven clusters topic research of yield and soil, agriculture sustainability and food sovereignty, biodiversity, sustainable agriculture, climate change on agroforestry, benefits analysis, wildlife. Top 25 keywords with the strongest citation bursts were performed in CiteSpace. Based on ESI database, there are 50 top papers that are both 50 highly cited paper and one hot paper. Most publications focus on five Sustainable Development Goals of 02 Zero Hunger, 15 Life on Land, 13 Climate Action, 03 Good Health and Well Being, 11 Sustainable Cities and Communities. The results help researchers to better understand the current research landscape, but also provide guidance for future research on Agroecology research.

INTRODUCTION

Agroecology has been defined as the science of applying ecological concepts and principles to the design and management of sustainable agriculture and food systems. An agroecological approach to food systems involves consideration of all their interactions with the major challenges of our time food security, water scarcity, climate change, socioeconomic disparity (NIKIEMA et al., 2023; SHAH et al., 2021). In general, agroecology deals with different topics and questions related to agricultural production.

A bibliometric analysis is a rigorous and structured approach to reviewing existing published work that addresses a range of issues within a particular topic or area of research. The goal of a bibliometric analysis is to identify and critically appraise relevant studies and to analyze evidence from reliable sources. Several studies have applied bibliometric approaches to analyze research trends in agroecology and VOSviewer map methods. Wezel and Soldat (2009) analyzed the historical evolution of the scientific discipline of agroecology with a quantitative bibliometric analysis of publications using the term agroecology, as well as a qualitative analysis of definitions, topics and scales on agroecology. Qualitative and quantitative analyses have been used to synthesize the role of permaculture within agroecological frameworks from design, movement, practice, and worldview (FERGUSON; LOVELL, 2014). The study presents the most comprehensive analysis of permaculture literature to date, systematically evaluating 975 peer-reviewed and non-peer-reviewed publications in English, Portuguese, French, and Spanish (TAYLOR et al., 2025). The development of agroforestry can be compared with that of agroecology. The recognition of agroecology as a science has introduced new ways of managing agroforestry systems (BARISAUX, 2017). The review analyses sustainability transitions within agrifood systems, focusing on the role of firms and industries, which provides a greater understanding of the current literature landscape of agrifood sustainable transitions relating to firms and industries and lay a foundation for future research (LEES et al., 2024). The "agroecological transition" has emerged as a framework that aims to explain the complex changes taking place in agrifood systems (FONSECA et al., 2024). Using a bibliometric approach, the paper analyzed studies on sustainability in the food industry in the context of the most cited articles, trends in the number of articles, most influential journals, most influential authors, most productive and influential institutions and countries, and future research directions (SIMSEK et al., 2024). Gervazio et al. (2025) employed a biometric approach to analyze scientific production on family farming and resilience between 2009 and 2023 using the Web of Science database. Sustainability strategies, such as sustainable intensification, multifunctional

agriculture, and agroecology should be implemented to improve sustainability in the dairy sector (MWIRIGI et al, 2025).

The bibliometric analysis points to the cross-sectorial role agroecological farming systems can play in contributing towards addressing the pressing issues of our times food and water security, climate change, socioeconomic disparities (SHAH et al., 2021). The farming systems management, agricultural intensification, and biodiversity management have long been addressed in the past, those relating to the study of strategies and determinants around the adoption of agroecology, the development of knowledge and innovations for food sovereignty, and the study of climate change impacts on farm productivity still need to be explored in depth (NIKIEMA et al., 2023). A bibliometric analysis of agroecological publications to identify sustainability indicators, shows that there is a gap of publications on agroecology and sustainability (CAMPOS et al., 2021). Bibliometric analysis of research paper published on agroecological weed management in Mediterranean landscapes according to the Scopus database (BOUTAGAYOUT, et al., 2023). The research provides valuable insights into the current landscape and future trends regarding the contributions of land restoration and biodiversity to food systems in Africa (RAPIYA et al., 2024). Using the techniques from network science and bibliometrics, the paper evaluates the degree to which the agroecological science transformation has taken place (MASON et al., 2021). The ability of the agroecological transition improves working conditions and provides new jobs (DEDIEU et al., 2022). Sun and Yuan have analyzed the maize or corn intercropping system based on Web of Science (SUN; YUAN, 2024), research trend of rice and greenhouse gases (YUAN; SUN, 2023), trend in landscape ecology topic research (YUAN, 2025a) and rural tourism and agritourism based on Web of Science (YUAN, 2025b). This study highlights the current state of research and the dominant themes in agroecology. However, there is a lack of studies that integrate emerging themes and their evolution in agroecology, limiting strategic guidance for future research.

The purpose of this paper was to use bibliometric methods to analyze the publications of “Agroecology” topic research based on the Clarivate Analytica’s Web of Science (WoS) core database and utilized CiteSpace and VOSviewer software for its bibliometric analysis. Citation topics and sustainable development goals (SDGs) were also analyzed based on WoS results. Therefore, the current study addresses this research gap by undertaking a systematic synthesis of existing research by incorporating bibliometric analysis techniques. By analyzing bibliometric factors such as publication trends, citations, and research networks, the current study sought to provide a comprehensive overview of the current research structure.

MATERIAL AND METHOD

This study employed a rigorous and structured approach to conduct a bibliometric analysis of published work on agroecology. The data sampling strategy was executed on December 3, 2024, utilizing the Web of Science (WoS) Core Collection. The search protocol encompassed the SCIE (1900–present) and SSCI (2005–present) indices, employing a comprehensive Boolean string: "Agroecology" OR “Agro Ecology” OR “Agro-Ecology” OR “Agroecological Intensification” OR “Agroecological Practices” OR “Agroecological Transition” OR “Agroecology Transition” OR “Political Agroecology” OR “Urban Agroecology”. To ensure analytical integrity and focus on original scientific contributions, the dataset was restricted exclusively to "articles" and "review articles," resulting in a final corpus of 3,865 documents.

The bibliometric analysis integrated quantitative indicators and network-based qualitative interpretations to map the field's intellectual structure. Productivity metrics, including the h-index, citation counts, and Impact Factors (JCR 2023), were systematized to evaluate the influence of journals and countries. Network maps for country co-authorship and keyword co-occurrence were generated via VOSviewer software (version 1.6.20), utilizing full counting methods to identify thematic clusters. Additionally, CiteSpace software (version 6.3.R1) was applied for citation burst detection across 25 keywords, allowing for the identification of emerging research fronts and temporal transitions in topical interests.

Network visualizations were created using VOSviewer to analyze collaboration and co-occurrence patterns. The co-authorship analysis of countries resulted in a network of 92 countries or regions that met the threshold of five publications and were grouped into eight clusters. The co-occurrence of all keywords was also visualized, which separated keywords into seven main clusters of topic research. To identify emerging research trends, we performed a citation burst analysis on the top 25 keywords using CiteSpace.

Finally, we analyzed the most influential papers by examining the 50 highly cited papers and one hot paper from the ESI database. The selection of papers was based on the stringent parameters of the Essential Science Indicators (ESI) database. Highly Cited Papers were defined as those ranked in the top 1% by citation count within their respective academic fields based on a citation threshold for their specific field and year of publication. To ensure analytical rigor, the inclusion criteria required documents to be formally indexed within the Essential Science Indicators categories at the time of data retrieval. These papers were analyzed to identify the most influential knowledge frontiers and foundational concepts in agroecological research.

The papers were also analyzed to determine their focus on the Sustainable Development Goals (SDGs), with the most papers focusing on five specific goals: Zero Hunger, Life on Land, Climate Action, Good Health and Well Being, and Sustainable Cities and Communities.

RESULTS AND DISCUSSION

Document type and language of publication

All the 3,865 publications were identified in SCIE (3,449, 89.237 %), SSCI (1,226, 32.755 %). The document types of all papers were article (3,408, 88.176 %) and review articles (457, 11.824 %). Almost papers were published in English (3,658, 94.644 %), and others were French (106, 2.743 %), Portuguese (47, 1.216 %), Spanish (46, 1.19 %), Czech (5, 0.129 %).

Publication output

Figure 1 illustrates publication trends in agroecology research from 1979 to 2025. The highest value was 487 papers in 2023. For the all papers, the *h*-index is 132, the total number of citations were 95,826 over the period and the average

citation per item was 24.79. The earliest paper on Agroecology topic research was "Investigations on Agroecology in Sunflower" written by Hargitay (1979) and published in *Novenytermeles*.

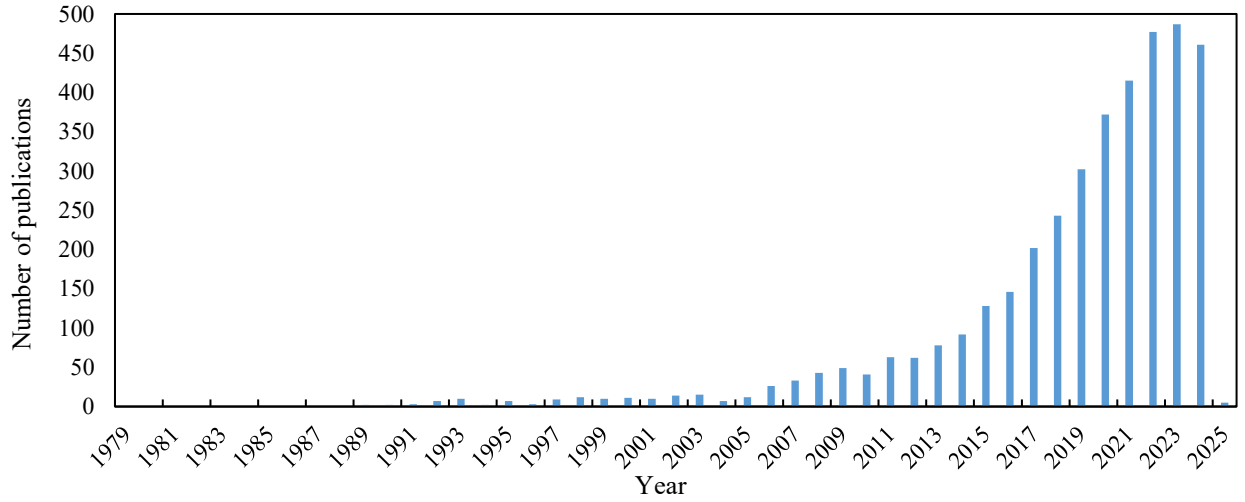

Figure 1. The quantity of published papers on Agroecology topic research from 1979 to 2025.

These results demonstrate that the expansion of publications after 2005 reflects a paradigm shift, in which agroecology has transcended local technical applications to become a pivotal transdisciplinary science addressing global crises such as climate change and food insecurity. This growth in scientific output observed since 2005 aligns with institutional milestones and global crises that established agroecology as a viable alternative to the conventional model. This observed increase coincides with the publication of the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD, 2009) report, which formally advocated for a transition toward agroecological practices to mitigate food insecurity and climate instability. Furthermore, the 2008 food price crisis and increasing pressure to meet biodiversity conservation targets stimulated investment in research networks, particularly in the USA, France, and Brazil, shifting academic focus toward resilient and diversified production systems. This temporal trend reflects the integration of agroecology into international public policy agendas, culminating in its central role in achieving the Sustainable Development Goals (SDGs) over the past decade.

Categories and research areas

There is total 128 subject categories and 79 research areas for Agroecology topic research during 1979-2025. Table 1 showed the top 15 categories and research areas on Agroecology research. The top five categories included Agriculture Multidisciplinary (900, 23.286%), Environmental Sciences (831, 21.501%), Green Sustainable Science Technology (704, 18.215%), Agronomy (582, 15.058%), Ecology (560, 14.489%). The top five research areas include Agriculture (1,688, 43.674%), Environmental Sciences Ecology (1,273, 32.937%), Science Technology Other Topics (821, 21.242%), Plant Sciences (302, 7.814%), Food Science Technology (210, 5.433%).

Table 1. Top 15 categories and research areas on Agroecology topic research from 1979 to 2025*

Rank	Categories			Research areas		
	Categories	No. papers	% total papers	Areas	No. papers	% total papers
1	Agriculture Multidisciplinary	900	23.286	Agriculture	1,688	43.674
2	Environmental Sciences	831	21.501	Environmental Sciences Ecology	1,273	32.937
3	Green Sustainable Science Technology	704	18.215	Science Technology Other Topics	821	21.242
4	Agronomy	582	15.058	Plant Sciences	302	7.814
5	Ecology	560	14.489	Food Science Technology	210	5.433
6	Environmental Studies	439	11.358	Biodiversity Conservation	165	4.269
7	Plant Sciences	302	7.814	Entomology	127	3.286
8	Food Science Technology	210	5.433	Geography	112	2.898
9	Biodiversity Conservation	165	4.269	Development Studies	111	2.872
10	Entomology	127	3.286	Sociology	105	2.717
11	Soil Science	125	3.234	Veterinary Sciences	93	2.406
12	Agriculture Dairy Animal Science	120	3.105	Meteorolog Atmospheric Sciences	92	2.38
13	Multidisciplinary Sciences	117	3.027	Anthropology	89	2.303
14	Geography	112	2.898	History Philosophy of Science	86	2.225
15	Development Studies	111	2.872	Business Economics	77	1.932

* Clarivate Analytics's Web of Science categories

Journal Co-Citation Analysis

All publications were published in 758 journals and book series. The top 20 core journals were displayed in the Table 2, and Journal impact factor as IF 2023 and IF 5 years, Quartile rank in category, total citations and average citations per paper. As to one journal belongs to different WoS category, and the Quartile rank in category was selected the highest one.

Table 2. Top 20 core Journals on Agroecology topic research indexed in the Web of Science (WoS)

Rank	Journal	TP	Ratio	IF 2023	IF 5 year	QC	Citations	Avg. citations
1	Agroecology and Sustainable Food Systems	269	6.96	2.4	3.3	Q1	4421	16.4
2	Sustainability	205	5.304	3.3	3.6	Q2	3582	17.5
3	Frontiers in Sustainable Food Systems	137	3.545	3.7	4.7	Q2	1285	9.4
4	Agriculture Ecosystems Environment	127	3.286	6	6.4	Q1	7395	58.2
5	Agronomy for Sustainable Development	109	2.82	6.4	7.9	Q1	8667	79.5
6	Agricultural Systems	94	2.432	6.1	6.4	Q1	2824	30.0
7	Agriculture and Human Values	74	1.915	3.5	4.2	Q1	1354	18.3
8	Journal of Peasant Studies	63	1.63	4.6	5.7	Q1	3031	48.1
9	Agronomy Basel	58	1.501	3.3	3.7	Q1	583	10.1
10	Journal of Applied Ecology	54	1.397	5	6.2	Q1	2390	44.3
11	Elementa Science of the Anthropocene	51	1.32	4.7	5.2	Q1	453	8.9
12	Cahiers Agricultures	48	1.242	1	1.1	Q3	294	6.1
13	Fourrages	44	1.138	0.1	0.2	Q4	1609	36.6
14	Journal of Rural Studies	44	1.138	5.1	5.5	Q1	51	1.2
15	Heliyon	41	1.061	3.4	3.9	Q1	212	5.2
16	Agroforestry Systems	40	1.035	2	2.5	Q2	609	15.2
17	International Journal of Agricultural Sustainability	40	1.035	3.3	4.2	Q1	892	22.3
18	Land	39	1.009	3.2	3.4	Q2	267	6.8
19	European Journal of Agronomy	35	0.906	4.5	5.1	Q1	1107	31.6
20	Renewable Agriculture and Food Systems	33	0.854	2	2.5	Q2	555	16.8

Note: TP: Total publications; Ratio: Ratio of 3,865 (%); IF 2023: journal impact factor in 2023; IF5 year: journal impact factor of 5 years; QC: Quartile in category.

The top five journals are Agroecology and Sustainable Food Systems (269, 6.96%), Sustainability (205, 5.304 %), Frontiers in Sustainable Food Systems (137, 3.545), Agriculture Ecosystems Environment (127, 3.286%), Agronomy for Sustainable Development (109, 2.82%). Among the top 20 journals in Table 2, thirteen journals were in Quartile 1, five journals were in Quartile 2, one journal was in Quartile 3, one journal was in Quartile 4. Journals in the Q1 rank are considered to have the highest impact. Based on the average citations per papers in Table 2, the top five journals with average citations more than 36.6 times were Agronomy for Sustainable Development (79.5), Agriculture Ecosystems & Environment (58.2), Journal of Peasant Studies (48.1), Journal of Applied Ecology (44.3), Journal of Rural Studies (36.6).

According to citation sources analysed by VOSviewer, among the 758 journals, there were 140 journals met the thresholds of five and 135 journals connected to each other, which were separated into thirteen clusters (Figure 2). The center journals for thirteen clusters were Agronomy for Sustainable Development, Heliyon, Journal of Peasant Studies, Cahiers Agricultures, Agricultural Systems, Renewable Agriculture and Food Systems, Sustainability, Agriculture-Basel, Revista De La Facultad De Ciencias Agrarias, Land, Frontiers in Microbiology, Landbauforschung-Journal of Sustainable and Organic Agricultural Systems, Horticultura Brasileira, respectively. The analysis of international collaboration reveals that the eight identified clusters transcend geographic proximity and are structured around linguistic affinities and shared research agendas. The cluster led by France and Sub-Saharan African countries (such as Ethiopia) reflects a robust North-South cooperation focused on climate resilience and food security in tropical regions. Conversely, the cluster linking the USA and Brazil highlights a synergy in large-scale research on agroecological transition and public policy, leveraging the vast territorial extent of both nations for systemic impact studies. This fragmentation into clusters demonstrates that agroecological science is not monolithic; rather, it is stratified into distinct knowledge fronts ranging from biophysical ecological intensification to food sovereignty movements, consolidating a global network that enables the exchange of technologies adapted to diverse socioeconomic contexts.

Countries/regions co-authorship analysis

There were 143 countries or regions that contributed all papers. Table 3 represent the top 20 countries or regions that published equal to or more than 88 papers. Top 5 countries or regions were USA, France, Brazil, England and Spain. The top five countries with average citations per paper more than 39.2 times were Sweden, Netherlands, Germany, USA, Australia. Figure 3 show the publications trends for five countries or regions from 1979 to December 3, 2024. Based on the publications, USA and France are the first and second country on this topic and the published paper increased after 2005.

More cooperation could bring more advanced achievements in scientific research. Nowadays, increasing concept of international exchanges have promoted academic communications. Among 143 countries or regions, there are 92 countries or regions that met the threshold as five and connected with each other that were divided into eight clusters (Figure 4). According to number of publications from high to low among each cluster, the first cluster (red colour) consisted of twenty-four countries or regions as France, Ethiopia, et al. The second cluster (green) consisted of twenty-four countries

or regions as Spain, Italy, et al. The third cluster (blue) consisted of fourteen countries or regions as Peoples R China, Australia, et al. The fourth cluster (yellow) consisted of fourteen countries and regions as USA, Brazil, et al. The fifth cluster (violet) consisted of twelve countries and regions as England, Germany, et al. The sixth cluster (shallow blue) consisted of both Canada and Malawi. The seventh cluster (orange) consisted only Paraguay. The eighth cluster (pink) consisted only Taiwan of China. Taiwan, a region of China, shows the stronger research ability of agroecology research.

Table 3. Top 20 countries published papers of Agroecology topic research based on Web of Science (WoS)

Rank	Countries/Regions	Records	% of 3,865	Avg. citations
1	USA	886	22.924	40.3
2	France	828	21.423	27.3
3	Brazil	319	8.254	19.1
4	England	319	8.254	36.1
5	Spain	265	6.856	22.5
6	Italy	240	6.21	16.0
7	Ethiopia	239	6.184	28.7
8	Germany	224	5.796	43.4
9	Netherlands	216	5.589	46.0
10	Canada	207	5.356	34.7
11	Mexico	172	4.45	26.0
12	Peoples R China	140	3.622	27.2
13	Switzerland	120	3.105	36.0
14	Belgium	109	2.82	31.0
15	Australia	104	2.691	39.2
16	Argentina	99	2.561	22.2
17	India	94	2.432	14.2
18	Kenya	92	2.38	28.1
19	Sweden	91	2.354	49.1
20	Colombia	88	2.277	25.7

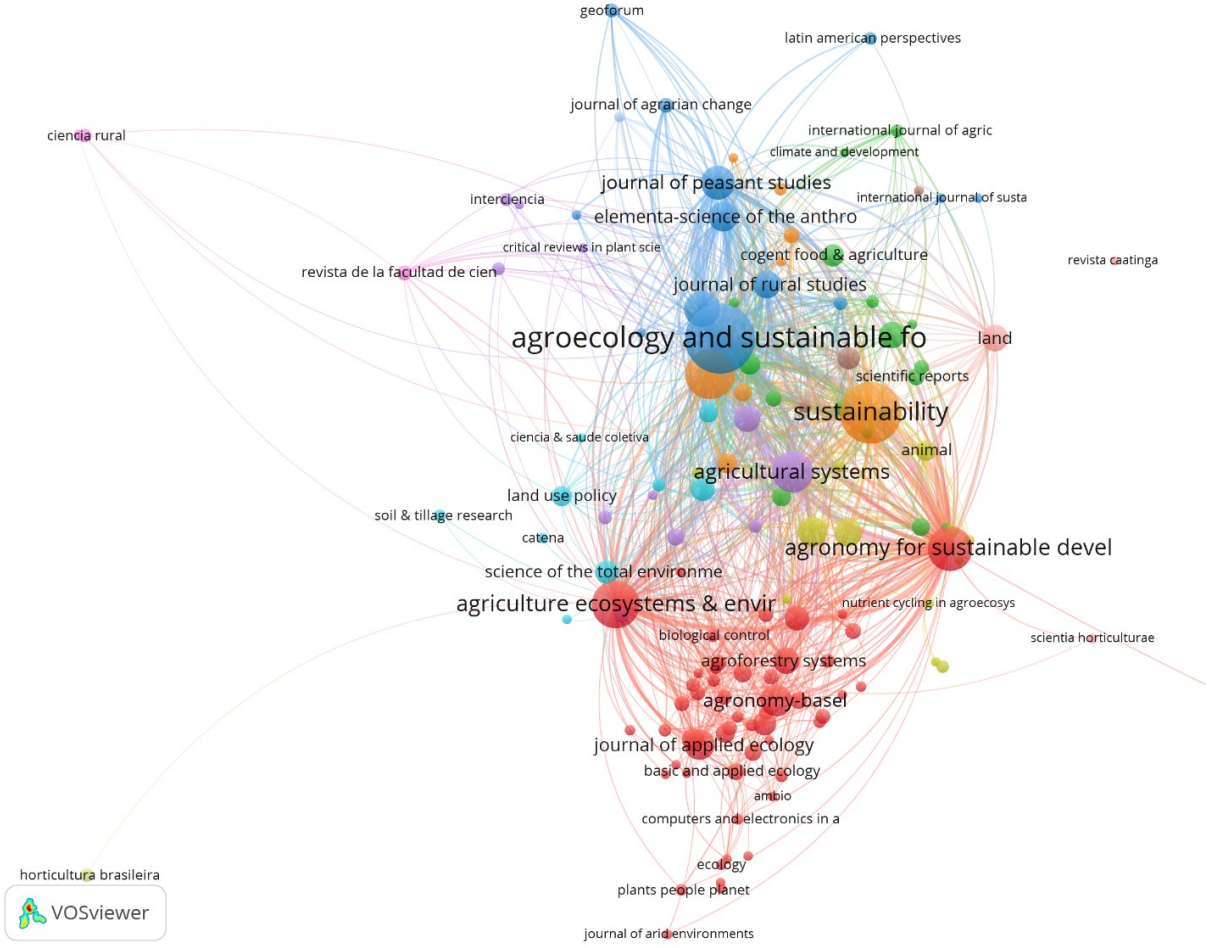

Figure 2. Network visualization maps of citation journals with minimum of 5 publications in the field of Agroecology topic research based on Web of Science (WoS) with 135 circles and thirteen clusters

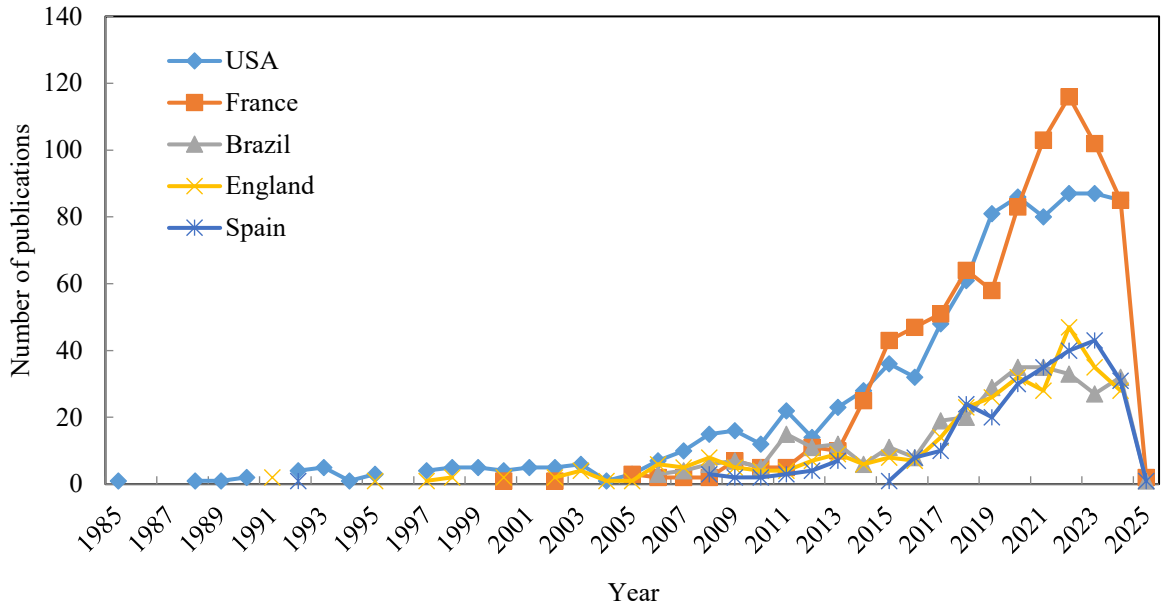

Figure 3. Trends of publications for five countries studied on the Agroecology.

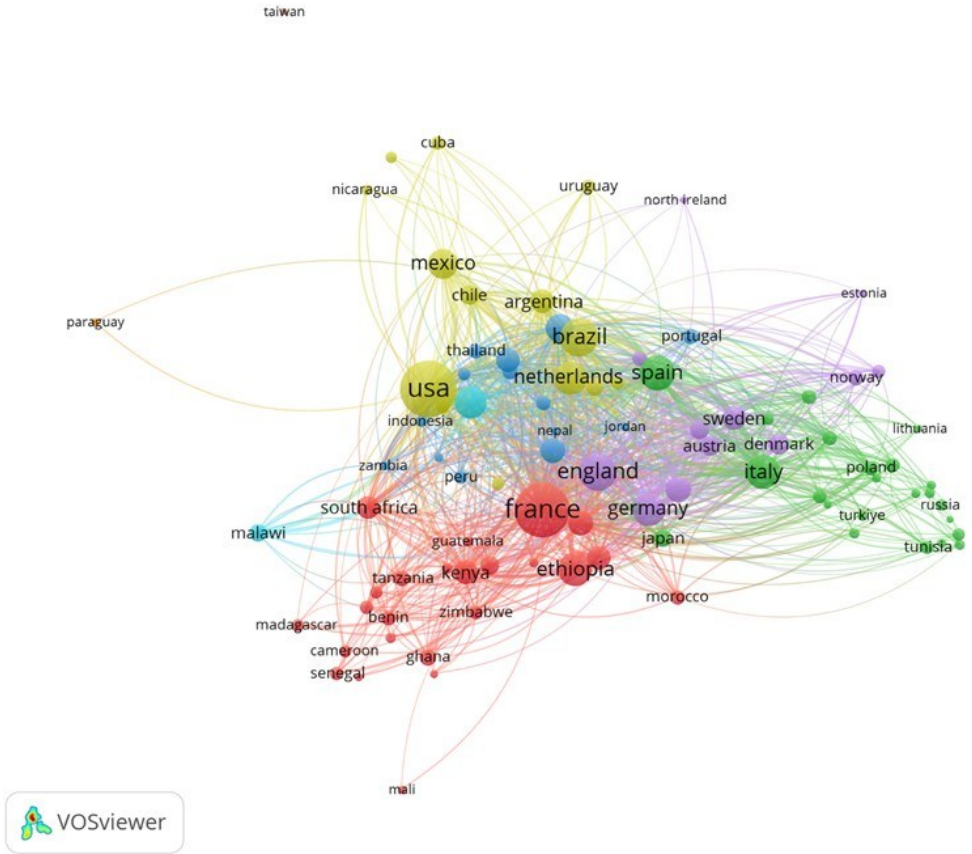

Figure 4. The country co-authorship network map of Agroecology topic research based on Web of Science (WoS) with 92 nodes and eight clusters. The different colors group represented the different clusters formed by sets of countries.

All Keywords co-occurrence analysis

Keywords serve as concise summaries of the main themes in the literature. By the co-occurrence, author keywords, keywords plus and all keywords as unit were chosen and analysed. Here, co-occurrence network visualization of all keywords was analysed.

For the author keywords by full counting method for co-occurrence analysis, there were total 9,663 author keywords, and 601 author keywords met the threshold level of five, which were separated into fourteen clusters in network map visualization. The top twenty co-occurrence author keywords were agroecology, agro-ecology, ecosystem services, biodiversity, sustainable agriculture, sustainability, food security, food sovereignty, agriculture, climate change, agroforestry, organic farming, agroecological transition, organic agriculture, resilience, food systems, agrobiodiversity,

biological control, Ethiopia, Brazil, each author keywords occurred more than 50 times.

For the keywords plus, there were total 6,278 keywords plus, and 797 keywords plus met the threshold level of five and were separated into eight clusters in network map visualization. The top twenty co-occurrence keywords plus were management, agriculture, biodiversity, systems, diversity, agroecology, ecosystem services, sustainability, conservation, food, soil, yield, climate-change, farmers, growth, impact, dynamics, land-use, knowledge, biological-control, each keyword plus occurred more than 119 times.

For all keywords, there were total 14,294 all keywords, and 1,337, 1098, 905 all keywords met the threshold level of five, six, seven, respectively. There are seven main clusters that represent different viewpoints on Agroecology topic research met the threshold level of seven (Figure 5). The top twenty co-occurrence all keywords were agroecology, biodiversity, agriculture, management, sustainability, diversity, systems, ecosystem services, conservation, food sovereignty, sustainable agriculture, agro-ecology, food security, yield, soil, food, farmers, climate-change, growth, nitrogen, each all keywords occurred more than 139 times.

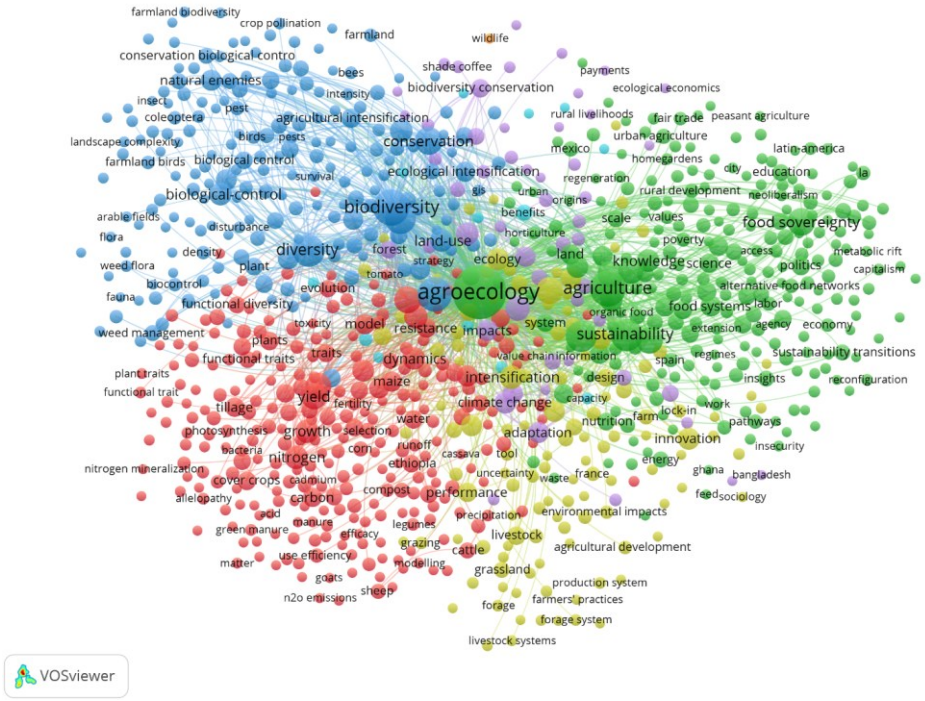

Figure 5. VOSviewer co-occurrence network visualization of most frequent all keywords on Agroecology topic research with seven main clusters. Co-occurrence network of all keywords including author keywords and keywords plus.

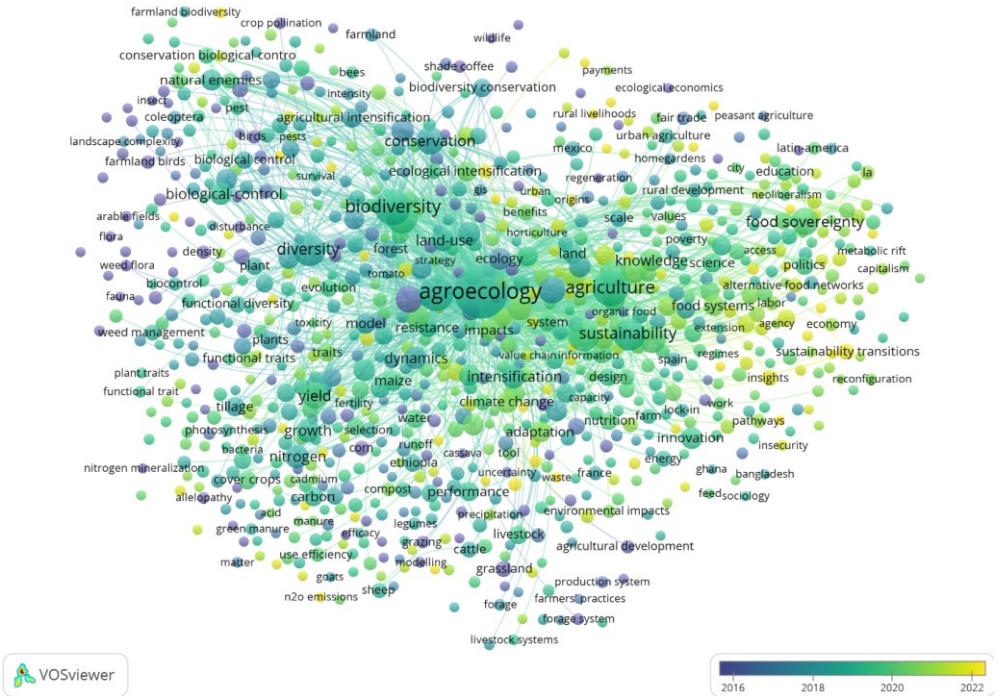

Figure 6. VOSviewer co-occurrence overlay visualization mapping of most frequent all keywords on Agroecology topic research. The years in which specific keywords frequently occur are shown by different colours.

The same data in Figure 5 were then arranged by a period of Agroecology topic research as overlay map (Figure 6). In Figure 6, blue colour indicated earlier research topics, whereas yellow and green colours indicate the more recent topics of interest. Yellow and green circles present those research fronts. The second cluster (green in Figure 5) represent the agriculture sustainability and food sovereignty was the front research.

Here, the seven clusters for different topics on Agroecology topic were given in Figure 5, such as crop yield and soil in agro-ecology system, agriculture sustainability and food sovereignty, biodiversity, sustainable agriculture, climate change on agroforestry, benefits analysis, wildlife.

The first cluster (red in Figure 5) has 278 all keywords met the threshold level of seven and focused on crop yield and soil in agro-ecology system, and the top 20 most frequently used all keywords includes agro-ecology yield, soil, growth, nitrogen, impact, dynamics, productivity, quality, cropping systems, maize, model, carbon, resistance, tillage, water, wheat, cover crops, plants, strategies, each all keywords occurred more than 59 times.

The second cluster (green in Figure 5) has 247 all keywords and represent the agriculture sustainability and food sovereignty, and top 20 most frequently used agroecology, agriculture, sustainability, systems, food sovereignty, food security, food, farmers, knowledge, resilience, organic agriculture, food systems, land, agroecological transition, networks, science, transition, Africa, health, policy, each all keywords occurred more than 66 times. This cluster was the front research (Figure 6).

The third cluster (blue in Figure 5) has 194 all keywords and represent the biodiversity, and the 20 most frequently used biodiversity, management, diversity, ecosystem services, conservation, land-use, biological-control, landscape, abundance, communities, natural enemies, ecological intensification, agroecosystems, organic farming, agricultural intensification, vegetation, biological control, agricultural landscapes, species richness, plant, each all keywords occurred more than 52 times.

The fourth cluster (yellow in Figure 5) has 119 all keywords and represents the sustainable agriculture, and 20 most frequently all keywords include as sustainable agriculture, intensification, ecology, innovation, conservation agriculture, framework, farming systems, adoption, performance, crop, livestock, indicators, design, environment, trade-offs, grassland, Europe, participatory research, principles, technology, each all keywords occurred more than 33 times.

The fifth cluster (violet in Figure 5) has 53 all keywords and focused on climate change on agroforestry, and top 21 all keywords include as climate-change, agroforestry, climate change, impacts, adaptation, sustainable intensification, agrobiodiversity, biodiversity conservation, forest, smallholder farmers, coffee, vulnerability, diversification, Sub-Saharan Africa, agroforestry systems, risk, perceptions, deforestation, crop diversification, land use, trees, each all keywords occurred more than 22 times.

The sixth cluster (shallow blue in Figure 5) has 13 all keywords and is focused on the benefits analysis, which includes of benefits, metanalysis, food production, capacity, diet, preferences, crop management, trade-off, ecological engineering, ecological restoration, attitudes, demand, world.

The seventh cluster (orange in Figure 5) has only one keywords of wildlife, more than 9 times.

Burst of keywords

A keyword with strong emergence can reflect a new perspective with a high impact in a certain period, thus showing a phase of academic frontier. The word frequency exploration was performed in CiteSpace (Basic version 6.3.R1), and the top 25 keywords related to Agroecology topic research from 1994 to 2024 were used (Figure 7). The keywords are sorted by the beginning years of bursts. The period during which these keywords are more popular among scholars is depicted in red. Emerging research trends in agroecology can be identified through the temporal dynamics and intensity of keyword citation bursts. Top 25 keywords with the strongest citation bursts were diversity, sustainable agriculture, agricultural intensification, management, agricultural landscapes, biodiversity conservation, abundance, ecology, innovation, conservation, cropping systems, services, cropping system, political ecology, resilience, governance, model, land, plant, intensification, agroforestry, plants, security, benefits, animal production.

The influence of the identified top papers lies in their capacity to provide the conceptual and methodological foundations that define contemporary agroecology. Works such as Altieri (1999) and Cassman (1999) established the core principles of ecological intensification by integrating agricultural productivity, functional biodiversity, and soil quality, offering a robust conceptual alternative to conventional intensification models. Subsequent studies, including Pretty (2008) and Tscharntke et al. (2012), expanded this framework by explicitly linking agroecology, biodiversity conservation, and global food security through widely replicated empirical evidence. Contributions such as Gianinazzi et al. (2010) introduced key ecological mechanisms, particularly the role of arbuscular mycorrhizal fungi, thereby strengthening the functional basis of ecosystem services in agroecological systems. Furthermore, Altieri and Toledo (2011), Wezel et al. (2014), and Altieri et al. (2015) were instrumental in systematizing agroecology as a science, practice, and socio-political movement, integrating resilience, food sovereignty, and climate change adaptation. These manuscripts are highly cited because they continue to guide research design, public policy formulation, and contemporary scientific agendas in agroecology.

Top papers based on Essential Science Indicators (ESI)

Here, the ESI database has been updated as November 14, 2024, data covers 10-year and 8-month period: January 1, 2014 - August 31, 2024. Based on ESI database, there are 50 top papers that are both 50 highly cited paper and one hot paper. These 50 top papers were published in different year with 2014 (4), 2015 (5), 2016 (2), 2017 (5), 2018 (7), 2019 (2), 2020 (6), 2021 (5), 2022 (5), 2023 (5) and 2024 (4). And these top papers published in journals with more than two papers were Agronomy for Sustainable Development (11), Journal of Peasant Studies (5), Agricultural Systems (3), Ecology Letters (2), Journal of Rural Studies (2), Proceedings of the National Academy of Sciences of the United States of America (2).

The annual citations of the eight papers showed an increasing trend after year of publication (Figure 8). The eight papers were written by Altieri (1999), Tscharntke et al. (2012),

Cassman (1999), Pretty (2008), WEZEL et al. (2014), Altieri and Toledo (2011), Altieri et al. (2015), Gianinazzi et al (2010). Here, the total citations for the most eight frequently cited articles were more than 576 times. From the publication year to December 3, 2024, the total citations for each paper of the most citation eight papers were 1536, 1269, 961, 923, 678, 636, 611 and 576 times, and the average citation per year each paper were 59.08, 97.62, 36.96, 54.29, 61.64, 45.43, 61.1 and 38.4 times. Among the eight articles, the highest average citation paper per year were 97.62 (TSCHARNTKE et al., 2012), also includes other two papers both Wezel et al. (2014) and Altieri et al. (2015), which they were the top papers (highly cited paper) based on Essential Science Indicators.

Figure 7. Information about top 25 keywords of Agroecology research with the strongest citation bursts from 1994 to 2024. Begin, year when the burst begins; End, year when the burst ends. Red grids indicate the years when a particular term started to be frequently used. A longer the red bar, the keywords has been cited for a longer duration.

Citation topics Meso and Micro

Based on the analysis results, there are 108 levels of Meso-topics and 298 levels of Micro-topics for Agroecology topic research papers. Table 4 show the top 10 Meso-topics and Micro-topics for all research papers. In Table 4, the most five Meso-topics are 6.263 Agricultural Policy (1385, 35.834 %), 3.45 Soil Science (429, 11.1 %), 3.40 Forestry (377, 9.754 %), 3.32 Entomology (355, 9.185 %), 3.4 Crop Science (188, 4.864%); and the most five Micro-topics are 6.263.1407 Urban Agriculture (765, 19.793 %), 6.263.898 Farmers (522, 13.506 %), 3.45.112 Microbial Biomass (142, 3.674%), 3.32.54 Biological Control (137, 3.545 %), 3.40.195 Maxent (122, 3.157 %).

Sustainable development goals

According to the InCites Benchmarking & Analytics Help File, The Sustainable Development Goals (SDGs) schema allows to explore and analyse according 17 SDGs. Table 5 show all Sustainable Development Goals for Agroecology research papers. The analysed publications addressed all seventeen SDGs, and the most papers are focused on five Sustainable Development Goals of 02 Zero Hunger (2,688, 69.547 %), 15 Life on Land (2,205, 57.05 %), 13 Climate Action (1,429, 36.973 %), 03 Good Health and Well Being (1,249, 32.316 %), 11 Sustainable Cities and Communities (1,002, 25.925 %).

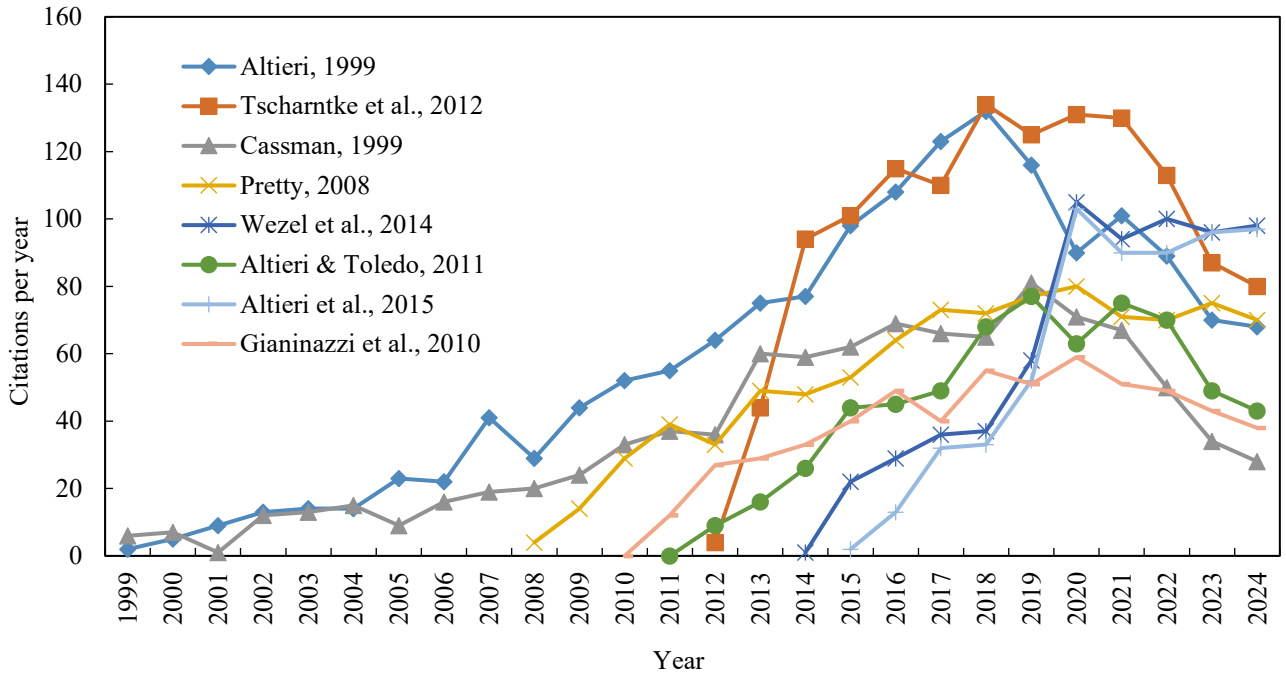

Figure 8. Comparison of the citations per year of the most eight papers related to Agroecology topic research from their initial publications to December 3, 2024.

Table 4. Comparison of the top 10 Citation Meso-topics and Citation Micro-topics for Agroecology topic research papers.

Rank	Citation Topics Meso			Citation Topics Micro		
	Meso-topics	No. papers	% of 3,865	Micro-topics	No. papers	% of 3,865
1	6.263 Agricultural Policy	1385	35.834	6.263.1407 Urban Agriculture	765	19.793
2	3.45 Soil Science	429	11.1	6.263.898 Farmers	522	13.506
3	3.40 Forestry	377	9.754	3.45.112 Microbial Biomass	142	3.674
4	3.32 Entomology	355	9.185	3.32.54 Biological Control	137	3.545
5	3.4 Crop Science	188	4.864	3.40.195 Maxent	122	3.157
6	3.275 Crop Protection	134	3.467	3.275.705 Herbicide Resistance	116	3.001
7	3.97 Plant Pathology	124	3.208	3.45.1616 Intercropping	101	2.613
8	6.153 Climate Change	98	2.536	3.32.750 *Apis mellifera*	92	2.38
9	3.51 Dairy & Animal Sciences	58	1.501	6.263.1720 Edible Insects	88	2.277
10	3.16 Phytochemicals	52	1.345	3.40.627 Deforestation	82	2.122

Table 5. All seventeen Sustainable Development Goals for Agroecology topic research papers.

Rank	Sustainable Development Goals	Record Count	% of 3,865
1	02 Zero Hunger	2,688	69.547
2	15 Life on Land	2,205	57.05
3	13 Climate Action	1,429	36.973
4	03 Good Health and Well Being	1,249	32.316
5	11 Sustainable Cities and Communities	1,002	25.925
6	12 Responsible Consumption and Production	914	23.648
7	14 Life Below Water	680	17.594
8	06 Clean Water and Sanitation	166	4.295
9	01 No Poverty	150	3.881
10	07 Affordable and Clean Energy	66	1.708
11	09 Industry Innovation and Infrastructure	65	1.682
12	08 Decent Work and Economic Growth	19	0.492
13	04 Quality Education	14	0.362
14	10 Reduced Inequality	9	0.233
15	05 Gender Equality	5	0.129
16	16 Peace and Justice Strong Institutions	5	0.129
17	17 Partnerships for the Goals	2	0.052

The strong convergence of agroecological research with SDG 2 (Zero Hunger), SDG 15 (Life on Land), and SDG 13 (Climate Action) is rooted in the inherently multifunctional nature of the discipline, which leverages biodiversity to simultaneously promote food security and climate mitigation. The alignment with SDG 2 reflects agroecology's role in establishing sovereign and resilient production systems, while SDG 11 (Sustainable Cities and Communities) gains prominence through the expansion of urban agriculture, linking rural production to conscious consumption in urban centers.

However, a critical gap is observed regarding social and institutional dimensions. SDGs such as 05 (Gender Equality), 10 (Reduced Inequalities), and 16 (Peace, Justice, and Strong Institutions) show minimal representation in the analyzed literature, indicating that scientific focus remains heavily skewed toward biophysical and productive metrics. This underrepresentation suggests a strategic opportunity for future research to integrate social equity and agrarian justice as inseparable components of sustainability, moving the field toward a more holistic approach to sustainable development.

CONCLUSIONS

The agroecology research landscape has shown accelerated and substantial growth, with the number of publications increasing rapidly after 2005. The largest contributions to agroecology research originated from five countries, two on the American continent, the USA and Brazil, and three European ones, France, England, and Spain, in five main journals. The analysis of keyword co-occurrence revealed that the central research themes are organized into seven topic clusters: yield and soil, agriculture sustainability and food sovereignty, biodiversity, sustainable agriculture, climate change on agroforestry, benefits analysis, and wildlife. Additionally, the majority of articles focused on five Sustainable Development Goals (SDGs). These findings offer a clear view of the current research situation, highlighting the areas of greatest focus and providing a strategic basis for future investigations.

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