



Integrating Environmental, Social, and Policy Dimensions in Sustainable Agriculture: A Bibliometric Review (2000–2025)

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ABSTRACT

Literature on sustainable agriculture following the establishment of the Sustainable Development Goals or SDGs in 2015 has experienced a significant growth escalation of 36.29 percent annually encompassing 8272 publications across 2148 academic journals. This discourse attempts to conduct a multidimensional integration that includes the Ecological Footprint, Human Development Index, Sustainable Livelihood Approach, and SDGs. Bibliometric analysis indicates that the integration of the global paradigm remains partial because the SDGs dominate network centrality, while other crucial dimensions tend to be in peripheral positions, with the international collaboration rate limited to 36.58 percent. Current research communities are rigidly segregated into three closed disciplinary silos without comprehensive synergistic modeling, so that various fundamental paradoxes remain unresolved. These fundamental issues include the tension between productivity and ecological burden, the dilemma of income intensification versus pollution, and the gap in causal mechanisms regarding the relations among contextually different dimensions. Extreme geographical disparity is clearly visible through the dominance of half the publications by China compared to the marginalization of the African region, which indicates the presence of epistemological colonialism practices in knowledge production. Future research strategies mandate a profound investigation of the causality of multidimensional interactions, accompanied by the incorporation of local wisdom and the development of standardized composite metrics. The initiation of inclusive cross-disciplinary collaboration, especially from the Global South perspective, is a crucial prerequisite for transforming theoretical fragmentation into tangible sustainability praxis on the ground.

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Introduction

Sustainable agriculture has occupied a central position in the international research discourse since the last decade of the 20th century. The agricultural sector faces a dualistic challenge of fulfilling the food demands of a growing population while preserving environmental and natural resource sustainability (Lestari et al., 2024). Recent bibliometric analyses indicate a significant escalation in sustainable agriculture research, with particular attention to eco-friendly practices, resource management, and digital technology innovation (Szomszor, 2025). The advancement of these research stages signifies the global recognition of the urgency of sustainability, especially amid the climate crisis. The UN Sustainable Development Goals emphasize the need for fundamental reforms in the agricultural sector. A

profound understanding of the complexity of agricultural sustainability requires an analytical framework that can synthesize diverse research perspectives.

Environmental factors are vital components of sustainable agriculture, particularly through the concept of the Ecological Footprint (EF), which quantifies the impact of agriculture on ecosystem biocapacity (Dedy et al., 2023). Agricultural intensification methods, including the use of fertilizers, pesticides, and water extraction, have significantly expanded the ecological footprint of this sector (Ahmed et al., 2025). A comprehensive analysis of the ecological footprint subcomponents includes carbon emissions, land use, energy consumption, and water quality. The agricultural industry contributes to one-third of global greenhouse gas emissions, which potentially degrades agricultural productivity (Li et al., 2025). Developing countries and high-risk regions bear the most severe consequences of increased ecological footprints (Naglaa et al., 2014). Understanding the biophysical impacts of agriculture through the ecological footprint requires the integration of the social dimension, which is often neglected in technical studies. A comprehensive evaluation of agricultural sustainability must consider the social aspects of agrarian communities.

The social dimension of sustainable agriculture encompasses human capital and livelihood security in agrarian communities. The Human Development Index (HDI) evaluates per capita income, life expectancy, and education level (Prameswari & Purbadharmaja, 2024). These variables significantly influence agricultural productivity and the adoption of sustainable agricultural practices (Ajao et al., 2013). The Sustainable Livelihood Approach (SLA) offers a conceptual framework that integrates assets, institutions, strategies, and outcomes (Lusinga-Machikicho & Mutanana, 2022). This methodology has proven effective in dissecting the complexities of rural life and formulating development initiatives that empower communities (Molosi-France & Dipholo 2020). The primary emphasis of the SLA implementation is on family farming and small-scale agriculture. The transition from technical methodologies to a comprehensive approach demonstrates the recognition of the local socio-economic environment. The integration of environmental and social factors serves as the foundation for a more holistic global policy framework (ReliefWeb, 2019).

The international policy framework for sustainable agriculture is manifested in the Sustainable Development Goals (SDGs), which set ambitious targets for the transformation of food systems by 2030 (United Nations 2019). SDG 2 specifically mandates the elimination of hunger, achievement of food security, improvement of nutrition, and promotion of sustainable agriculture (Hiywotu 2025). The components of this goal include increasing the productivity of small-scale farmers, facilitating technological access, and strengthening their land tenure rights. Sustainable agricultural systems support the achievement of various Sustainable Development Goals (SDGs), including poverty eradication in SDG 1, gender equality in SDG 5, renewable energy in SDG 7, and preservation of terrestrial biodiversity in SDG 15 (Robinson, 2024). Agricultural transformation acts as a catalyst for systemic change, affecting various development dimensions. The SDGs provide an integrated framework that consolidates environmental, social, and policy aspects into a single agenda (Weiland et al., 2021). The complex interactions among these three aspects and the continually evolving research landscape demand an analytical approach capable of systematically identifying knowledge dynamics.

Bibliometric analysis provides a robust instrument for understanding the evolution of research and identifying emerging themes on complex issues such as sustainable agriculture. Existing literature reviews on the EF, HDI, SLA, and SDGs tend to examine these elements in a fragmented manner. This disciplinary separation creates a significant research gap. In practice, policy targets (SDGs) will not be effective in reducing environmental degradation (EF) if they ignore the socio-economic capacity and livelihoods of communities (the HDI and SLA). An analysis that simultaneously integrates these four dimensions is required. This



integration is necessary to evaluate whether the global knowledge structure has bridged the trade-offs among ecology, society, and policy. A comprehensive understanding of this research landscape can provide practical implications for academics and policymakers. This study aims to fill this literature gap by mapping the interdisciplinary evolution of sustainable agriculture research from 2000 to 2025. Specifically, this study aims to answer the following research question (RQ): How do global sustainable agriculture studies develop across publication growth, collaboration networks, conceptual integration, and emerging research agendas, and what gaps remain in advancing inclusive, multidimensional, and empirically grounded research?

Methodology

Basis Data

The bibliometric data in this study were obtained exclusively from the Scopus database based on its comprehensive coverage and representativeness of international scientific publications in the fields of sustainable agriculture, environment, economics, and development policy. The selection of Scopus as a single source ensured metadata consistency and avoided cross-database duplication. Scopus provides a standardized citation indexing system that is compatible with the Bibliometrix package in the R environment and VOSviewer, enabling comprehensive analytical integration between publication performance analysis and scientific network mapping. All data were downloaded in CSV (comma-separated values) format to facilitate conversion into a bibliographic data frame within the R environment using the Bibliometrix package. This format allows seamless data processing and is compatible with the bibliometric analysis software used in this study.

Data Search Strategy

The search strategy was systematically designed to identify literature relevant to the environmental, social, and policy dimensions of sustainability in agriculture. The search syntax used in the Scopus advanced search was as follows

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TITLE-ABS-KEY ("Sustainable Agriculture") AND ("Ecological Footprint" OR "Human Development Index" OR "HDI" OR "Sustainable Development Goals" OR "SDGs" OR "Sustainable Livelihoods" OR "SLA") AND PUBYEAR > 1999 AND PUBYEAR < 2026 AND (LIMIT-TO(DOCTYPE,"ar"))
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The search was restricted to scientific articles, excluding conference proceedings, book chapters, and other publication formats. The publication timeframe was set from 2000 to 2025 to capture the significant transformation phase of the global sustainable agriculture research paradigm. The dataset represents a global collection of publications illustrating the integration of sustainable agriculture with the EF, HDI, SDGs, and SLA dimensions. Complete metadata from each publication were extracted, including the title, authors, affiliated institutions, publication year, journal name, abstract, keywords, references, and citation information.

Data Screening dan Cleaning Process

Data screening and cleaning processes were systematically conducted to ensure the validity and relevance of the dataset. Because the initial search using acronyms often retrieved irrelevant articles (false positives) owing to ambiguous meanings, an eligibility evaluation was performed manually at the title and abstract levels to eliminate articles outside the context of sustainable agriculture.

Subsequently, data cleaning was performed prior to the visualization analysis stage. This stage involved standardizing author names to prevent identity duplication, harmonizing keyword synonyms, and removing incomplete metadata entries. Through these comprehensive



screening and cleaning procedures, a final dataset comprising 8,272 valid and representative articles was obtained and was ready for further analysis to map the bibliometric network.

Result and Discussion

Result

This dataset encompasses 8,272 articles from 2,148 publication sources distributed globally, generating 62,855 references that demonstrate the depth and breadth of the knowledge network in the field of sustainable agriculture. The annual publication growth rate reached 36.29%, indicating a highly significant increase in research interest in this topic throughout the final quarter of the 21st century's second decade.

Research collaborations demonstrated a robust pattern, with an average of 5.08 co-authors per document, reflecting the collaborative nature of sustainable agriculture research that spans multidisciplinary and geographical boundaries. The proportion of international collaborations reached 36.58%, indicating that more than one-third of the publications involved researchers from different countries. Single-authored publications accounted for only 516 of the total 8,272 articles, validating the findings regarding the dominance of collaborative research in this field.



Figure 1. Corpus dataset

The document contents are indexed by 19,624 Keywords Plus (ID) and 20,954 Author's Keywords (DE), illustrating the wealth of terminology and concepts used by the research community. The average number of citations per document is 18.27, signifying a substantial level of publication impact, while the average document age of 2.38 years indicates that the dataset is dominated by recent publications that reflect the contemporary research trends.

Publication and Citation Trends

The annual scientific production graph illustrates an exponential growth pattern in sustainable-agriculture publications from 2000 to 2025. The initial phase (2000–2013) was characterized by low and stable production, averaging fewer than 100 articles per year. This reflects an emerging period when research on sustainable agriculture across environmental, social, and policy dimensions was still in the consolidation stage. A dramatic shift occurred starting in 2014, with significant acceleration post-2015, coinciding with the launch of the Sustainable Development Goals (SDGs) by the United Nations, which positioned sustainable agriculture as a global priority.

The year 2024 recorded the highest achievement, with over 2,000 published articles, reflecting an unprecedented acceleration in research. The average annual growth rate of 36.29% over the 25-year period demonstrates a consistent and sustained increase, far exceeding the average growth rate of scientific publications. This pattern indicates that sustainable agriculture, with a focus on environmental, social, and policy dimensions, has emerged as one of the most dynamic research areas in contemporary science and engineering.



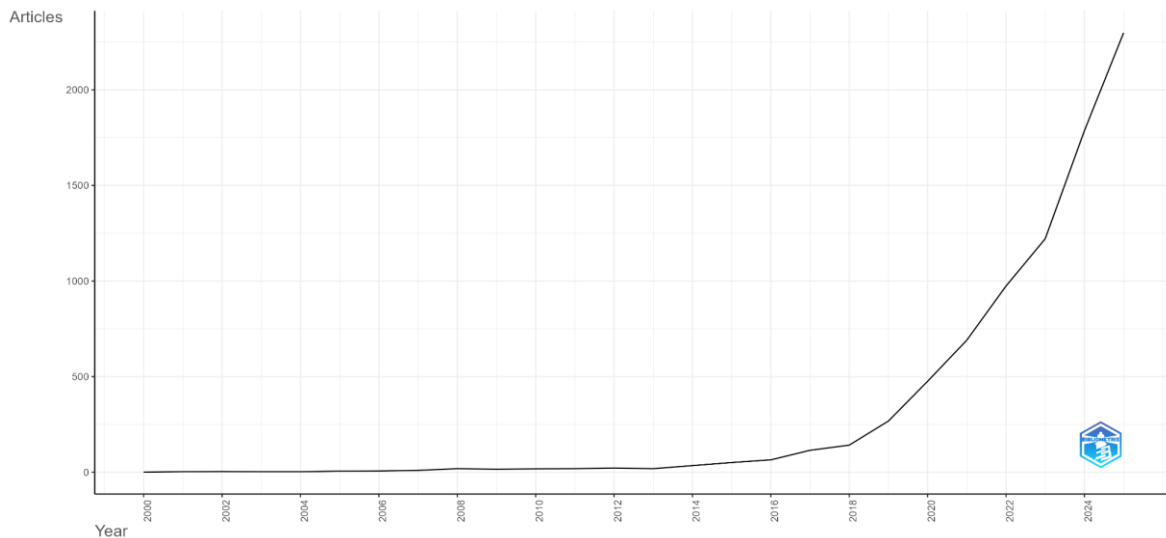


Figure 2. Annual scientific production

The average citations per year graph displays a fluctuating pattern that reflects the changing dynamics of the scientific impact of the publications. The early period (2000–2003) exhibited a high average citation value, reaching over ten citations per article in 2003. Owing to the relatively low number of publications, seminal works have received substantial attention. Subsequently, the average number of citations experienced a gradual decline until it reached a low of approximately 2.5 citations per article in 2013. This was followed by a resurgence, peaking again at nearly 10 citations per article in 2017, indicating the significant scientific impact of publications from 2014 to 2016.

The final period (2018–2025) showed moderate fluctuations, with average citations ranging from 3 to 8 per article and a downward trend towards the end of the period. This represents a normal methodological artifact, as recent publications have not yet received complete citations. Nevertheless, the overall average of 18.27 citations per document across the dataset demonstrates that publications on sustainable agriculture have a substantial academic impact. The integration of these two trends reveals that the dramatic quantitative transformation since 2014 has not been accompanied by a consistent proportional decline in average citations, indicating that research quality has been maintained despite the exponential increase in research production.

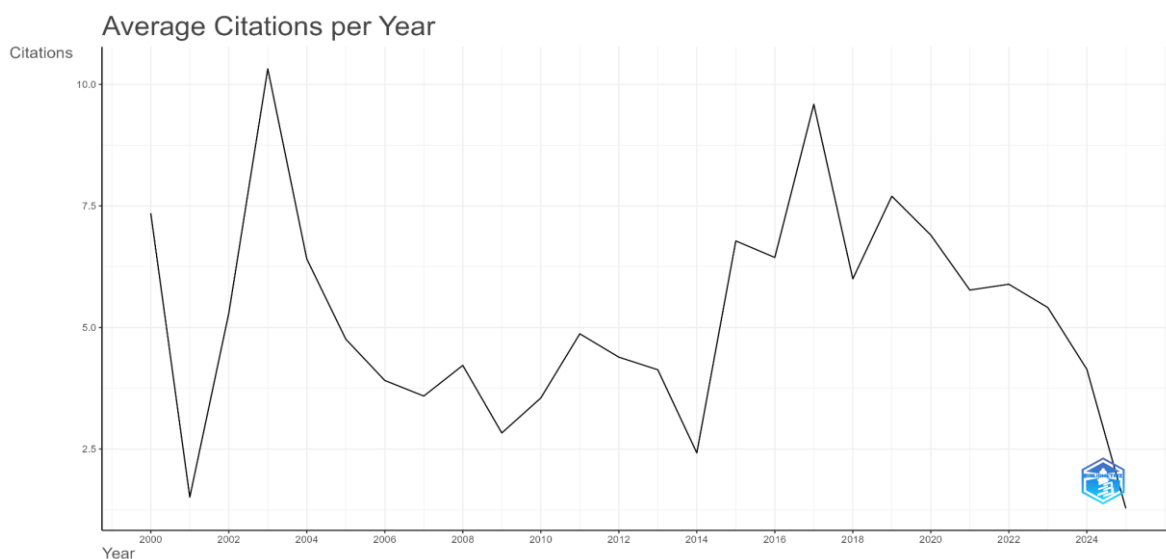


Figure 3. Average citations per article per year



An analysis of the most productive authors reveals a pattern of research concentration among a smaller group of researchers in the field. Rattan A. Lal ranks first with 18 publications, followed by Hosein Azadi and Hamid El Bilali with 16 publications each. The group of highly productive authors includes Romanus A. Osabohien, Stefan Sieber, and Dalia Streimikienė with 14 publications each, as well as A. Cerdà, Abbas Ali Chandio, Muhammad Usman, and Fusuo Zhang with 13 publications. The co-authorship network visualization demonstrates that these researchers are connected within several distinct collaboration clusters, indicating that despite their individual productivity, they actively establish partnerships with fellow researchers across institutions and countries.

The co-authorship network reveals the presence of several major collaboration clusters, each centered on specific researchers or themes. The red cluster indicates a robust collaboration network surrounding A. Cerdà, Lei Wang, and Fusuo Zhang, reflecting research focused on land and soil conservation aspects. The blue cluster displays collaboration around Muhammad Usman, Gang Deng, and Qamar Uz Zaman, representing research on policy and livelihood dimensions. The purple-green cluster represents a network involving Abbas Ali Chandio, Romanus A. Osabohien, and other collaborators, indicating interdisciplinary research encompassing social and economic dimensions. This pattern suggests that research collaboration is segmented based on specific topics; however, communication channels between clusters are maintained through key researchers with extensive networks, such as Hosein Azadi.

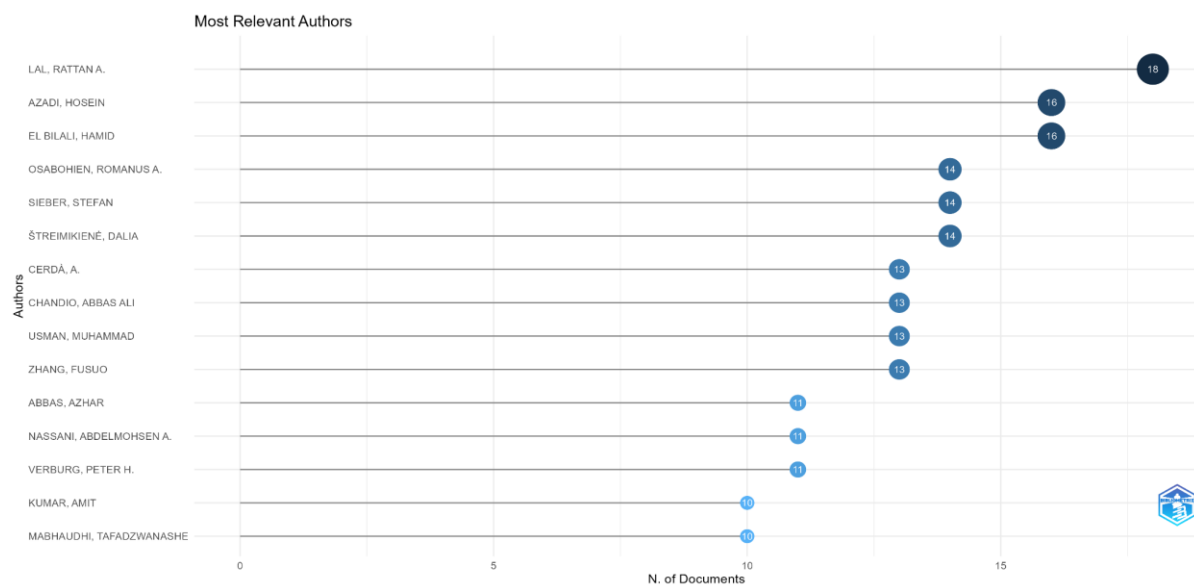


Figure 4. Productivity of the most relevant author

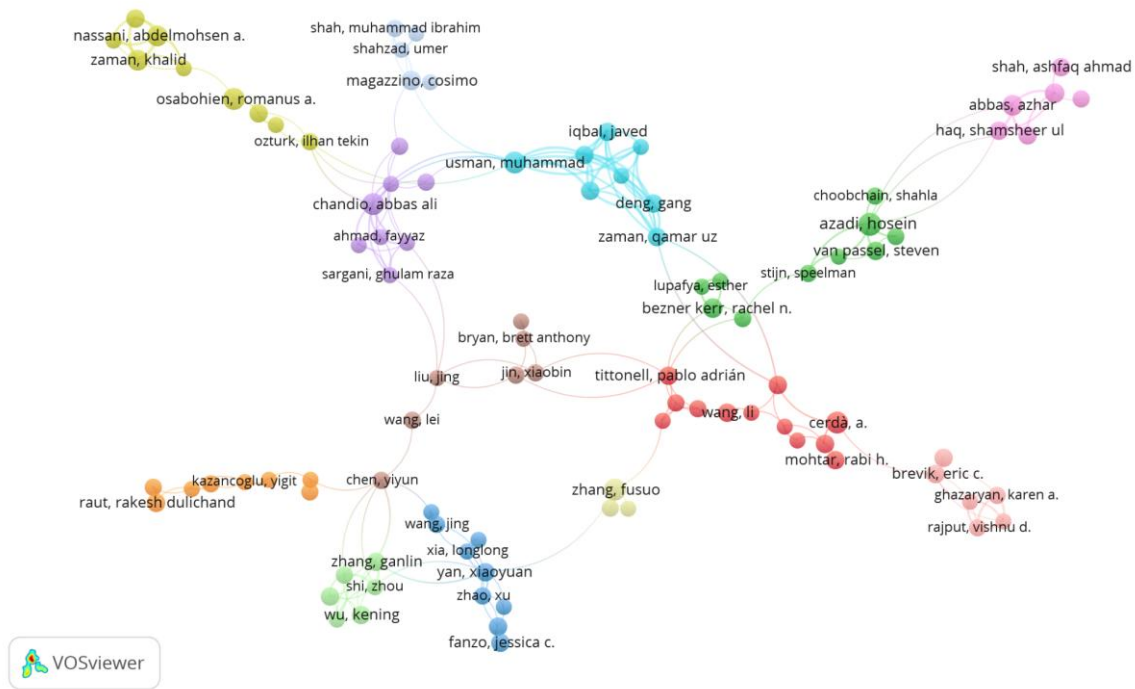


Figure 5. Network co-authorship

Research Institutes and Educational Institutions

Institutional contributions demonstrate the clear dominance of universities in Asia, particularly China. The University of Chinese Academy of Sciences led with 402 publications, followed by Wageningen University and Research from the Netherlands with 367 publications. The next three institutions are Northwest A&F University (290), China Agricultural University (261), and Beijing Normal University (167), all of which are based in China. Other institutions in the top 15 include Nanjing Agricultural University, Kwame Nkrumah University of Science and Technology, Universidade de São Paulo and Sichuan Agricultural University.

The dominance of Chinese institutions in sustainable agriculture research reflects the country's commitment to agricultural development and environmental protection. Wageningen University, as Europe's leading agricultural university, maintains a strong position as the second research hub, indicating a significant contribution from Europe in shaping the sustainable agriculture literature. Institutions from Africa (Kwame Nkrumah), South America (Universidade de São Paulo), and Europe demonstrate global participation in this research, albeit with varying levels of contribution.



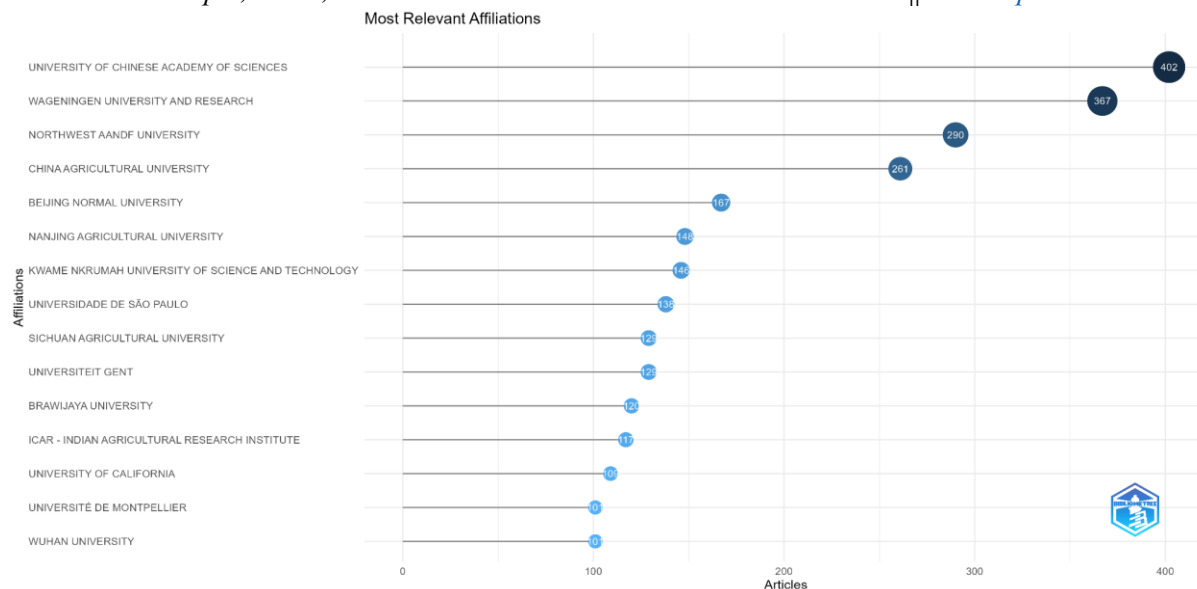


Figure 6. Institutions with the most publications

Geographic Distribution and International Collaboration

The geographical distribution map of publications reveals that China dominates with 7,185 publications, far exceeding that of other countries. India ranked second with 3,666 publications, followed by the United States (2,664), Italy (1,764), and Indonesia (1,582). The group of countries with moderate contributions included the United Kingdom (1,535), Germany (1,293), Brazil (1,277), Spain (1,150), and Australia (926). The international collaboration network displays a complex pattern, with various regional collaboration hubs interconnected globally.

Analysis of the collaboration network among countries reveals a structure consisting of several interacting geographical clusters. The large red cluster encompasses East Asian and South Asian countries (China, India, Pakistan, Bangladesh, Indonesia, Malaysia, Thailand, Hong Kong, Taiwan, South Korea, and the United Arab Emirates), indicating intensive regional collaboration. The green cluster displays European countries (the United Kingdom, Germany, the Netherlands, Italy, Spain, France, Portugal, Austria, Romania, Poland, and Lithuania), which also demonstrate robust collaboration patterns with one another. The smaller blue cluster includes African countries (Ghana, Nigeria, Tanzania, Zimbabwe, and South Africa) with limited yet significant connections. Latin American countries (Brazil, Argentina, Peru, Ecuador, and Mexico) appear in an intermediate position, with strong connections to both the European cluster and other developing countries. The international co-authorship rate of 36.58% indicates that more than one-third of the publications involve cross-border collaborations, signifying that sustainable agriculture research is a globally collaborative endeavor.



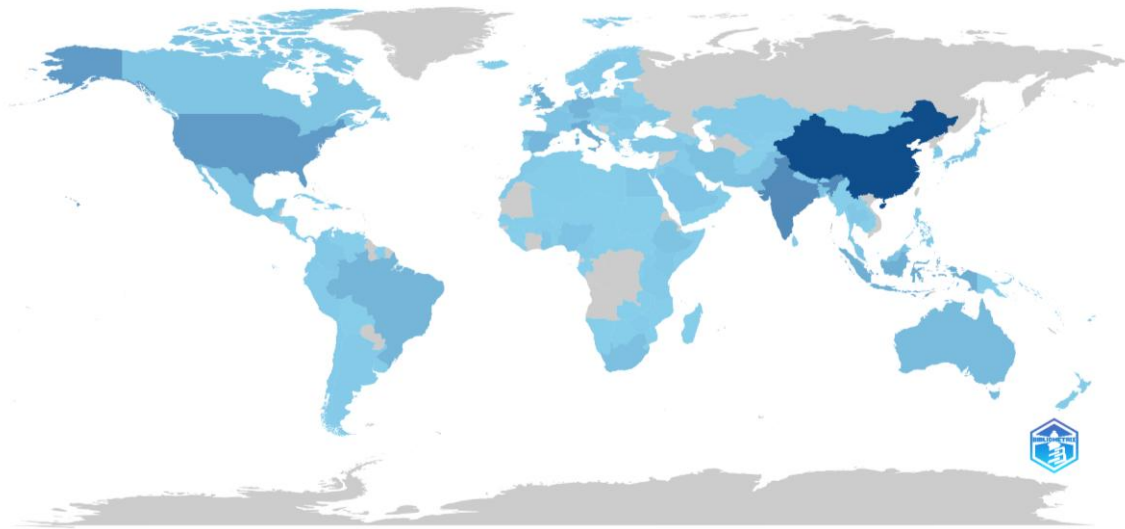


Figure 7. Distribution of countries with the highest publication frequency

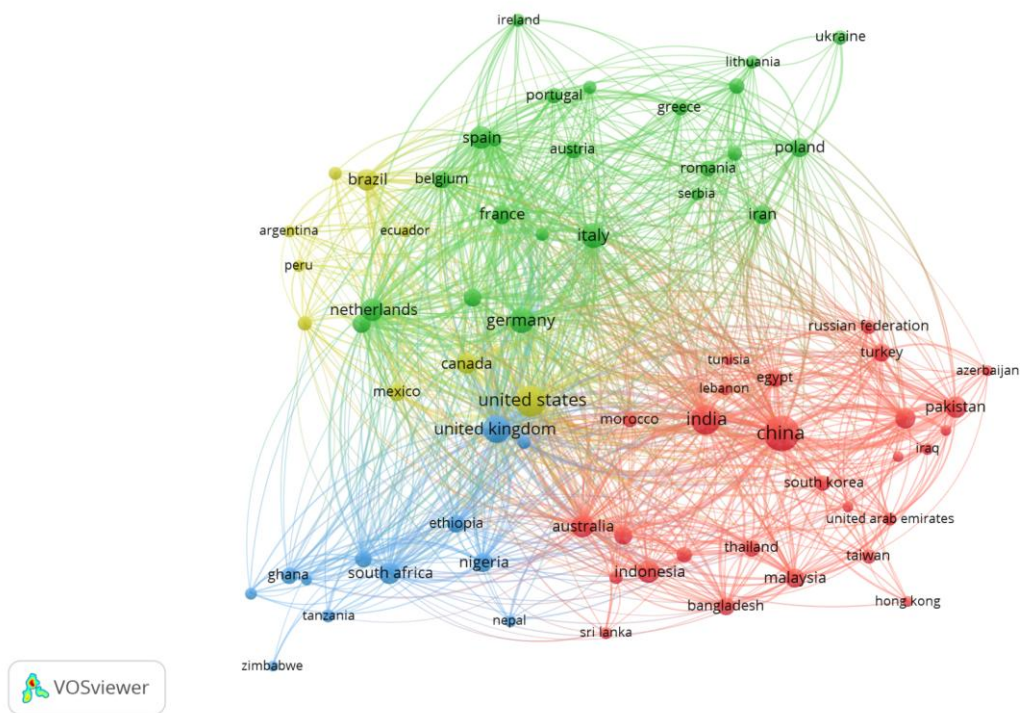


Figure 8. Collaboration network between countries

Identify Dominant Topics

The keyword network derived from the bibliometric analysis identifies the primary discourse clusters guiding the direction of the sustainable agriculture research. The SDGs occupy a central position within the network structure, serving as the primary nexus of global policy dimensions, governance, and food system development. The close interconnections between agricultural development, governance approaches, food security, and innovation reinforce the role of the SDGs as a normative framework for shaping sustainability discourse across disciplines and regions.

Themes representing social and economic constructs appear to dominate the human development cluster. General keywords such as agricultural economics, rural development, and



poverty emerged as major topics in this network, which conceptually serve as the driving variables for HDI indicators. The integration of these social topics with food security and governance indicates that contemporary research is increasingly focused on the welfare conditions of agricultural communities. The current development paradigm does not solely focus on economic output but rather emphasizes the quality of life and the involvement of rural communities in the adaptation and transformation processes of sustainable agri-communities.

Environmental and resource efficiency topics are visualized through a cluster that closely intersects with EF indicators. Macro issues such as economic development, carbon, circular economy, energy efficiency, soil quality, and water management dominate discussions in this area. The network structure reveals that EF is positioned by researchers as a barometer or primary indicator for evaluating the ecological impacts of various agricultural practices. The utilization of this evaluation framework guides research toward more sustainable natural resource management.

The subsequent cluster is again dominated by themes representing social constructs at the community level, particularly resilience, rural development, poverty and livelihoods. These general topics fundamentally constitute the elements that shape the SLA framework. Network mapping highlights the research focus on strengthening the adaptive capacity of rural communities. Researchers have explored these social, economic, and ecological issues as manifestations of multidimensional strategies aimed at improving the welfare and resilience of agricultural communities. The close interconnection between this local discourse and food security, as well as governance approaches, illustrates that the sustainable livelihood approach is becoming increasingly central to shaping agricultural transformation at both the grassroots and policymaker levels.

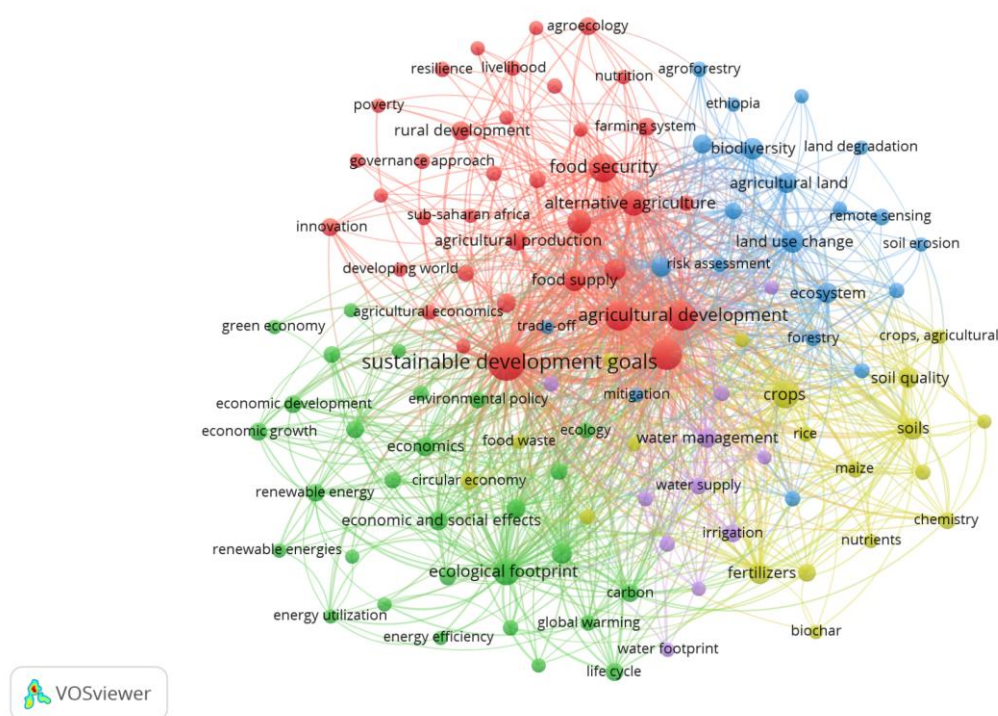


Figure 9. Co-occurrence network

The co-occurrence density results within the network indicate SDGs, governance, resilience, innovation, and food security as themes with increasing frequency in recent publications (2022–2025). This mapping clarifies the conceptual separation between research topics and their measurement indicators. The themes representing social, ecological, and

of publications, while Africa, a region facing the most severe challenges, remains marginalized. The production of knowledge regarding sustainability is paradoxical, as it demonstrates an unsustainable pattern (Tamene, 2015).

An intractable paradox emerges when evaluating the interactions among these four dimensions. The tension between EF and SDGs becomes apparent because the agricultural intensification mandated by SDG 2 inherently increases the ecological burden. Meanwhile, most publications merely identify these trade-offs without offering innovative, win-win solutions. A potential relationship exists between HDI and SLA based on the assumption that higher education can enhance the adoption of sustainable technologies. However, the literature has not comprehensively explained this mechanism, and it remains an open question whether higher education drives youth outmigration to urban areas (Afolayan, 2010; Rochman, 2025). A productivity paradox is also evident in the relationship between EF and HDI. Agricultural intensification raises incomes, thereby increasing the HDI, but simultaneously triggers environmental pollution, which elevates the EF. An optimal formula has not yet been discovered, especially given the varying geographical contexts: frontier regions like Sub-Saharan Africa are still experiencing deforestation, consolidation regions like South Asia are input-intensive, and intensive regions like East Asia have stable land conditions (Coggins et al., 2025; Thomson et al., 2019). Furthermore, a scale gap exists between the SDGs and the SLA. The SDGs have clear global targets for 2030, but their implementation guidelines remain vague. Conversely, the SLA has highly detailed operationalization but is rarely connected to global macro-policies.

The integration of these four dimensions into a cohesive framework remains rare, despite the presence of 8,272 publications across 2,148 journals. Articles claiming to use an integrated approach often merely stack these four dimensions without genuinely modeling their interactions or potential synergies. Deeply rooted academic structures are the primary cause of this phenomenon; researchers are typically trained in isolated disciplines, research funding is segmented for specific topics, and publication patterns continue to reinforce these boundaries (Feng & Kirkley, 2020). Significant research opportunities arise from the separation of these three communities. There is massive potential in using dynamic system modeling to simulate complex inter-dimensional trade-offs, agent-based modeling to capture the heterogeneity of farmers' decisions, and transdisciplinary research designs that integratively combine environmental science, development economics, political ecology, and social anthropology. The most urgent need is the presence of research facilitators or boundary-spanning researchers capable of bridging these three disparate groups to create knowledge synergy.

Sustainable agriculture research has reached a critical juncture, where incremental improvements in isolated studies are no longer adequate. Digital transformation, the urgency of the climate crisis, and the dynamics of social movements render the preservation of disciplinary silos untenable in the contemporary world. Future research directions require the execution of four strategic steps. First, transitioning from mere network analysis to causal research that examines the actual interactions of the four dimensions in the field is required. Second, recognizing local knowledge, which has often empirically integrated these four dimensions but is frequently overlooked in formal academic discourse, is essential. Third, developing standardized composite metrics to measure environmental, social, developmental, and policy achievements in comparable units is necessary. Fourth, establishing cross-disciplinary and cross-geographical research teams with the active involvement of researchers from Africa and South Asia to mitigate Western perspective bias. Concrete implementation should encompass the analysis of educational mechanisms in driving the adoption of sustainable practices, spatially based SDG-EF trade-off modeling, the utilization of SLA as an SDG policy evaluation instrument, and the creation of feedback loops from local implementation to macro-level policy adjustments.



Conclusion

Sustainable agriculture research has grown exponentially at 36.29 percent annually, with four main dimensions, namely the EF, HDI, SLA, and SDGs, becoming global references across 8272 publications. Nevertheless, substantial integration among these dimensions remains partial because research communities operate in isolation due to entrenched academic structures and funding fragmentation. This condition creates a productivity paradox, where increased agricultural output aligns with escalating environmental pollution, while the causal relationships among variables remain unclearly mapped. Furthermore, geographical inequality is highly conspicuous, with China dominating over half of the publications, which marginalizes the African continent and ultimately creates a form of epistemological colonialism. Therefore, future research must comprehensively trace the empirical linkages among these four dimensions by acknowledging farmers local knowledge and developing multidimensional measurement metrics. The establishment of inclusive, cross-disciplinary, collaborative teams, especially with the active involvement of researchers from the Global South, is urgently needed to transform the fragmented research landscape into tangible action on the ground.

Limitation

This study has inherent limitations regarding the use of the Scopus database as the sole source in the bibliometric data collection process. The selection of this database was based on the reputation of Scopus for its broad citation coverage and strict curation standards; however, it potentially excludes relevant literature indexed exclusively in other databases such as Web of Science or Google Scholar. Linguistic and geographical biases may affect the completeness of the data, given that the dominance of English-language publications in Scopus tends to marginalize vernacular research or local case studies that are not translated into international forums. The interpretation of the knowledge development map in this study must be understood within the context of global mainstream academic literature so that discourse dynamics that are highly local or published in the grey literature may not be fully captured. Nevertheless, the analyzed dataset is still considered representative for illustrating the macro trends in the evolution of the sustainable agriculture concept and its interaction with ecological and social dimensions over the last two decades.

Funding Declaration

This research did not receive any specific grants from any funding agency in the public, commercial, or not-for-profit sectors.

Competing Interests

The author(s) declare (s) no conflict of interest.

Data Availability

The data used to support the findings of this study were sourced from the Scopus database, which is publicly accessible to researchers. To ensure transparency and reproducibility, the search strategy, keywords, and inclusion criteria were described in detail in the methodology section. Therefore, other researchers can retrieve and verify the same dataset by following the procedures outlined in this study.



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