Mapping Research Trends on Agricultural Resilience in Publications from 2012 to 2024

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Article Info

ABSTRACT

This study aims to map the development of agricultural resilience research published between 2012 and 2024 using a bibliometric approach based on the Scopus database. By employing VOSviewer for network, overlay, and density visualizations, the study analyzes publication trends, collaboration patterns, and thematic structures within the field. The results show a significant increase in scholarly output over time, with climate change, agriculture, and food security emerging as the central pillars of the research landscape. Co-authorship and country collaboration networks indicate that the United States and India serve as major global hubs, supported by strong institutional clusters in China and growing contributions from African countries. The keyword co-occurrence analysis reveals a multidisciplinary structure integrating socio-ecological adaptation frameworks with agronomic and biological approaches. Overlay visualization suggests a recent shift toward molecular, genetic, and physiological studies addressing drought and abiotic stress, reflecting a growing emphasis on technological innovation. Agricultural resilience research demonstrates increasing integration across disciplines and regions, highlighting the need for balanced strategies that combine systemic adaptation, sustainability, and crop-level innovation to strengthen agricultural systems under climate uncertainty.

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1. INTRODUCTION

Agricultural resilience is increasingly recognized as a crucial factor for ensuring sustainable food systems and rural livelihoods in the face of multiple stressors, including climate change, economic uncertainties, and social disruptions. In recent decades, the agricultural sector has faced significant challenges such as climate variability, resource depletion, and growing population pressures, all of which undermine food security and agricultural productivity [1], [2]. As a result, enhancing agricultural resilience has become a global priority, particularly for countries heavily dependent on agriculture as a means of subsistence and economic growth. Agricultural resilience refers to the capacity of agricultural systems to anticipate, prepare for, respond to, and recover from adverse conditions or disturbances while maintaining their essential functions, structures, and systems [3].

The concept of resilience in agriculture encompasses not only environmental and ecological aspects but also socio-economic, political, and institutional dimensions. In this context, it is imperative to explore how agricultural systems can adapt to and recover from disruptions, including extreme weather events, pest outbreaks, market volatility, and shifts in policy [3]. In particular, the integration of resilient practices within farming systems, such as crop diversification, improved soil management, and access to innovative technologies, plays a pivotal role in safeguarding the livelihoods of farmers and the sustainability of agricultural ecosystems. Over time, agricultural resilience has evolved from a purely ecological concept to an interdisciplinary field that includes aspects of governance, policy, and socioeconomic structures [4], [5].

Research on agricultural resilience has grown in scope and depth, addressing a range of topics that contribute to the enhancement of resilience in both developed and developing countries. Studies have focused on developing adaptive strategies for farmers to cope with the challenges posed by climate change, as well as exploring the role of agricultural technology, sustainable practices, and policy frameworks in enhancing resilience [6]. The growing body of literature in this field highlights the importance of integrating climate-smart agriculture, agroecological practices, and participatory approaches to strengthen the resilience of agricultural systems. This research trajectory has led to a significant expansion in the number of publications dedicated to understanding, measuring, and promoting agricultural resilience across diverse geographies and socio-economic settings.

In recent years, a shift has occurred in research that emphasizes the need for resilience to be considered within broader socio-environmental frameworks. Researchers are exploring how resilience can be strengthened through community-based initiatives, local governance structures, and innovative financial mechanisms [7]. The role of indigenous knowledge and traditional agricultural practices, which have evolved over centuries, is also gaining attention as they often offer insights into adaptive strategies that are rooted in local contexts. Additionally, resilience research has become more interdisciplinary, drawing from the fields of economics, sociology, political science, and environmental science. The integration of these diverse perspectives enhances the understanding of agricultural resilience as a dynamic, multi-dimensional phenomenon that is essential to achieving long-term sustainability.

Despite the growing interest and body of research, challenges persist in ensuring that resilience-building strategies are effectively implemented at the ground level. Factors such as insufficient access to finance, lack of market infrastructure, inadequate knowledge dissemination, and limited policy support hinder the adoption of resilient agricultural practices, particularly in rural and marginalized communities. Furthermore, there remains a gap in understanding how global resilience strategies can be tailored to specific regional and local contexts, considering the varying environmental, economic, and social conditions that shape agricultural practices. These issues underscore the need for continuous research and innovation in the field of agricultural resilience, as well as the importance of international collaborations and cross-sectoral partnerships.

Despite the growing body of research, challenges persist in translating resilience theory into practical, actionable solutions for farmers and policymakers. Agricultural systems in many regions continue to face mounting pressures from climate change, unsustainable land use practices, and limited access to resources. There is a significant knowledge gap regarding the implementation of resilience-enhancing strategies at the local

level, particularly in areas most vulnerable to climate variability. Furthermore, insufficient integration of indigenous knowledge and local coping mechanisms in mainstream resilience strategies has led to ineffective interventions. The lack of a cohesive framework for assessing and monitoring agricultural resilience across diverse regions and farming systems further exacerbates these challenges, resulting in limited policy support and insufficient resource allocation to tackle the complex dynamics of agricultural resilience. The objective of this study is to map the current research trends in the field of agricultural resilience by analyzing publications from 2012 to 2024.

2. METHOD

This study employs a bibliometric analysis to map the research trends in agricultural resilience from 2012 to 2024. The primary data source for this analysis is Scopus, a comprehensive and authoritative database of academic literature that includes a wide range of peer-reviewed journals, conference papers, and research articles. The Scopus database was used to identify relevant publications related to agricultural resilience by searching for keywords such as "agricultural resilience," "climate-smart agriculture," and "sustainable farming systems." The search was refined to include only articles published between 2012 and 2024, and all selected publications were then exported for further analysis. This approach allows for a detailed exploration of the quantity and quality of publications, as well as the identification of emerging research areas and key authors in the field.

The bibliometric analysis was conducted using VOSviewer, a software tool specifically designed for visualizing and analyzing bibliometric networks. VOSviewer was used to generate co-occurrence networks of keywords, authorship collaborations, and citation relationships within the selected publications. The software's ability to produce visual maps of these networks facilitated the identification of prominent research themes, clusters, and trends in the agricultural resilience literature. By examining the patterns of co-authorship, keyword co-occurrence, and citation analysis, the study provides a comprehensive view of the evolution of agricultural resilience research, highlights key areas of focus, and identifies potential gaps in the literature.

3. RESULT AND DISCUSSION
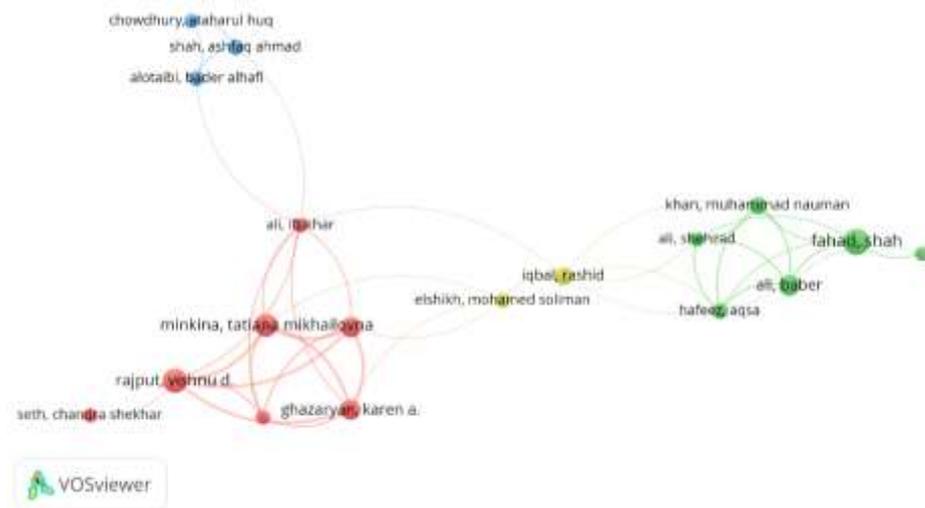**Co-Authorship Analysis**

Figure 1. Author Visualization
Source: Data Analysis

Figure 1 reveals several distinct yet interconnected collaboration clusters. The red cluster appears as one of the most cohesive groups, characterized by strong collaborative ties among authors such as Rajput Vishnu D., Minkina Tatiana Mikhailovna, and Ghazaryan Karen A., indicating intensive internal collaboration and likely high joint productivity. Similarly, the green cluster demonstrates solid internal connectivity, with Fahad Shah emerging as a central figure who plays a key role in linking co-authors within the group. In contrast, the blue cluster is smaller and more peripheral, showing relatively limited connectivity compared to the two main clusters. Notably, bridging authors such as Iqbal Rashid and Ali Iftikhar function as intermediaries connecting different clusters, suggesting their strategic role in facilitating knowledge exchange across collaborative networks.
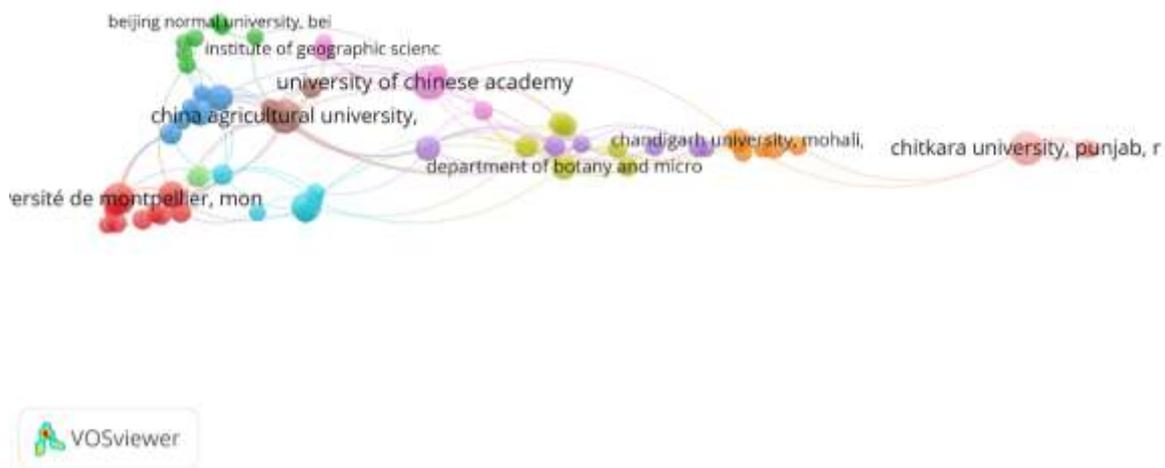

Figure 2. Institution Visualization
Source: Data Analysis

Figure 2 shows a structure dominated by several central universities that function as major hubs. The University of Chinese Academy of Sciences appears as one of the most prominent and well-connected institutions, linking with China Agricultural University, the Institute of Geographic Sciences, and Beijing Normal University, forming a strong Chinese research cluster. This indicates that China plays a leading and highly coordinated role in this research domain. Another visible cluster is centered around Chandigarh University, Mohali, which connects outward to Chitkara University, Punjab, suggesting a regional collaboration network in India. Meanwhile, Université de Montpellier forms a separate European cluster with relatively cohesive internal ties but fewer cross-regional links compared to the Chinese network. The visualization suggests that agricultural resilience research is shaped by strong national or regional institutional collaborations, with a few central universities acting as bridges that connect broader international research partnerships.
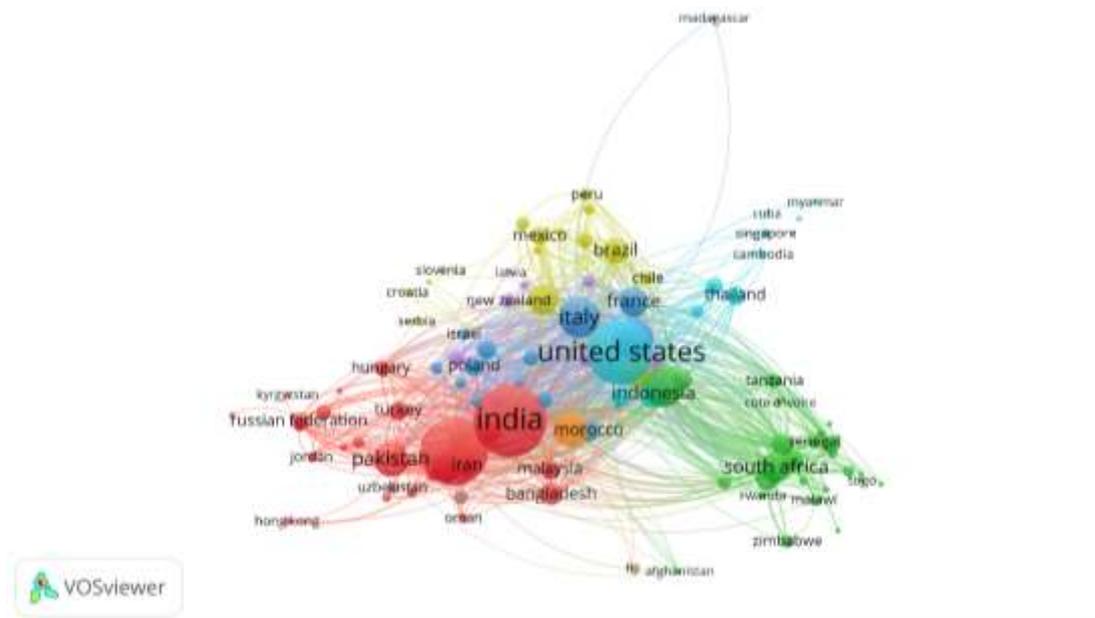
Figure 3. Country Visualization
Source: Data Analysis

Figure 3 highlights the United States and India as the most central and influential actors, indicated by their larger node sizes and dense linkages with multiple countries. The United States functions as a global hub, connecting with European countries such as Italy and France, as well as Asian and African nations, reflecting broad international collaboration. India also emerges as a strong regional and global contributor, closely linked with Pakistan, Iran, Bangladesh, and Malaysia, forming a dense South Asian cluster. Another prominent cluster is centered around South Africa, which connects with several African countries such as Senegal, Rwanda, Zimbabwe, and Tanzania, suggesting growing regional collaboration within Africa. Meanwhile, European and Latin American countries, including Italy, Brazil, Mexico, and Chile, form interconnected sub-networks that bridge transcontinental partnerships.
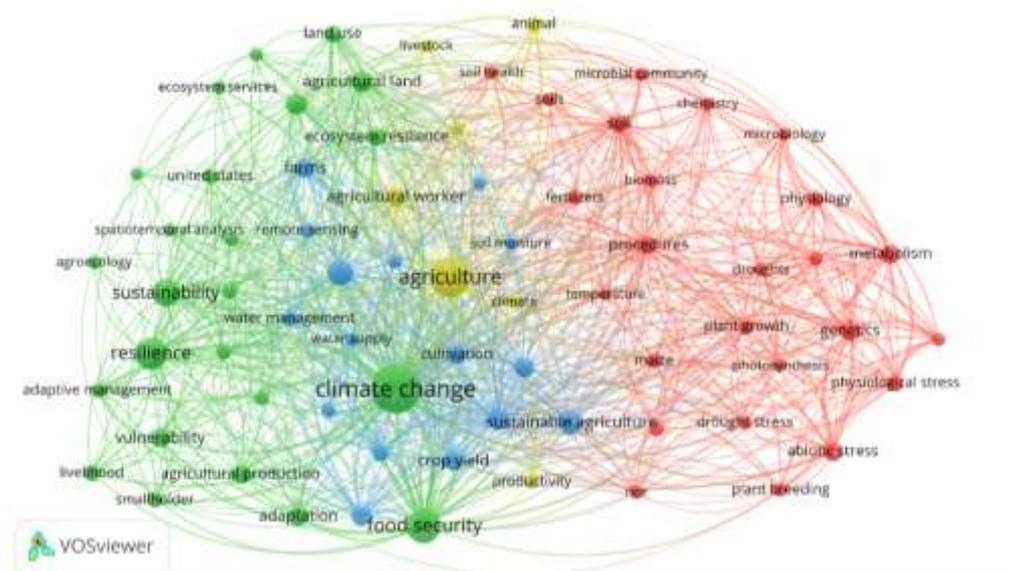
Keywords Co-Occurrence Analysis

Figure 4. Network Visualization
Source: Data Analysis

Figure 4 reveals that climate change occupies a highly central position within agricultural resilience research, acting as the primary conceptual anchor connecting multiple thematic clusters. Closely linked terms such as agriculture, food security, adaptation, and sustainability indicate that the discourse is strongly oriented toward understanding how agricultural systems respond to climate-related pressures while maintaining productivity and livelihoods. The prominence of these nodes suggests that resilience is predominantly framed within the broader climate change adaptation agenda. The green cluster emphasizes socio-ecological and sustainability-oriented dimensions of resilience. Keywords such as resilience, vulnerability, adaptive management, ecosystem services, agroecology, and smallholder reflect a systems-based perspective that integrates environmental management with livelihood security. This cluster highlights the importance of governance, water management, land use, and farming systems in strengthening adaptive capacity, particularly for vulnerable rural communities.

The red cluster, in contrast, is heavily oriented toward plant physiology and biophysical stress responses. Terms such as drought stress, abiotic stress, genetics, photosynthesis, plant breeding, and physiological stress indicate a strong focus on crop-level resilience mechanisms. This suggests that a substantial portion of the literature approaches agricultural resilience from a biological and experimental standpoint, aiming to enhance crop tolerance to drought and temperature extremes through genetic and physiological improvements. The yellow cluster bridges agricultural production and environmental conditions, with keywords like agriculture, soil health, soil moisture, fertilizers, livestock, and animal. This indicates attention to soil systems, nutrient management, and integrated farming practices as components of resilience. The presence of productivity, crop yield, and cultivation further suggests that maintaining stable production under climatic stress remains a central concern in the field.

The network demonstrates that agricultural resilience research is multidisciplinary, integrating climate science, socio-ecological systems, agronomy, and plant biology. While climate change and food security form the conceptual core, the literature spans from macro-level adaptation strategies to micro-level physiological mechanisms. The dense interconnections among clusters indicate increasing integration across disciplinary boundaries, signaling a mature and evolving research landscape focused on building resilient agricultural systems in the face of global environmental change.
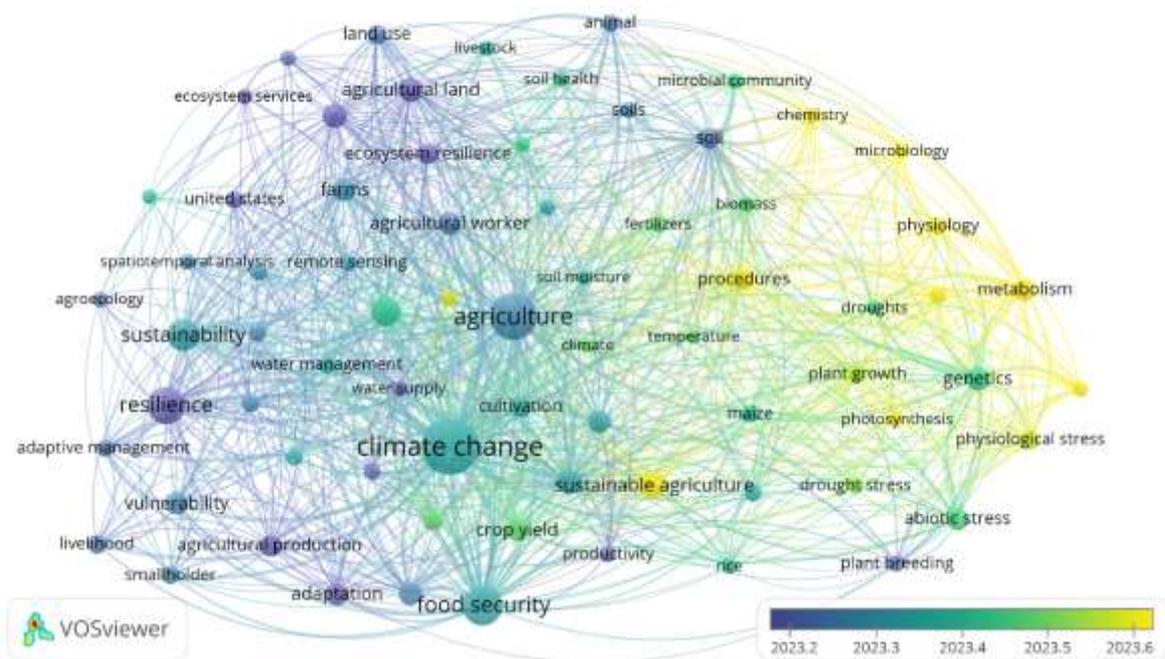
Figure 5. Overlay Visualization
Source: Data Analysis

Figure 5 illustrates the temporal evolution of keywords in agricultural resilience research, with colors ranging from earlier publications (blue) to more recent ones (yellow). Core terms such as climate change, resilience, sustainability, and food security appear in cooler blue and green tones, indicating that these themes have been foundational and consistently studied over time. Their central position in the network confirms that climate-driven adaptation and food system stability form the long-standing backbone of agricultural resilience scholarship. In contrast, keywords shown in yellow—such as genetics, metabolism, physiology, microbiology, and chemistry—represent more recent research directions. This suggests a growing scientific emphasis on plant-level and molecular mechanisms to enhance crop tolerance to drought and abiotic stress. The increasing prominence of terms like physiological stress, plant growth, and droughts reflects a shift toward more technical and experimental approaches, aiming to strengthen resilience through biological innovation and crop improvement strategies. Meanwhile, mid-spectrum green keywords such as sustainable agriculture, productivity, crop yield, and soil health indicate an ongoing transition that bridges traditional adaptation studies with newer technological and agronomic advancements.
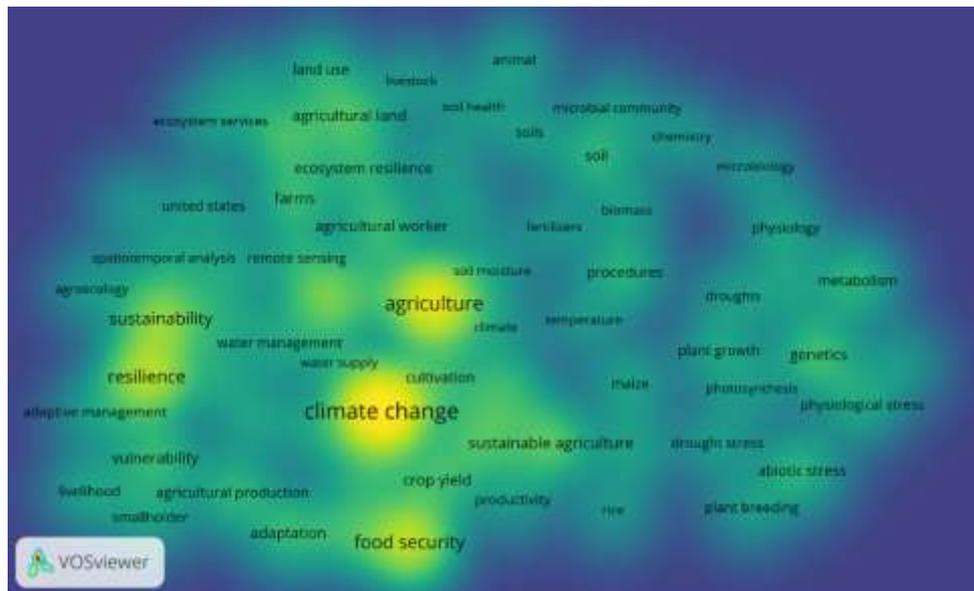
Figure 6. Density Visualization
Source: Data Analysis

Figure 6 highlights the most intensively studied themes in agricultural resilience research through brighter yellow areas. The strongest concentration appears around climate change, agriculture, and food security, indicating that these topics form the core intellectual foundation of the field. Closely related terms such as resilience, sustainability, and adaptation also show relatively high density, suggesting that much of the literature focuses on how agricultural systems respond to climate pressures while ensuring stable production and livelihood security. This confirms that the dominant narrative in the field links resilience directly to climate-driven risks and long-term food system sustainability. In contrast, areas with cooler green and blue shades—such as genetics, physiology, microbiology, plant breeding, and abiotic stress—represent more specialized or emerging subfields with comparatively lower overall frequency. Although these topics are clearly connected to the broader resilience framework, they are less central than the climate–food security nexus.

Table 1. Top Cited Literature

Citations	Authors and Year	Title
2,445	[8]	Natural climate solutions
2,138	[9]	Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation–Lancet Commission on planetary health
1,563	[10]	Climate-smart agriculture for food security
1,524	[11]	Plant growth-promoting rhizobacteria: Context, mechanisms of action, and roadmap to commercialization of biostimulants for sustainable agriculture
1,453	[12]	Restoring soil quality to mitigate soil degradation
1,192	[13]	Genetic strategies for improving crop yields
1,030	[14]	Agroecology and the design of climate change-resilient farming systems
956	[15]	The Amazon basin in transition
889	[16]	Ecosystem services in biologically diversified versus conventional farming systems: Benefits, externalities, and trade-offs
879	[17]	Landscapes that work for biodiversity and people

Source: Scopus, 2026

Discussion

This bibliometric mapping of agricultural resilience research (2012–2024) reveals a rapidly expanding and increasingly multidisciplinary field anchored in the nexus of climate change, agriculture, and food security. The dominance of these core keywords across the network, overlay, and density visualizations confirms that resilience in agriculture is primarily conceptualized as a response to climate-related risks and the need to safeguard food systems. The strong centrality of terms such as adaptation, sustainability, and resilience indicates that the literature consistently frames agricultural systems as socio-ecological systems that must absorb, adapt to, and recover from environmental shocks. This reinforces the understanding that resilience is not merely a production concern, but a systemic capacity involving environmental, social, and economic dimensions.

The co-authorship and country collaboration networks demonstrate that research productivity and influence are concentrated in a few dominant hubs, particularly the United States and India, followed by strong institutional clusters in China and emerging networks in Africa and Europe. The United States functions as a global connector, bridging collaborations across continents, while India leads a dense regional cluster in South Asia. This pattern suggests that agricultural resilience research is both globally distributed and regionally structured, reflecting the localized nature of climate vulnerabilities and agricultural systems. The increasing involvement of African countries, especially South Africa, signals a growing recognition of resilience challenges in climate-vulnerable regions, highlighting a gradual shift toward more geographically inclusive scholarship.

Institutional mapping further shows that leading universities and research centers, particularly in China and India, act as central knowledge producers and network integrators. The strong clustering around institutions such as the University of Chinese Academy of Sciences and major agricultural universities indicates that resilience research is embedded within well-established agricultural and environmental science infrastructures. However, cross-institutional bridges remain limited, suggesting that while collaboration is strong within regional clusters, there is still potential to strengthen intercontinental research partnerships to enhance knowledge diffusion and comparative learning.

The thematic evolution captured in the overlay visualization suggests a notable shift in recent years. Earlier research emphasized broad socio-ecological concepts such as vulnerability, adaptive management, and sustainability. More recent studies increasingly focus on technical and biological dimensions, including genetics, physiology, microbiology, and abiotic stress. This transition reflects a growing interest in crop-level and molecular approaches to resilience, particularly in addressing drought and temperature extremes. While this scientific deepening strengthens the technological base of resilience strategies, it also signals a need to balance biophysical innovations with socio-institutional considerations to ensure practical applicability and equitable benefits for smallholders.

The findings indicate that agricultural resilience research has matured into a highly interconnected yet thematically diverse domain. Climate change and food security remain the intellectual core, but the field is expanding toward integrative approaches that combine sustainability science, agronomy, biotechnology, and policy-oriented adaptation strategies. Future research could benefit from stronger integration between socio-economic resilience frameworks and plant-level scientific innovations, as well as from broader cross-regional collaborations. By bridging systemic adaptation strategies with technological

advances, the field can move toward more comprehensive and actionable models of resilient agricultural systems in the face of accelerating global environmental change.

socio-ecological adaptation, vulnerability, and sustainability frameworks, more recent studies increasingly incorporate biological, genetic, and physiological approaches to enhance crop-level resilience. Collaboration patterns indicate that a few leading countries and institutions act as global knowledge hubs, although regional clusters remain prominent. Overall, the field shows growing integration across disciplines and regions, suggesting a progressive shift toward more comprehensive and technologically informed strategies to strengthen agricultural systems against climate and environmental uncertainties.

4. CONCLUSION

This bibliometric study demonstrates that agricultural resilience research between 2012 and 2024 has evolved into a dynamic and multidisciplinary field centered on the interconnection between climate change, agriculture, and food security. The findings reveal that while early research emphasized

REFERENCES

[1]   C. Kantor, J. D. Eisenback, and M. Kantor, "Biosecurity risks to human food supply associated with plant-parasitic nematodes," *Front. Plant Sci.*, vol. 15, 2024, doi: 10.3389/fpls.2024.1404335.

[2]   A. Kononiuk and A. Magruk, "BUILDING RESILIENCE IN EUROPEAN FOOD SUPPLY CHAINS: RESULTS OF A DELPHI STUDY," *Econ. Environ.*, vol. 87, no. 4, 2023, doi: 10.34659/eis.2023.87.4.758.

[3]   J. E. Hobbs, "Food supply chain resilience and the COVID-19 pandemic: What have we learned?," *Can. J. Agric. Econ.*, vol. 69, no. 2, pp. 189–196, 2021, doi: 10.1111/cjag.12279.

[4]   G. Zhao, S. Liu, H. Lu, C. Lopez, and S. Elgueta, "Building theory of agri-food supply chain resilience using total interpretive structural modelling and MICMAC analysis," *Int. J. Sustain. Agric. Manag. Informatics*, vol. 4, no. 3–4, pp. 235–257, 2018, doi: 10.1504/IJSAMI.2018.099236.

[5]   E. Vogel and R. Meyer, "Climate change, climate extremes, and global food production—adaptation in the agricultural sector," *Resilience*, pp. 31–49, 2018.

[6]   A. P. Torres and M. I. Marshall, "Does social capital explain small business resilience? A panel data analysis post-Katrina," in *2015 AAEA & WAEA Joint Annual Meeting, July 26-28, San Francisco, California*, Agricultural and Applied Economics Association, 2015.

[7]   T. Fellmann, "The assessment of climate change-related vulnerability in the agricultural sector: reviewing conceptual frameworks," *Build. Resil. Adapt. to Clim. Chang. Agric. Sect.*, vol. 23, p. 37, 2012.

[8]   B. W. Griscom *et al.*, "Natural climate solutions," *Proc. Natl. Acad. Sci.*, vol. 114, no. 44, pp. 11645–11650, 2017.

[9]   S. Whitmee *et al.*, "Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health," *Lancet*, vol. 386, no. 10007, pp. 1973–2028, 2015.

[10]   L. Lipper *et al.*, "Climate-smart agriculture for food security," *Nat. Clim. Chang.*, vol. 4, no. 12, pp. 1068–1072, 2014.

[11]   R. Backer *et al.*, "Plant growth-promoting rhizobacteria: context, mechanisms of action, and roadmap to commercialization of biostimulants for sustainable agriculture," *Front. Plant Sci.*, vol. 9, p. 1473, 2018.

[12]   R. Lal, "Restoring soil quality to mitigate soil degradation," *Sustainability*, vol. 7, no. 5, pp. 5875–5895, 2015.

[13]   J. Bailey-Serres, J. E. Parker, E. A. Ainsworth, G. E. D. Oldroyd, and J. I. Schroeder, "Genetic strategies for improving crop yields," *Nature*, vol. 575, no. 7781, pp. 109–118, 2019.

[14]   M. A. Altieri, C. I. Nicholls, A. Henao, and M. A. Lana, "Agroecology and the design of climate change-resilient farming systems: MA Altieri et al.," *Agron. Sustain. Dev.*, vol. 35, no. 3, pp. 869–890, 2015.

[15]   E. A. Davidson *et al.*, "The Amazon basin in transition," *Nature*, vol. 481, no. 7381, pp. 321–328, 2012.

[16]   C. Kremen and A. Miles, "Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs," *Ecol. Soc.*, vol. 17, no. 4, 2012.

[17]   C. Kremen and A. M. Merenlender, "Landscapes that work for biodiversity and people," *Science (80-.).*, vol. 362, no. 6412, p. eaau6020, 2018.