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Article

Agroecology in Brazil: A Scientometric Analysis of Knowledge Production and Research Trends (2010-2025)

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RESUMO

Este estudo cienciométrico analisa 449 publicações sobre agroecologia no Brasil (2010-2025) da Web of Science, revelando três achados principais. Primeiro, o Brasil domina a produção global (899 artigos) com crescimento anual de 2,7 trabalhos, mas apresenta baixa influência (mediana de 16 citações contra 299 de líderes internacionais). Segundo, a análise de redes identifica três perfis: produtores de volume (ex.: Rosset PM, 15 artigos), especialistas influentes (Giraldo OF, 6,6 citações/artigo) e colaboradores intensivos (Meek D, 6,98 artigos fracionados). Terceiro, os clusters temáticos mostram fragmentação - enquanto "agroecologia" funciona como um ponto central (TLS=497), temas sociopolíticos como "soberania alimentar" (29 ocorrências) permanecem periféricos às pesquisas técnicas sobre solos. O mapeamento institucional revela dominância do Sudeste (EMBRAPA, USP) junto a polos emergentes no Nordeste (UECE com 29 artigos em 2021). Os dados expõem um paradoxo: apesar da robusta produção científica, a pesquisa brasileira falha em influenciar políticas ambientais. Os resultados destacam a necessidade urgente de integrar disciplinas e transformar capital acadêmico em mudança prática, especialmente para agricultura familiar e comunidades tradicionais.
Palavras-chave: redes de conhecimento; contexto histórico; agricultura sustentável.

ABSTRACT

This scientometric study analyzes 449 agroecology publications from Brazil (2010-2025) extracted from Web of Science, revealing three key findings. First, Brazil dominates global output (899 articles) with 2.7 annual growth, yet shows limited influence (median 16 citations vs. 299 for international leaders). Second, network analysis identifies three research profiles: high-volume producers (e.g., Rosset PM, 15 articles), influential specialists (Giraldo OF, 6.6 citations/article), and intensive collaborators (Meek D, 6.98 fractionalized articles). Third, thematic clusters demonstrate fragmentation - while "agroecology" serves as central hub (TLS=497), social-political themes like "food sovereignty" (29 occurrences) remain peripheral to technical soil research. Institutional mapping shows southeastern dominance (EMBRAPA, USP) alongside emerging northeastern hubs (UECE's 29-article surge in 2021). The study exposes a paradox: despite robust scientific production, Brazilian research struggles to influence policy amid environmental deregulation. These findings highlight the urgent need to bridge disciplinary divides and transform academic capital into practical change, particularly for family farming and traditional communities facing agribusiness expansion.
Keywords: knowledge networks; historical context; sustainable agriculture.

Introduction

Brazil is a world leader in tropical agriculture, but this has produced environmental damage that cannot always be calculated. But there is hope and the emergence of agroecological movements in the 1990s has become more prominent today, bringing with it a greater awareness among the population of the need to consume environmentally and socially correct products, such as organic and agroecological ones. Addressing the history of agriculture, agroecology and the resulting movements, as well as their aspects and this awakening

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to a more sustainable agriculture will provide support and greater understanding to society in general, since the subject is multidisciplinary and needs to be increasingly disseminated in the scientific and social environment. There is an urgent need to address the issue in the most diverse areas and spheres.

In 1960, there was a successive demand for food and other products, thus beginning a process of modernization known as the Green Revolution. It was a period of agricultural modernization and new forms of farming, which led to changes in livestock and agriculture (Balsan 2006; Faria 2014). The devastation of nature and the environment, the environmental exploitation caused by technological, scientific and economic development have generated a degenerative process of nature, causing worldwide concern about the recovery, conservation and management of natural resources. (Rampazzo 1997; Balsan 2006; Faria 2014).

Furthermore, the use of agricultural machinery has resulted in the decay and alienation of farmers, causing economic, social and cultural damage, as well as the loss of traditional peoples' knowledge, techniques and cultures to make way for a culture manufactured and sold by agribusiness industries. And the issue of land and territoriality, in which traditional peoples (such as indigenous peoples, quilombolas, etc.), peasants and others have a relationship of survival with them, but have faced oppression and disapproval from small capitalist groups over many years, owners of large plots of land from which their profits and status are obtained through the exploitation of labor, forests and traditional territories. (Fiorini 2021).

A bibliometric study aims to identify current trends in this field, helping to pinpoint gaps and areas requiring further development. Such findings enhance our understanding of Agroecology's influence and guide future research directions. An analytical overview of the field's current status supports robust scientific conclusions by examining progress made, evolutionary trends, and identifying research gaps and future developments (Zhang et al. 2025).

Accordingly, we conducted a comprehensive bibliometric and network analysis of academic research on Agroecology, focusing on its socio-historical development in Brazil. This approach visualizes the current landscape while analyzing future development trends in the field.

Material and methods

Data collection and analysis

For this bibliometric analysis, we selected the Web of Science (WoS), recognized as one of the leading global academic databases due to its comprehensiveness and reliability (Archambault et al. 2009). The research was conducted in the WoS Core Collection, covering the period from 2010 to July 30, 2025, with the aim of mapping studies on the history and evolution of Agroecology in Brazil. The search strategy employed the following terms:

•Agroecological Practices: TS = ("organic agricultur" OR "organic farm" OR agroecolog* OR "agro-ecolog*");

•Socio-Educational Dimensions: TS = ("histor" OR "rural education" OR "education for sustainab" OR "peasant movement" OR "social movement");

•Geographical Focus: ALL = ("Brazil" OR "Brazilian").

The TS (Topic Search) approach, based on Boolean logic, enables comprehensive retrieval of relevant literature using a focused set of descriptors (Mongeon e Paul-Hus 2016; Li et al. 2020). Initially 490 documents were reported. After applying filters and removing duplicates, we obtained a final corpus of 449 publications (2010-2025), represented by English (311), Portuguese (114), Spanish (22) and French (2). The extracted metadata included authors, institutions, keywords, publication year, journals, and references (Abdeljaoued et al.

2020; Shi et al. 2021). To ensure data quality, we performed standardization of synonymous terms, elimination of inconsistent records, and consolidation of duplicates (Chen et al. 2021).

Bibliometric analysis methods

Bibliometrics has established itself as an essential tool for synthesizing large volumes of scientific production (Aznar-Sanchez et al., 2018). In this study, we employed VOSviewer (VOSviewer 2025) and R language (R Core Team 2021) to develop bibliometric maps, analyzing: (1) collaboration networks among authors and institutions (Caparrós-Martínez et al. 2021); (2) contributions by countries and institutions; and (3) term co-occurrence and thematic clustering. VOSviewer's methodology involves three key stages: co-occurrence matrix construction; similarity matrix generation (with frequency variation adjustments); spatial mapping via Euclidean distance minimization; and cluster definition with chromatic distinction between themes (van Eck e Waltman 2006). This approach enables identification of current trends and future perspectives in agroecological practices, socio-educational dimensions, and their geographical focus on Brazil (Zhu and Liu 2020).

Results and Discussion

Distribution of publications over the years

The annual article output shows marked growth starting in 2016 (from 18 to 35 articles), stabilizing post-2020 at approximately 40-45 articles/year, with a peak in 2021 (53 articles) (Figure 1-A). The regression equation ($y = 4549.88 + 2.27x$, $R^2 = 0.58$) indicates a significant upward trend (≈2.7 articles/year) through 2024. The country-specific scientific production reveals Brazil's exponential dominance (from 12 to 899 articles over 15 years), contrasting with the linear growth of the US (150 articles) and the delayed progression of Mexico and Spain (Figure 1-B).

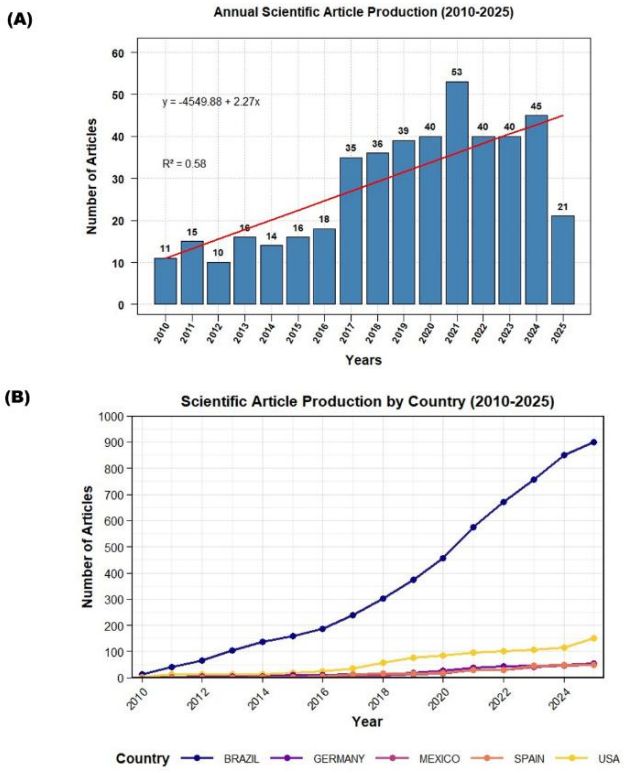

Figure 1. (A) Temporal trends in annual scientific article production (2010-2025); (B) Country-specific production patterns. Source: data obtained from Web of Science (2025).

Analysis of the journals, citations, publications and authors

The scientometric analysis identified 28 journals grouped into seven thematic clusters (Figure 2-A), revealing distinct publication patterns. Cluster 1, featuring journals like Agriculture, Ecosystems & Environment and Soil & Tillage Research (notable for high impact, with Soil & Tillage Research receiving 330 citations); Cluster 2 (Agroecology and Sustainable Food Systems with 596 citations); while Cluster 7 contained the most-cited journal (Journal of Peasant Studies, 1,281 citations). Brazilian journals (*Revista Brasileira de Ciência do Solo, Ciência Rural*) showed strong regional representation but limited global reach, whereas international journals dominated citation counts.

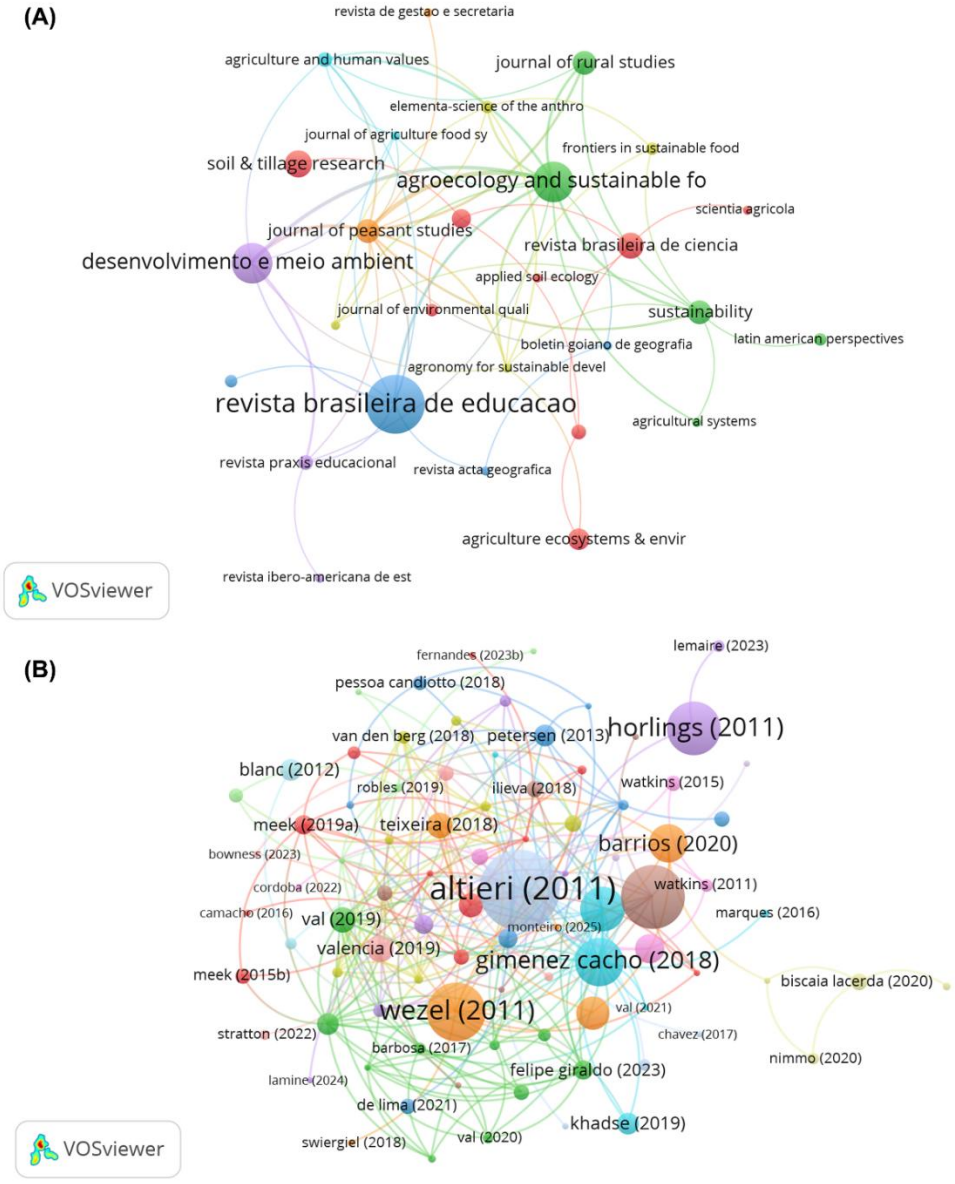

Figure 2. (A) Co-occurrence of journals; (B) Citation network. Source: data obtained from Web of Science (2025).

The citation network analysis reveals a distribution with 15 clusters (Figure 2-B), where the top 10 documents (3.3% of the dataset) account for 38% of total citations, led by Altieri and Toledo (2011) seminal paper with 696 citations (Table 1). This demonstrates the field's reliance on foundational theoretical works, while recent publications (2020-2024) show accelerated citation rates (e.g., Wezel et al. (2020) with 73 citations/year) but limited network integration (median links=1), suggesting emerging research fronts have yet

to achieve the connectivity of established clusters. Notably, 47% of documents received zero citations, indicating either niche specialization or low visibility, and Brazilian-affiliated authors appear predominantly in low-citation publications (median=16 citations vs. 299 for international lead authors), highlighting persistent Global North dominance in knowledge dissemination despite the geographic focus on Brazil.

Table 1. Bibliometric indicators of scientific publications on agroecological practices, historical context, and socio-educational dimension, based on the 8 most cited records.

Papers	Journals	Year	TC	TC / Year	NTC
The agroecological revolution in Latin America: rescuing nature, ensuring food sovereignty and empowering peasants	Journal of Peasant Studies	2011	696	46,40	6,57
Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review	Agronomy for Sustainable Development	2020	438	73,00	13,70
Agroecology as a Science, a Movement and a Practice	Sustainable Agriculture Vol. 2	2011	357	23,80	3,37
Towards the real green revolution? Exploring the conceptual dimensions of a new ecological modernisation of agriculture that could 'feed the world'	Global Environmental Change	2011	299	19,93	2,82
Bringing agroecology to scale: key drivers and emblematic cases	Agroecology and Sustainable Food Systems	2018	239	29,88	6,36
Solutions for humanity on how to conserve insects	Biological Conservation	2020	231	38,50	7,22
Agroecology as a territory in dispute: between institutionality and social movements	Journal of Peasant Studies	2018	199	24,88	5,30
Low-carbon agriculture in South America to mitigate global climate change and advance food security	Environment International	2017	167	18,56	9,74

Total citations (TC); Citations per year (TC/YR); Normalized citations (NTC). Source: data obtained from Web of Science (2025).

Table 2 reveals three distinct research profiles: Rosset PM leads in publication volume (15 articles) yet shows moderate impact (55 citations), while Giraldo OF demonstrates greater relative influence (53 citations from 8 articles = 6.6 citations/article). Meek D emerges as the primary collaborator (6.98 fractionalized articles), with intermediate producers (Giraldo OF, Val V) exhibiting higher citation ratios than top publishers, suggesting a quantity-quality tradeoff. These patterns identify three strategic approaches: the high-volume individual producer (Rosset PM), the networked collaborator (Meek D), and the focused influencer (Giraldo OF).

Table 2. Leading authors by productivity (articles) and influence (local citations).

Rank	Author	Articles	Local Citations	Articles Fractionalized
1	ROSSET PM	15	55	5.07
2	MEEK D	10	40	6.98
3	GIRALDO OF	8	53	2.32
4	VAL V	8	32	2.15
5	BARBOSA LP	7	28	1.95
6	ROSSET P	6	35	1.34

Fractionalized counts reflect shared authorship credit. Source: data obtained from Web of Science (2025).

Network analysis of the institutions

Network analysis reveals *Empresa Brasileira de Pesquisa Agropecuária* (EMBRAPA) as the dominant Brazilian institution (52 publications), followed closely by the University of São Paulo (49) and Federal University of Rio Grande do Sul (47), confirming a productivity hierarchy concentrated in southeastern Brazil (Figure 3-A). However, citation metrics show persistent asymmetries - while São Paulo state institutions (USP, UNESP) lead in volume, international collaborators like Wageningen UR (27 publications) and ECOSUR (20) maintain disproportionate influence through high-impact networks. Notably, Ceará State University (39 publications) emerges as an unexpected connector, suggesting regional specialization in agroecological research.

The data reveal three distinct institutional profiles: (1) high-volume/low-connectivity Brazilian universities (e.g., UFSC 38 pubs), (2) strategic international bridges (Wageningen, ECOSUR), and (3) EMBRAPA as both productive (52 pubs) and moderately connected, reflecting its dual role as national research leader and international collaborator in agricultural sciences. This tripartite structure underscores Brazil's challenge in converting publication volume into global research leadership, with the exception of EMBRAPA's effective bridging position in environmental-agricultural interfaces.

Temporal analysis (Figure 3-B) reveals three distinct institutional trajectories in Brazilian agroecological research: (1) Steady leaders (USP, UFSC) showing consistent annual growth since 2010 (USP: 1→49 articles; UFSC: 2→38), (2) Late accelerators (EMBRAPA, UFRGS) with exponential growth post-2015 (EMBRAPA 2→52; UFRGS 0→47), and (3) Recent emergers (UECE) demonstrating rapid adoption since 2019 (0→39). Notably, São Paulo institutions (USP, UNESP) maintain stable leadership, while EMBRAPA's research output surpassed all universities after 2021, reflecting shifting national priorities. The data exposes regional disparities - Southern institutions (UFSC, UFRGS) developed earlier (2010-15) than Northeastern counterparts (UECE only active post-2015), suggesting infrastructure and funding imbalances. Particularly striking is UECE's meteoric rise (29 articles in 2021 alone), indicating successful regional capacity-building in Northeast Brazil. These patterns collectively depict a maturing yet uneven national research ecosystem, where historical advantages (USP), federal investments (EMBRAPA), and strategic regional development (UECE) create divergent productivity pathways."

Cluster analysis (Figure 3-C) highlights distinct agroecology collaboration patterns: Cluster 1 (*EMBRAPA Agrobiologia, Universiade Federal de Viçosa*, Wageningen) focuses on technical research (soils, sustainable systems); Cluster 2 (ECOSUR, UECE, Chulalongkorn) addresses social and educational dimensions of agroecology; Cluster 3 (UFSC, Unicamp, Michigan) connects studies on agroecological transition and public policies; while Cluster 4 (UNAM, UFRJ) features sporadic, less thematic collaborations. The most robust networks in Brazil integrate technical research (Cluster 1) and critical approaches (Cluster 2), with EMBRAPA and ECOSUR serving as anchor institutions in their respective domains.

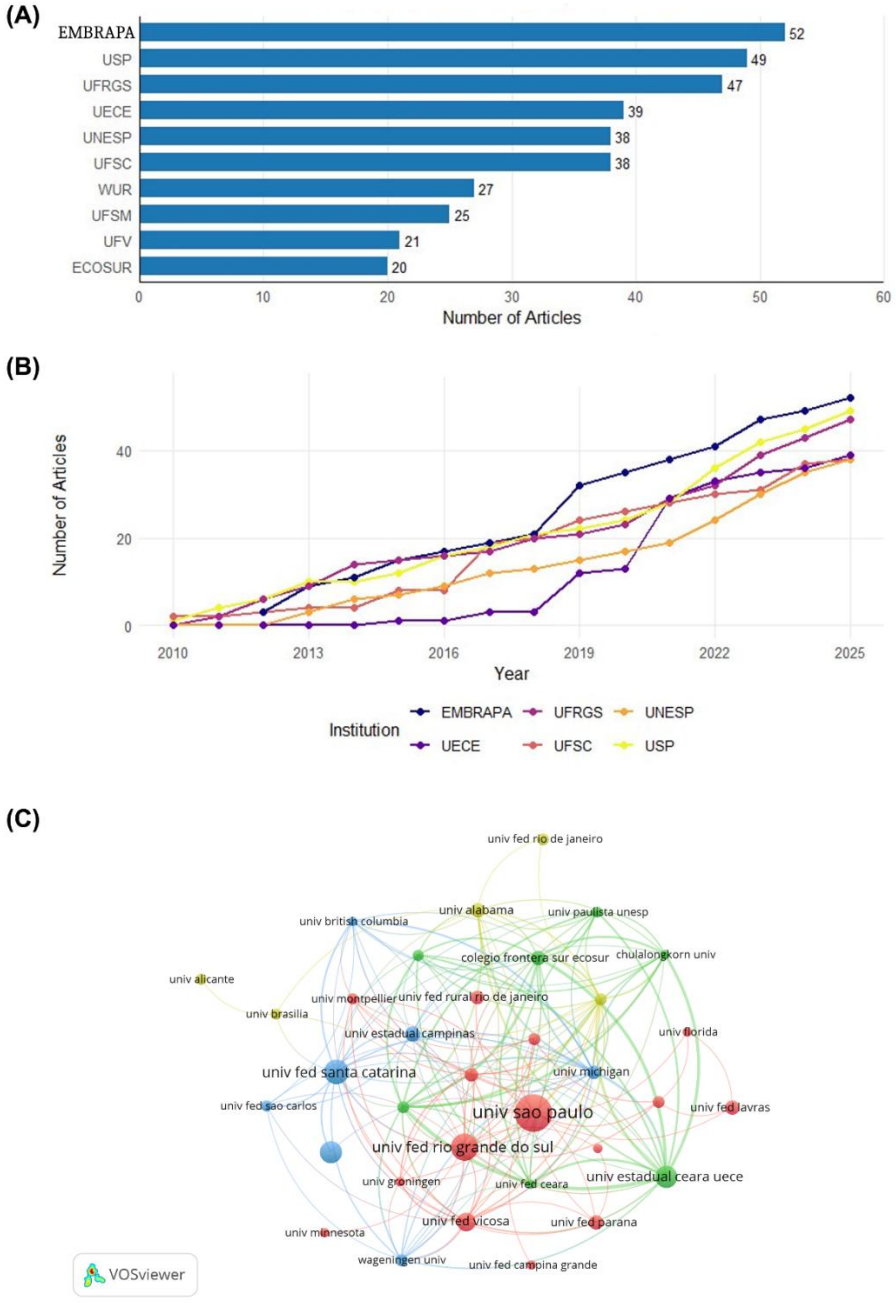

Figure 3. Institutional scientific production. (A) Top 10 institutions by article; (B) Temporal trends (2010-2025) per institutions; (C) Collaboration network clusters by institutions. Horizontal bar chart displaying the top 10 most productive institutions ranked by publication output. Institutions are labeled with their acronyms: EMBRAPA (Brazilian Agricultural Research Corporation), USP (University of São Paulo), UFRGS (Federal University of Rio Grande do Sul), UECE (State University of Ceará), UNESP (São Paulo State University), UFSC (Federal University of Santa Catarina), WUR (Wageningen University & Research, Netherlands), UFSM (Federal University of Santa Maria), UFV (Federal University of Viçosa), and ECOSUR (The College of the Southern Border, Mexico). Source: data obtained from Web of Science (2025).

Network analysis of cooperation between countries

The distribution of scientific production among countries reveals a highly concentrated output, with Brazil emerging as the dominant contributor (899 articles), followed distantly by the United States (150 articles) and Germany (54 articles) (Figure 5-A). This asymmetry suggests a strongly centralized collaboration network, where Brazil potentially serves as a hub for international cooperation in this research domain. The steep decline in productivity among subsequent countries (e.g., Mexico 50, Spain 48, France 46) indicates a long-tail distribution characteristic of preferential attachment networks, where established collaborators attract more partnerships. Notably, 60% of countries (30/50) contributed ≤5 articles, reflecting peripheral network participation.

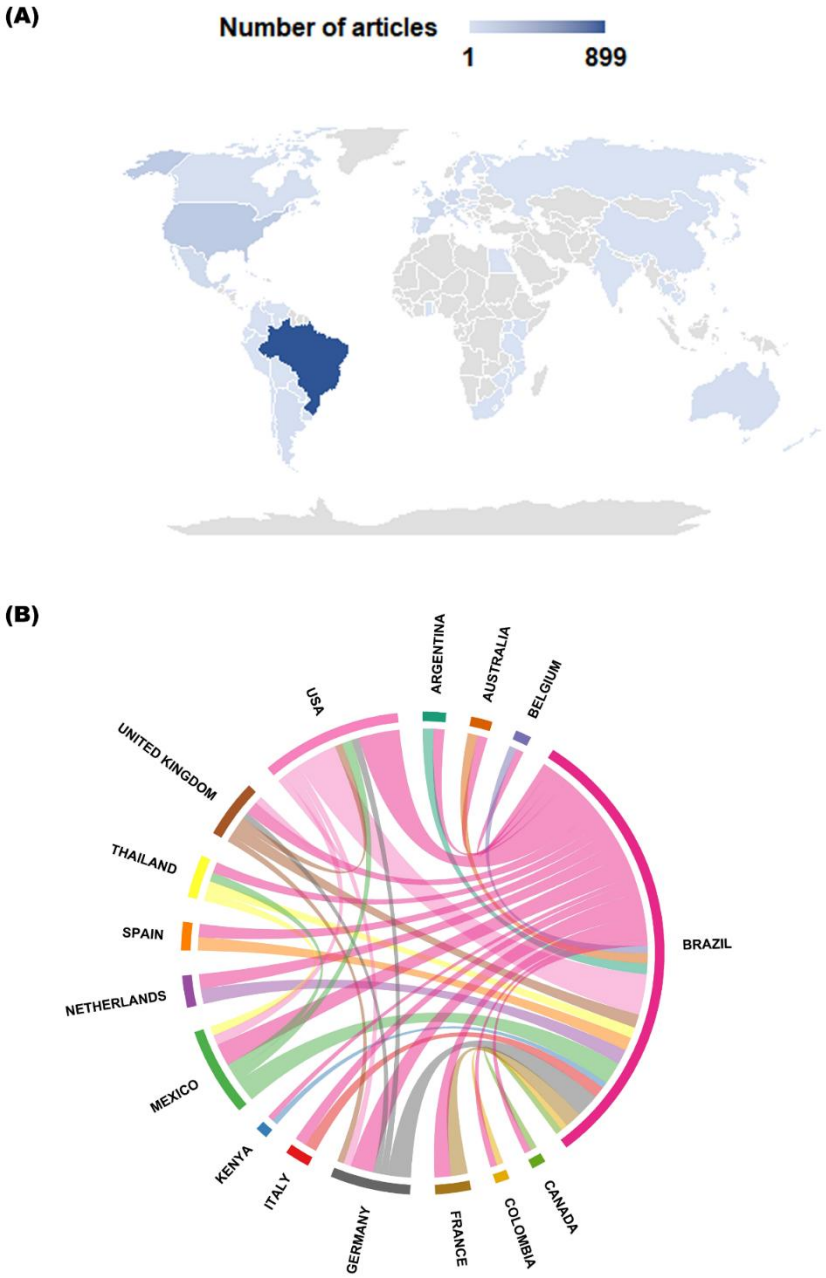

Figure 5. (A) Country-level scientific output distribution; (B) Collaboration network chord diagram visualizing international partnerships with the top 16 countries. Source: data obtained from Web of Science (2025).

The chord diagram highlights Brazil as the central nucleus of scientific collaborations (Figure 5-B), with strongest partnerships to the US (49), Germany (28), and Mexico (27), revealing asymmetric global networks.

The predominance of traditional partners (US and Europe) demonstrates reliance on established networks, underscoring the need for diversification, particularly within Latin America.

Co-occurrence analysis of the keywords

The data reveal that "agroecology" (129 occurrences) (Figures 6A and 6B), "organic-matter" (26), and "brazil" (43) emerge as the most frequent terms, indicating their centrality in the analyzed literature. The high frequency of "agroecology" reflects its consolidation as a dominant conceptual framework, while the prominent presence of "brazil" demonstrates the geographic bias of the studies. Terms like "food sovereignty" (29), "social movements" (23), and "rural education" (23) highlight the strong intersection between technical and sociopolitical dimensions in agroecological research. The distribution follows a typical power law, with a few terms accounting for most occurrences.

The total link strength (TLS) shows that "agroecology" (TLS=497) has the largest co-occurrence network (Figure 6C), serving as a conceptual hub connecting multiple subfields. Terms like "management" (TLS=227) and "organic-matter" (TLS=179) demonstrate high connectivity, suggesting their importance as cross-cutting themes. Notable patterns include: (1) strong associations between agronomic topics ("carbon" TLS=115; "phosphorus" TLS=60) and ecological ones ("biodiversity" TLS=124), and (2) bridges between natural and social sciences ("political ecology of education" TLS=59). Network analysis would reveal distinct yet interconnected thematic clusters.

Agroecology: history and concept

For Gliessman (2000), Agroecology is descended from Ecology and Agronomy, and is influenced by traditional farming systems, mainly those of indigenous peoples and peasants in developing countries, which researchers call exemplary sites of agroecosystem management. For Guzmán (2004), Agroecology is the ecological management of natural resources collectively adhered to social actions, which would therefore be a way forward in the face of civilization's collapse, with the help of farmers' actions, collective planning and the local bond resulting from the connection between rural groups.

Agroecology emerged in the 1980s with the aim of bringing together Agronomy and Ecology (Caporal 2005). Agroecology was born in the 1980s, with epistemological and methodological bases of transdisciplinary knowledge inspired by the social, agricultural and natural sciences, especially applied ecology. It seeks to recover traditional agriculture, even if only to use it on a new basis. Agroecology therefore encompasses popular knowledge about the environment and the management of natural resources "in agricultural or extractive production processes, which has been accumulated by traditional or peasant communities over the years, thus articulating scientific knowledge with this knowledge" (Assis e Romeiro 2005; Caporal 2005; Fonseca 2009).

The first studies on Agroecology began in the 20th century, but it only became more widespread in the 1980s (as did its conceptual and methodological basis) with Miguel Altieri and Stephen Gliessman being its crucial propagators (Moreira e Carmo 2004). From the influence of the European school, Agroecology in the 2000s brought a slightly more sociological perspective on agroecosystems, renewing their cultural, socioeconomic and even socio-political aspects. (Casado et al. 2000)

The concept of agroecology has become more widespread because of academics who have endeavored to extend the scientific basis of the agroecological practices of community movements with a view to changing agriculture, as well as society and its food systems. Furthermore, there was a consensus of observations and criticisms about research into transgenics, its regulation and application to agricultural productivity (Lacey 2007; Tomich et al. 2011). And it is precisely this discussion about the transformation of agriculture and how to reduce the impacts of agriculture that will lead to agroecology.

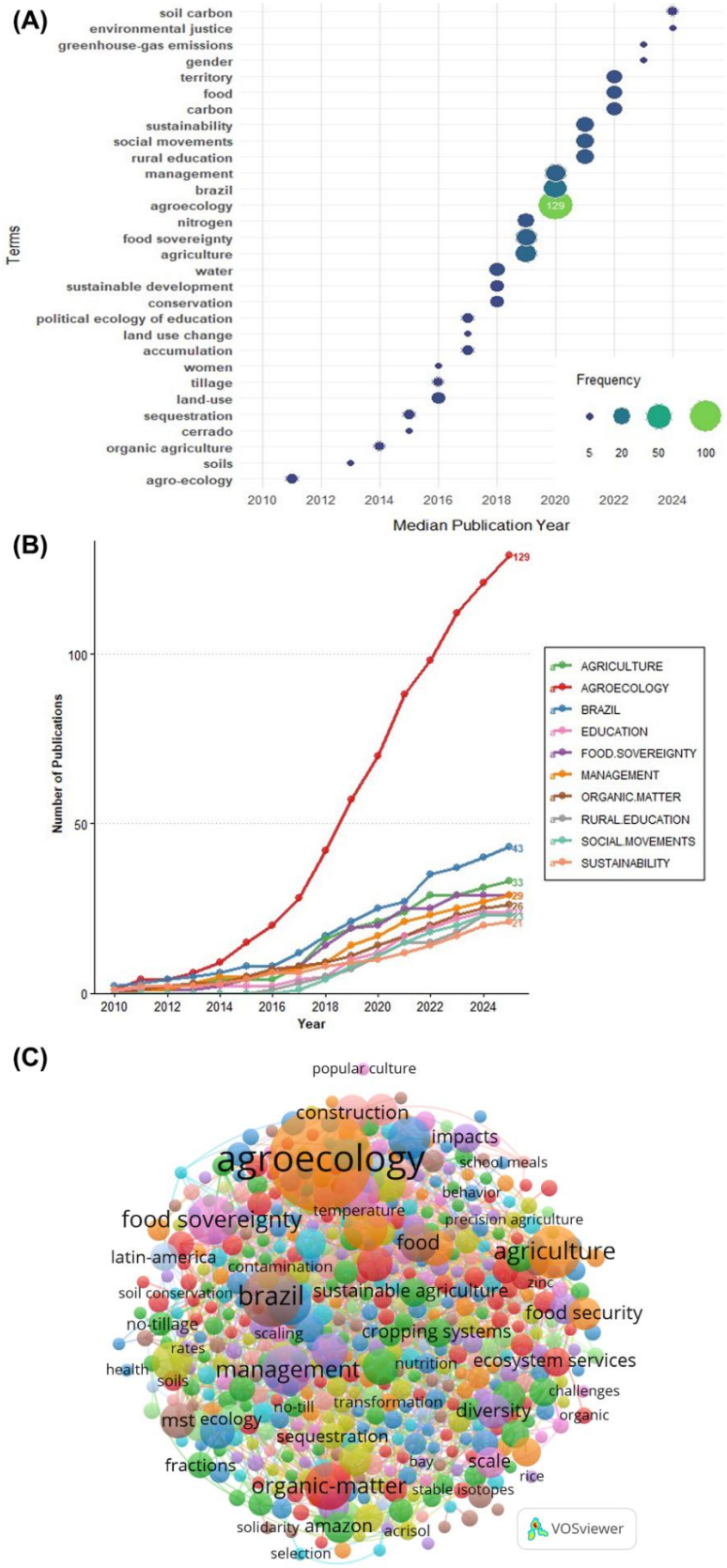

Figure 6. (A) Temporal evolution of keywords (2010-2025); (B) Annual trend of publications related to the search terms; (C) Keywords co-occurrence network. Source: data obtained from Web of Science (2025).

Agriculture is the human activity that occupies the largest areas of the planet and that most affects the environment. However, it is possible to minimize its harmful effects through planning and the attitudes needed

to improve favorable influences, and it is possible for farming to generate benefits for the biophysical and socio-economic environment (Leite and Torres 2008; Araujo et al. 2010).

Caporal says that there are various types of alternative agriculture with different philosophical orientations and methodological perspectives (various practices and technologies, bans on certain inputs, among others), which are: Natural, Ecological, Biological or Organic, Biodynamic, Permaculture, and so on. However, these various currents do not necessarily follow the same basic principles and knowledge as Agroecology. According to the same author, "an agriculture that, for example, only deals with replacing conventional chemical inputs with "alternative", "ecological" or "organic" inputs will not necessarily be an ecological agriculture in the broadest sense" (Caporal 2009).

Agroecological movements

Faced with industrial activities and the social and environmental adversities they caused, various groups around 1960 challenged the current model of life (consumerism, use of pesticides, deforestation, etc.) around the world and began a process of suggesting other ways of living. (Santos 2015). In Brazil, one of these protest groups that stood out was that of alternative agriculture, in 1970, which sought a new model of society proposing equality, justice and social transformation (Brandenburg 2002). This alternative agriculture later influenced what became Agroecology (Padula et al. 2013). After that, the participation of agronomists in rural environmental and social movements grew. Alternative agriculture came to embrace the various lines of contestation against the prevailing model, such as Natural, Organic, Permaculture, and so on (Nanni et al. 2018).

In 1975, the Pastoral Land Commission (PLC) was created, an important means of mobilizing Brazilian rural dwellers. It was the beginning of the Basic Ecclesial Communities (BEC) which, together with some Catholic and Protestant churches (which were fundamental because they were closer to these people and also because they were not targets of state repression), served the peasants as a space to reflect on what they were experiencing and how to face the misfortunes of a time when repression was used to contain those who wanted Agrarian Reform (Betto 1985; Petersen and Almeida 2006).

The BEC organized their actions according to the daily lives of family members, valuing the cultural practices of each region, as well as innovative initiatives, in addition to promoting alternative techniques used today, such as organic fertilizers (manure, green manure, organic compost), soil conservation practices, etc. They encouraged collective gardens, joint efforts, and families to consume what they produced (so as not to be dependent on the market and to obtain a diet free of pesticides). Some of the leaders who emerged from the BEC were essential in the social movements that erupted later, such as the rural workers' union movement (Petersen e Almeida 2006; Monteiro e Londres 2017).

In the 1970s, José Lutzemberger, an agronomist, founded the Gaucho Association for the Protection of the Natural Environment. He was a great critic of the agricultural model based on deforestation and pesticides. Although the military regime repressed political protests, environmental criticisms were allowed and this is how Lutzemberger gained the support of Brazilian agronomists and agronomy students who began to oppose the content of the category's professional training, which was aimed at the financial and productive aspects of agriculture, but left aside social and environmental issues (Costa et al. 2015).

The agronomist also drew attention to the disruption caused by mechanization, the production of genetic varieties made and designed for greater productivity and which contained a high level of agrochemicals and substances that could cause environmental damage (a technology that seduced the agro-industries, but which was conflicting for a country with a tropical ecology), among many other criticisms. Subsequently, a series of events on alternative agriculture began, which led many agronomists to become involved in rural social and environmental movements. Alternative agriculture came to designate "sister" currents that challenged the

prevailing model, such as Organic, Natural, Biological agriculture, Permaculture, Biodynamics, and so on (Merrill 1983; M. B. B. Costa et al. 2015). In 1980, the work of PTA-FASE (Federation of Organs for Social and Educational Assistance, set up in 1983) and the establishment of the PTA Network (Alternative Technologies Project, formed in 1988) were responsible for the start of autonomous NGOs helping Brazilian family farmers (Monteiro and Londres 2017).

According to Leão and Vital (2011), due to the effects of more than a century of industrial revolution, environmental and social degradation and the Green Revolution, there was an urgent need for a response capable of containing such demands, transforming government policies and actions and suggesting "new regulatory frameworks to replace those that favored the indiscriminate use of soil, water and air resources in various territories, in promotion of industrial progress" (Leão and Vital 2011).

As agriculture has changed, focusing primarily on economic issues to the detriment of environmental and social issues, agroecological agriculture has emerged as an opposite response to the concept of conventional agriculture. It therefore wants to preserve the knowledge, techniques and practices of the locals, as they relate to the way these farmers live and produce. In this way, it ensures that the autonomy of these individuals is guaranteed, as well as their access to and continuity in their territories (Conti et al. 2021).

According to Conti et al. (2021), ecologically-based agriculture can be seen from two perspectives: one that is close to "market niches and the corporate sectors of large-scale production" and a second that shows political and cultural aspects whose aim is to maintain the environment and health with a view to autonomy and food sovereignty.

In the 1980s, agroecology gradually emerged as a social movement linked to agricultural activities. This agroecological movement encompassed farmers who sought food sovereignty and autonomy, as well as food security, but also social movements that called for public policies geared towards their assumptions. Even so, Agroecology was the target of farmers' movements that turned to alternative agriculture, "through social partnerships, to better respond to the ecological and environmental challenges of highly specialized agricultural production" (Abreu et al. 2016).

Over time, the notion of organized agriculture using alternative techniques suffered a cultural crack in the environmentalist milieu, and alternative agriculture gradually gave way to an agriculture born in Latin America called sustainable agriculture, which had the great author Altieri together with NGOs (non-governmental organizations) and agronomists (associations of agronomists). However, the movement fell apart because there were disagreements about the Green Revolution and very little practical experience of ecologically-based agriculture (Abreu et al. 2016).

That said, the projects and organizational structures among family farmers and in Latin countries were decisive, as they made it possible to experiment in Brazil. In addition to the extremely important work of NGOs, the Family Farming and Agroecology Association (AS-PTA) was unique in this process, as it aimed to limit the growth of landowners and the rural exodus by supporting family farmers and encouraging them to organize, raise awareness and adhere to a new form of development based on three pillars: locality and development of new paths for rural production; dissemination of the situation of Latin American family farmers and instigation of the creation of public policies. (Abreu et al. 2016).

Thus, as already mentioned, Agroecology has several sister currents in which it presents low-impact or, so to speak, more ecological agriculture, such as Organic, Biological, Natural, Permaculture and Biodynamic Agriculture (among many others). We'll talk about these sister currents below.

Organic agriculture and Law 10.831: an important milestone for sustainable agriculture in Brazil

Organic agriculture in Brazil emerged around 1970 through the promotional activities of José Lutzenberger (Instituto Brasil Orgânico 2022) and is an agricultural productivity technique characterized according to the social context in which the farmer is inserted, the social structuring model of his production and the market. (Assis and Romeiro 2002). As such, this production system is based on process technologies, which means that it adheres to a series of procedures with plants, soil and climatic conditions in order to produce healthy food, respecting their natural flavors and benefiting consumers. (Penteado 2000). And it is from a holistic perspective that production management within Organic agriculture aims to develop agrobiodiversity and biological cycles, the "social, environmental and economic sustainability of the unit, in time and space" (Almeida et al. 2000).

In addition to the different aspects of sustainable agriculture, another point that needs to be highlighted for its relevance is the Brazilian framework for sustainable agriculture, which was Law 10.831 in 2003 (Lei n.° 10.831 de 23 de dezembro de 2003). - Decree 6.323 in 2007 and the Normative Instructions in 2008 and 2009. This law defined the rules for adherence to sanitary and phytosanitary measures preserving the quality of the organic production system, as well as for its identification, inspection and sanction processes, and the registration of inputs. (Pereira 2021). After being regulated by the federal government through Decree No. 6.323 of December 27, 2007 (Decreto n.° 6.323 de 27 de dezembro de 2007) production, storage, labeling, transport, assessment of organic conformity, identification in marketing and inspection of products (Pereira, 2021).

Agroecology and its challenges in times of environmental crisis

The indiscriminate use of pesticides is undoubtedly one of the challenges, since they are used in modern agriculture to achieve high productivity (Javaid et al. 2016). Pesticides are also used to combat pests that affect both the quantity of production and its quality and cooperate with its growth, making it faster and more effective. However, prolonged or frequent use of pesticides leads to accumulation and an imbalance in the soil and its chemical properties, thus damaging the ecosystem with their toxicity (Navarro et al. 2021; Silva et al. 2022).

In Brazil, policies to encourage the production of commodities are responsible for the rise in the use of pesticides (Delgado 2020; Daufenback et al. 2022) and as of 2019, ANVISA (the National Health Surveillance Agency), which is the agent in charge of toxicological analysis, and MAPA (the Ministry of Agriculture, Livestock and Supply), which is responsible for these elements, have indicated that around 1,059 pesticides have been registered and have become permitted. In addition, data from the Ministry of Health and Anvisa show that a quarter of Brazilian municipalities have a cocktail of 27 pesticides in their water and that 51% of the food consumed by Brazilians contains residues of pesticides. (Acosta and Carneiro 2021).

Deforestation also contributes to the problem of the environment and sustainability. Fires and cutting down trees for commercial purposes are among the causes of the reduction in forest extensions, as well as the devastation of territories for agricultural use, or even due to natural phenomena themselves. In addition, the removal of trees with the intention of promoting agriculture, as well as for housing construction or to serve as a source of energy, is a practice that has been present throughout human history.

On the other hand, it can be seen that in developed countries (as opposed to developing ones) the timber trade is carried out within a sustainable logic, and even so, since 1970, deforestation in the Amazon has reached high levels. After 1995, there were changes in the rates due to various causes of deforestation in the region, such as the increase in agricultural activity, the timber trade, fires, growth in the number of inhabitants and tax incentives. This contributes to the loss of biodiversity, a reduction in water cycling and also affects global warming, as the gases emitted by fires intensify the greenhouse process (Arraes et al. 2012).

The pressure on indigenous and traditional peoples is also part of the environmental challenges and is a very complex issue, because throughout human history, traditional peoples have carried out tasks linked to nature, making use of ecosystems, developing ways of producing food and technologies (Costa 2012). Numerous indigenous tribes, for example, had exquisite production systems with agricultural calendars based on astrology and soil selection and management systems, as well as crop diversification (Alves 2001). In other words, various aspects of agroecology relate to indigenous practices, because insofar as it is based on sustainable modes of production, agroecology joins indigenous culture and its way of relating to nature, transmuting itself into a science that encompasses both traditional and modern knowledge, which makes it multidisciplinary, interdisciplinary and also transdisciplinary (Santos 2020).

Traditional peoples are organized in Brazil through politics and articulated actions based on their ethnicity (as well as their culture and history), including quilombolas, caiçaras, riverine communities, traditional and artisanal fishermen, gypsies, coconut breakers, among others. These traditional peoples manage the soil and use production techniques geared towards a family diet and preserving nature, so agriculture is a strategy through which the reproduction and food security of the family nucleus can be guaranteed (Fidelis 2011).

Various organic technologies have been used for around 6,000 years to make agriculture sustainable while conserving soil, water, energy and biological resources. The benefits of organic technologies include higher soil organic matter and nitrogen content, lower fossil energy inputs, yields similar to conventional systems and conservation of soil moisture and water resources, especially advantageous in drought conditions. Traditional organic farming technologies can be adopted by conventional agriculture to make it more sustainable and environmentally friendly (Pimentel and Burgess 2014).

The challenges facing agriculture in the context of the environmental, social and energy crises could be tackled by Agroecology, which has been growing and strengthening among the interdisciplinary segments of teaching, research and extension (Carneiro et al. 2015). To give you an idea, the data systematized by Sousa and Martins (2013) based on information from the National Council for Scientific and Technological Development (CNPq) indicated that in 2000 six research groups mentioned agroecology in their name or description. By 2012, this number had risen to 226. The number of researchers working with agroecology in research groups registered with the CNPq grew from 43 to 550 between 2000 and 2010.

Agroecology is not limited to the technical aspects of production and environmental conservation. As a nationwide social movement, the construction of practices and concepts has proved crucial in debates about the direction of rural development and has proven to help agriculture fulfill multiple functions in society, including the production of healthy food; overcoming rural poverty; liberating women; encouraging youth leadership; promoting higher levels of food and nutritional security and population health; protecting and not polluting land, water and biodiversity; preserving rural landscapes; boosting local markets; creating decency in rural areas; working with and valuing local culture and knowledge (Carneiro et al. 2015).

The Brazilian government is very flexible and efficient in supporting export monocultures, but it is inefficient in regulating the use of pesticides and extremely slow in implementing policies that seek to strengthen family farming, traditional peoples and the greater inclusion of agroecology in the national territory.

Final considerations

Scientometric analysis reveals a rapidly expanding yet structurally contradictory field. While Brazil has emerged as a global leader in scientific output (899 articles) with exponential publication growth (2.7 articles/year since 2010), this contrasts sharply with limited global influence (median of 16 citations for national authors versus 299 for international leaders). Collaboration networks demonstrate the dominance of Southeastern institutions alongside emerging regional hubs in Northeast Brazil, yet persistent asymmetries

remain: technical research (soils, management) achieves greater immediate impact while sociopolitical themes (rural movements, environmental justice) remain marginalized in traditional metrics.

The centrality of "agroecology" as a key term (TLS=497) obscures internal fragmentation - thematic clusters show weak connectivity between natural and social sciences. These patterns reflect a dual challenge: consolidating the interdisciplinary approach the field advocates while transforming scientific volume into political influence, particularly amid the dismantling of environmental policies.

Here, scientometrics serves not merely to map academic production, but to expose the fundamental tensions between knowledge, power, and social transformation within Brazilian agroecology. The metrics ultimately reveal a paradox: a thriving research field struggling to translate its findings into systemic change against entrenched agricultural paradigms.

References

Abdeljaoued, Emna, Mathieu Brulé, Saida Tayibi, et al. 2020. "Bibliometric Analysis of the Evolution of Biochar Research Trends and Scientific Production". *Clean Technologies and Environmental Policy* 22 (10): 1967–97. https://doi.org/10.1007/s10098-020-01969-x.

Abreu, Lucimar Santiago, Stéphane Bellon, e Tércia Z. TORRES. 2016. *A contribuição das ciências e do movimento social para a agroecologia no Brasil.* 182 vols. ComCiência. https://www.alice.cnptia.embrapa.br/bitstream/doc/1054395/1/2016AP05.pdf.

Acosta, J., e F. Carneiro. 2021. "Governo Bolsonaro tem recorde de mortes e de agrotóxicos". Campanha Permanente Contra os Contra os Agrotóxicos e Pela Vida. https://contraosagrotoxicos.org/governo-bolsonaro-tem-recorde-de-mortes-e-de-agrotoxicos/.

Almeida, D. L., M. S. F. R. Azevedo, M. O. Cardoso, et al. 2000. *Agricultura orgânica: instrumento para sustentabilidade dos sistemas de produção e valorização de produtos agropecuários*. No. 122. Embrapa Agrobiologia. https://www.bdpa.cnptia.embrapa.br/consulta/busca?b=ad&id=622799&biblioteca=vazio&busca=622799&qFacets=622799&sort=&paginacao=t&paginaAtual=1.

Altieri, Miguel A., e Victor Manuel Toledo. 2011. "The Agroecological Revolution in Latin America: Rescuing Nature, Ensuring Food Sovereignty and Empowering Peasants". *Journal of Peasant Studies* 38 (3): 587–612. https://doi.org/10.1080/03066150.2011.582947.

Alves, R. N. B. 2001. *Características da agricultura indígena e sua influência na produção familiar da Amazônia*. Vol. 105. Embrapa Amazônia Oriental.

Araujo, Maria Lucia Martins Nóbrega, Lediam Rodrigues L. R. Reinaldo, Pedro Gomes Almeida, José Alberto calado Wanderley, e José Silva Sousa. 2010. "IMPACTOS AMBIENTAIS NAS MARGENS DO RIO PIANCÓ CAUSADOS PELA AGROPECUÁRIA". *Revista Brasileira de Gestão Ambiental* 4 (1): 13–33. https://www.gvaa.com.br/revista/index.php/RBGA/article/view/461.

Archambault, Éric, David Campbell, Yves Gingras, e Vincent Larivière. 2009. "Comparing Bibliometric Statistics Obtained from the Web of Science and Scopus". *Journal of the American Society for Information Science and Technology* 60 (7): 1320–26. https://doi.org/10.1002/asi.21062.

Arraes, Ronaldo de Albuquerque e, Francisca Zilania Mariano, e Andrei Gomes Simonassi. 2012. "Causas do desmatamento no Brasil e seu ordenamento no contexto mundial". *Revista de Economia e Sociologia Rural* 50 (1): 119–40. https://doi.org/10.1590/S0103-20032012000100007.

Assis, Renato Linhares de, e Ademar Ribeiro Romeiro. 2005. "Agroecologia e agricultura familiar na região centro-sul do estado do Paraná". *Revista de Economia e Sociologia Rural* 43 (1): 155–77. https://doi.org/10.1590/S0103-20032005000100009.

Assis, Renato Linhares, e Ademar Ribeiro Romeiro. 2002. "Agroecologia e agricultura orgânica: controvérsias e tendências". *Desenvolvimento e Meio Ambiente* 6: 67–80. https://doi.org/10.5380/dma.v6i0.22129.

Balsan, Rosane. 2006. "IMPACTOS DECORRENTES DA MODERNIZAÇÃO DA AGRICULTURA BRASILEIRA1 / DECURRENT IMPACTS OF THE AGRICULTURE MODERNIZATION IN BRAZIL". *CAMPO-TERRITÓRIO: REVISTA DE GEOGRAFIA AGRÁRIA* 1 (2): 2.

Betto, F. 1985. *O que é comunidade eclesial de base: primeiros passos*. 6º ed. Brasiliense.

Brandenburg, Alfio. 2002. "Movimento agroecológico: trajetória, contradições e perspectivas". *Desenvolvimento e Meio Ambiente* 6 (dezembro). https://doi.org/10.5380/dma.v6i0.22125.

Caparrós-Martínez, José Luis, Juan Milán-García, Rosa María Martínez-Vázquez, e Jaime de Pablo Valenciano. 2021. "Green Infrastructures and Grand Environmental Challenges: A Review of Research Trends by Keyword". *Agronomy* 11 (4): 4. https://doi.org/10.3390/agronomy11040782.

Caporal, Francisco Roberto. 2009. *Agroecologia: uma nova ciência para apoiar a transição a agriculturas mais sustentáveis*. Embrapa Informação Tecnológica. https://repositorio.ifs.edu.br/biblioteca/handle/123456789/1305.

Caporal, R. F. 2005. *Agroecologia não é um tipo de agricultura alternativa*. MDA/SAF/DATE. https://permaculturanaserra.files.wordpress.com/2018/10/agroecologia-nc3a3o-c3a9-um-tipo-de-agricultura-alternativa.pdf.

Carneiro, F. F., L. G. S. Augusto, R. M. Rigotto, K. Friedrich, e Búrigo. 2015. *Dossiê ABRASCO: um alerta sobre os impactos dos agrotóxicos na saúde*. Expressão Popular. https://www.abrasco.org.br/dossieagrotoxicos/wp-content/uploads/2013/10/DossieAbrasco_2015_web.pdf.

Casado, G. I. G., M. G. Molina, e E. S. Guzmán. 2000. *Introducción a la Agroecologia como Desarrollo Rural Sostenible*. Vol. 1. Mundi-Prensa.

Chen, Hua, Ming Cai, Ke Huang, e Shuxin Jin. 2021. "Classification and Evolution Analysis of Key Transportation Technologies Based on Bibliometrics". *Scientific Programming* 2021 (1): 2977998. https://doi.org/10.1155/2021/2977998.

Conti, Valquiria, Ivanio Folmer, e Carmen Rejane Flores. 2021. "A Transformação do Território a partir da Transição da Agricultura Convencional para a Agricultura Agroecológica: O Caso de Agudo/RS". *Diversitas Journal* 6 (3): 3375–90. https://doi.org/10.48017/Diversitas_Journal-v6i3-1963.

Costa, Manoel Baltasar Baptista, Monique Souza, Vilmar Müller Júnior, Jucinei José Comin, e Paulo Emílio Lovato. 2015. "Agroecologia no Brasil – 1970 a 2015". *Agroecología* 10 (2): 2. https://revistas.um.es/agroecologia/article/view/300831.

Costa, Sandra Helena Gonçalves. 2012. "A questão agrária no Brasil e a bancada ruralista no congresso nacional". Dissertação (Mestrado em Geografia Humana), Universidade de São Paulo. http://www.teses.usp.br/teses/disponiveis/8/8136/tde-08012013-143125/.

Daufenback, Vanessa, Adriana Adell, Milena Regina Mussoi, Adriella Camila Fedyna Furtado, Shirleyde Alves Santos, e Denise Piccirillo Barbosa Veiga. 2022. "Agrotóxicos, desfechos em saúde e agroecologia no Brasil: uma revisão de escopo". *Saúde em Debate* 46 (spe2): 482–500. https://doi.org/10.1590/0103-11042022e232.

Decreto n.° 6.323 de 27 de dezembro de 2007, Presidência da República (2007). http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/Decreto/D6323.htm#:~:text=Decreto%20n%C2%BA%206323&text=DECRETO%20N%C2%BA%206.323%2C%20DE%2027,que%20lhe%20confere%20o%20art.

Delgado, Guilherme Costa. 2020. "Questão agrária e capital financeiro na agricultura brasileira". *Caderno Prudentino de Geografia* 4 (42): 42. https://revista.fct.unesp.br/index.php/cpg/article/view/7765.

Eck, Nees Jan van, e Ludo Waltman. 2006. "Vos: A New Method for Visualizing Similarities between Objects". SSRN Scholarly Paper No. 902749. Social Science Research Network, abril 5. https://papers.ssrn.com/abstract=902749.

Faria, Lívia Mara Siqueira. 2014. "Aspectos Gerais da Agroecologia no Brasil". *Revista Agrogeoambiental* 6 (2): 2. https://doi.org/10.18406/2316-1817v6n22014556.

Fidelis, Lourival. 2011. "Quilombos, agricultura tradicional e a agroecologia: o agroecossistema do Quilombo João Surá sob a ótica da sustentabilidade". *Cadernos CERU* 22 (1): 1. https://doi.org/10.1590/S1413-45192011000100005.

Fiorini, Vanessa. 2021. "A questão agrária no Brasil da invasão ao século XXI uma história de espoliação". *Revista Resistência Litoral* 1 (1): 1. https://doi.org/10.5380/rrl.v1i1.82731.

Fonseca, M. F. A. C. 2009. *Agricultura orgânica: Regulamento técnico e acesso aos mercados dos produtos orgânicos no Brasil*. PESAGRO - RIO. https://ciorganicos.com.br/wp-content/uploads/2012/07/Agricultura_Organica.pdf.

Gliessman, S. R. 2000. *Agroecologia: processos ecológicos em agricultura sustentável*. UFRGS.

Guzmán, E. S. 2004. "La agroecologia como estrategia metodológica de transformación social". *Instituto de Sociología y Estudios Campesinos de la Universidad de Córdoba*. https://ilusionismosocial.org/pluginfile.php/605/mod_resource/content/2/la%20agroecologia.pdf.

Instituto Brasil Orgânico. 2022. "Uma breve história do movimento orgânico brasileiro". *Instituto Brasil Orgânico*. https://institutobrasilorganico.org/o-movimento-organico/nossa-historia/.

Javaid, Muhammad Kashif, Mehrban Ashiq, e Muhammad Tahir. 2016. "Potential of Biological Agents in Decontamination of Agricultural Soil". *Scientifica* 2016: 1–9. https://doi.org/10.1155/2016/1598325.

Lacey, Hugh. 2007. "Há alternativas ao uso dos transgênicos?" *Novos Estudos - CEBRAP*, nº 78: 31–39. https://doi.org/10.1590/S0101-33002007000200005.

Leão, Éder Lira Souza, e Tales Wanderley Vital. 2011. "Evolução e Situação Atual da Agricultura de Base Ecológica em Pernambuco". *Revista em Agronegócio e Meio Ambiente* 4 (2): 2. https://doi.org/10.17765/2176-9168.2011v4n2p%p.

Lei n.° 10.831 de 23 de dezembro de 2003 (2003). http://www.planalto.gov.br/ccivil_03/leis/2003/l10.831.htm.

Leite, Kaliane Costa, e Maria Betania Ribeiro Torres. 2008. "O Uso de Agrotóxicos Pelos Trabalhadores Rurais Do Assentamento Catingueira Baraúna-RN". *Revista Verde de Agroecologia e Desenvolvimento Sustentavel* 3 (4): 4. http://www.gvaa.com.br/revista/index.php/RVADS/article/view/165/193.

Li, Dongyang, Rui Zhao, Xing Peng, et al. 2020. "Biochar-Related Studies from 1999 to 2018: A Bibliometrics-Based Review". *Environmental Science and Pollution Research* 27 (3): 2898–908. https://doi.org/10.1007/s11356-019-06870-9.

Merrill, Margaret C. 1983. "Eco-Agriculture: A Review of Its History and Philosophy". *Biological Agriculture & Horticulture* 1 (3): 181–210. https://doi.org/10.1080/01448765.1983.9754395.

Mongeon, Philippe, e Adèle Paul-Hus. 2016. "The Journal Coverage of Web of Science and Scopus: A Comparative Analysis". *Scientometrics* 106 (1): 213–28. https://doi.org/10.1007/s11192-015-1765-5.

Monteiro, D., e F. Londres. 2017. "Pra que a vida nos dê flor e frutos: notas sobre a trajetória do movimento agroecológico no Brasil". Em *A política nacional de agroecologia e produção orgânica no Brasil: uma trajetória de luta pelo desenvolvimento rural sustentável*, organizado por R. H. R. SAMBUICHI. Ipea.

Moreira, Rodrigo Machado, e J. D. S. Carmo. 2004. "Agroecologia na construção do desenvolvimento rural sustentável". *Agricultura* 51 (2): 37–56.

Nanni, Arthur Schmidt, Arno Blankensteyn, Renata Palandri Sigolo, Soraya Nór, e Marcelo Venturi. 2018. "Construindo a Permacultura na academia brasileira". *Revista Brasileira de Agroecologia* 13 (1): 1. https://revistas.aba-agroecologia.org.br/rbagroecologia/article/view/22439.

Navarro, Laura, Ricardo Camacho, Julián E. López, e Juan F. Saldarriaga. 2021. "Assessment of the Potential Risk of Leaching Pesticides in Agricultural Soils: Study Case Tibasosa, Boyacá, Colombia". *Heliyon* 7 (11): e08301. https://doi.org/10.1016/j.heliyon.2021.e08301.

Padula, J., I. M. Cardoso, E. A. Ferrari, e F. K. Dal Soglio. 2013. "Os caminhos da agroecologia no Brasil". Em *Agroecologia: princípios e reflexões conceituais*, 2º ed. Embrapa. https://www.bdpa.cnptia.embrapa.br/consulta/busca?b=ad&id=1081090&biblioteca=vazio&busca=1081090&qFacets=1081090&sort=&paginacao=t&paginaAtual=1.

Penteado, S. R. 2000. *Introdução à agricultura orgânica: Normas e técnicas de cultivo*. Editora Grafimagem. https://www.bdpa.cnptia.embrapa.br/consulta/busca?b=ad&id=210478&biblioteca=vazio&busca=Introdu%C3%A7%C3%A3o%20%C3%A0%20agricultura%20org%C3%A2nica\:%20Normas%20e%20t%C3%A9cnicas%20de%20cultivo&qFacets=Introdu%C3%A7%C3%A3o%20%C3%A0%20agricultura%20org%C3%A2nica\:%20Normas%20e%20t%C3%A9cnicas%20de%20cultivo&sort=&paginacao=t&paginaAtual=1.

Pereira, G. B. 2021. "Sistematização e análise da oferta de produtos orgânicos na feira do Bom Pastor em Juiz de Fora, Minas Gerais". Dissertação (Mestrado Profissional em Agricultura Orgânica), Universidade Federal Rural do Rio de Janeiro. https://tede.ufrrj.br/jspui/bitstream/jspui/5519/2/2021%20-%20Gabriel%20Barbosa%20Pereira.pdf.

Petersen, P., e S. G. Almeida. 2006. "Rincões transformadores: trajetória e desafios do movimento agroecológico brasileiro – uma perspectiva a partir da Rede PTA". Em *Agricultura familiar camponesa na construção do futuro*. AS-PTA.

Pimentel, David, e Michael Burgess. 2014. "An Environmental, Energetic and Economic Comparison of Organic and Conventional Farming Systems". Em *Integrated Pest Management*, organizado por D. Pimentel e R. Peshin. Springer. https://link.springer.com/chapter/10.1007/978-94-007-7796-5_6.

R Core Team. 2021. *A Language and environment for statistical computing*. Versão V.4.1. QMS Developmente Team, released. https://cran.r-project.org. (R packages retrieved from MRAN snapshot 2022-01-01.

Rampazzo, S. E. 1997. "A questão ambiental no contexto do desenvolvimento econômico". Em *Desenvolvimento sustentável: necessidade e/ou possibilidade?*, organizado por D. F. Becker. EdUniSC - Santa Cruz.

Santos, Jairã Silva. 2020. "Abordagens teóricas sobre agroecologia e povos indígenas no Brasil". Trabalho de Conclusão de Curso (Graduação em Agronomia), Universidade Federal de Alagoas. http://127.0.0.1:8069/repositorio/publicacoes/3557.

Santos, L. 2015. "A permacultura como dispositivo de ressignificação do espaço geográfico". Trabalho de Conclusão de Curso (Graduação em Geografia), Universidade Federal de Santa Catarina. https://repositorio.ufsc.br/xmlui/bitstream/handle/123456789/182866/santos_2015.pdf?sequence=1&isAllowed=y.

Shi, Dongping, Chengyu Xie, Jinmiao Wang, e Lichun Xiong. 2021. "Changes in the Structures and Directions of Heavy Metal-Contaminated Soil Remediation Research from 1999 to 2020: A Bibliometric & Scientometric Study". *International Journal of Environmental Research and Public Health* 18 (14): 14. https://doi.org/10.3390/ijerph18147358.

Silva, Francinne Hellora Kaczurowski Pereira, Luiz Fernando Sousa Antunes, André Felipe Sousa Vaz, e Maura Santos Reis Andrade Silva. 2022. "Agrotóxicos no Brasil: uma compreensão do cenário atual de utilização e das propriedades do solo que atuam na dinâmica e retenção destas moléculas". *Research, Society and Development* 11 (9): 9. https://doi.org/10.33448/rsd-v11i9.31614.

Sousa, R. P., e S. R. Martins. 2013. "Construção do conhecimento agroecológico: desafios para a resistência científico-acadêmica no Brasil". Em *Agroecologia: princípios e reflexões conceituais*, organizado por J. C. C. Gomes e W. S. Assis. Embrapa.

Tomich, Thomas P., Sonja Brodt, Howard Ferris, et al. 2011. "Agroecology: A Review from a Global-Change Perspective". *Annual Review of Environment and Resources* 36 (1): 193–222. https://doi.org/10.1146/annurev-environ-012110-121302.

VOSviewer. 2025. *VOSviewer version 1.6.20*. Versão 1.6.20. Centre for Science and Technology Studies, Leiden University, released. Microsoft Windows systems. https://www.vosviewer.com/getting-started/.

Wezel, Alexander, Barbara Gemmill Herren, Rachel Bezner Kerr, Edmundo Barrios, André Luiz Rodrigues Gonçalves, e Fergus Sinclair. 2020. "Agroecological Principles and Elements and Their Implications for Transitioning to Sustainable Food Systems. A Review". *Agronomy for Sustainable Development* 40 (6): 40. https://doi.org/10.1007/s13593-020-00646-z.

Zhang, Tongkun, Heqing Cai, Yuan Tang, et al. 2025. "Visualising the Trends of Biochar Influencing Soil Physicochemical Properties Using Bibliometric Analysis 2010–2022". *Environment, Development and Sustainability* 27 (2): 2815–39. https://doi.org/10.1007/s10668-023-04065-4.

Zhu, Junwen, e Weishu Liu. 2020. "A Tale of Two Databases: The Use of Web of Science and Scopus in Academic Papers". *Scientometrics* 123 (1): 321–35. https://doi.org/10.1007/s11192-020-03387-8.