

Mapping Research Trends on Agricultural Resilience in Scholarly Publications (2012–2024)

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Article Info

Article history:

Received May, 2026

Revised May, 2026

Accepted May, 2026

Keywords:

Agricultural Resilience

Bibliometric Analysis

Climate Change

Food Security

Sustainable Agriculture

VOSviewer

ABSTRACT

Agricultural resilience has emerged as an increasingly important research domain in response to global challenges related to climate change, food security, environmental degradation, and sustainable agricultural development. This study aims to map the development, intellectual structure, collaboration patterns, and emerging themes of agricultural resilience research published between 2012 and 2024. A bibliometric approach was employed using scholarly publications indexed in Scopus as the primary data source. The collected bibliographic data were analyzed using VOSviewer to examine publication trends, co-authorship networks, institutional collaboration, country collaboration, citation structures, keyword co-occurrence, overlay visualization, and density mapping. The findings indicate that agricultural resilience research has experienced substantial growth and developed into a multidisciplinary field integrating environmental science, agricultural systems, sustainability studies, and technological innovation. Collaboration analysis identified the United States, China, and India as dominant contributors and central actors in global research networks, while institutional and author analyses revealed the existence of several interconnected scholarly communities. Citation analysis showed that the field is strongly influenced by foundational works on planetary boundaries, ecosystem resilience, climate-smart agriculture, biodiversity conservation, and sustainable development. Keyword mapping demonstrated that major themes include climate change, agriculture, food security, sustainable agriculture, crop resilience, and ecosystem management, with recent developments increasingly emphasizing precision agriculture, machine learning, physiological stress, and adaptive agricultural technologies.

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1. INTRODUCTION

Agriculture holds a strategic position in the sustenance of human life since it guarantees food security, employment opportunities, and economic stability to

billions of people globally [1]. Nevertheless, the agricultural industry is under constant threats of different environmental factors, such as climate change, land degradation, reduction in biodiversity, shortage of water

resources, and global economic instability. Extreme climatic conditions like droughts, floods, and unpredictable precipitation patterns have considerably impacted the productivity of agriculture in many nations. In light of these environmental and socio-economic concerns, the notion of agricultural resilience has gained much prominence in the literature in order to comprehend the ability of agricultural systems to endure and adapt to shocks without compromising on their basic functions [2]. Agricultural resilience has been gaining immense interest amongst academicians, researchers, policy-makers, and international institutions as resilient agricultural systems are deemed crucial for the accomplishment of sustainable development [3].

The trend of agricultural resilience has gained prominence through the exponential increase in the number of publications on issues related to agriculture and resilience. Academic focus has moved beyond the conventional areas such as crop resilience and management of disasters, shifting to more cross-disciplinary themes covering climate-smart agriculture, sustainable agriculture systems, innovations, resilience capability, ecology, and socio-economic resilience [4]. This literature shows that the concept of agricultural resilience does not merely relate to environmental sustainability but extends to other spheres such as institutional governance, rural development, technologic advancements, and social capital. Bibliometric analysis carried out in various domains has recorded an appreciable growth trend in the past decade regarding the number of publications on the issue of resilience. VOSviewer in analyzing databases makes the evaluation of publishing trends, collaboration networks, prolific scholars, and emerging research areas possible.

Between 2012 and 2024, significant developments within the global community led to changes within agricultural resilience discourse. In particular, the establishment of SDGs in 2015, in particular SDG 2 that aimed to ensure Zero Hunger, and SDG 13 that targeted Climate Action, facilitated

discussions about agricultural resilience. Additionally, numerous international agreements, including the Paris Agreement on Climate Change, called for adaptation and mitigation strategies to address climate challenges in agriculture. Over this time period, technologies, such as precision agriculture, use of AI, remote sensing, and digital farms became increasingly important aspects of research on agricultural resilience. Scientists started to investigate how technological innovation and adaptation could lead to higher agricultural yields while lowering vulnerability to climate change. The COVID-19 crisis also demonstrated the vulnerability of global food systems, thereby increasing research attention paid to agricultural resilience.

Though there is an increasing amount of research on agricultural resilience in the literature, the study of this subject continues to be fragmented in disciplinary, regional, and methodology terms. Indeed, while many scholars concentrate on particular issues of agricultural resilience, such as climate resilience, food security, sustainability, and resilience to disasters, they do not discuss its development and progress as a whole. In addition, the output of research into the problem in question is quite dispersed since it is published in numerous academic journals, universities, and different countries. The use of bibliometric methods appears to be an effective tool for solving this issue since it enables researchers to conduct quantitative mapping of scientific progress and visualize links between papers, keywords, scholars, and educational establishments. This way, bibliometric maps will help scholars discover gaps in the current research, identify new trends, the most influential publications, and future prospects in the field.

A number of bibliometrics studies have analyzed themes that relate to climate resilience, sustainable agriculture, food systems, and agricultural technology. Nevertheless, bibliometrics works focusing on the overall research trends regarding agricultural resilience during 2012-2024 are still rare. The current body of literature tends to focus more on a specific region, a certain

technology, or a specific topic rather than analyzing the overall research trend regarding agricultural resilience. Furthermore, the fast publication rate in recent years indicates the presence of emerging themes and collaboration networks in the field, which is under-represented in existing reviews. Thus, it is necessary to conduct a bibliometric analysis of publications related to agricultural resilience from 2012 to 2024 because such an analysis would provide a systematic review of the field. Such an analysis would allow identifying such aspects as the growth of publications, key researchers and institutions in the field, frequently used keywords, and emerging collaboration networks within the field.

Despite the great development that this area has experienced during the last decade, the emergence of studies in the area of agricultural resilience is scattered in various disciplines, research topics, and locations. The increasing number of publications has made it difficult for researchers to track the existing research trends, significant authors, thematic development, and collaboration networks within the studied sphere. Current researches usually concentrate their attention on particular issues of agricultural resilience, like climatic adaptation, food security, or innovations but fail to give a comprehensive overview of the development of agricultural resilience research. Besides, very few bibliometric studies investigate the development of agricultural resilience from the perspective of publications published during the 2012-2024 period, although much has changed in the world since then in terms of agriculture and environment. This means that not enough information is available about what issues have become the focus of agricultural resilience research in recent years, what problems remain unresolved, and what areas need additional research. The objective of this study is to conduct a bibliometric analysis of the trend of literature on the topic of agricultural resilience during the time period 2012 to 2024.

2. METHODS

The current bibliometric study utilized a research design known as bibliometric for investigating scientific publications concerning agricultural resilience for the years ranging from 2012 to 2024. Bibliometric studies were chosen as an appropriate technique since they provide researchers with tools necessary for assessing scientific literature using quantitative methods that may include, among others, analyzing publication patterns, citation patterns, co-authorship networks, and keywords' connections. Intellectual structure and thematic evolution of scientific literature regarding agricultural resilience became the focus of this particular study. The scientific database used as the source of data collection in the course of conducting the current study is Scopus as a well-known reputable international scientific database. Search strings were formed by keywords associated with concepts such as agricultural resilience, resilient agriculture, farming resilience, and many more. In addition, only journal articles, conference papers, and reviews that were written in English from 2012 to 2024 were included in the sample.

Following the data collection procedure, the chosen documents were exported in formats that would allow for bibliometric analysis. First, the screening procedure included deleting duplicates, incomplete metadata information, and non-relevant literature to the research area. Further, descriptive bibliometrics was used to investigate the trends of annual publications growth, citation impact, top authors, journals, institutions, and countries in relation to the research topic. At the same time, network analysis was performed for analyzing patterns of collaboration between authors, institutions, and countries. Moreover, keyword co-occurrences were explored to investigate thematic development within the subject area under consideration.

VOSviewer was used to create network visualizations on co-authorship, co-citation, and keyword co-occurrence, whereas the software called Biblioshiny was used for descriptive statistics and thematic mapping.

The output of the visualization was analyzed qualitatively in order to understand the relationship between different research topics and the progress of research on agriculture resilience.

3. RESULT AND DISCUSSION

3.1 Co-Author Analysis

The co-authorship network diagram shows how the collaboration is carried out among the researchers working on agricultural resilience research and helps

identify several clearly defined communities of researchers, linked with each other through selective inter-community cooperation. In this case, several clusters with different colors show different communities of researchers who work together often in the same research field. Larger circles show influential or productive authors, while thick lines indicate higher collaboration frequencies between the authors. It can be concluded from the structure of this network that agricultural resilience research is conducted through several independent scientific communities.

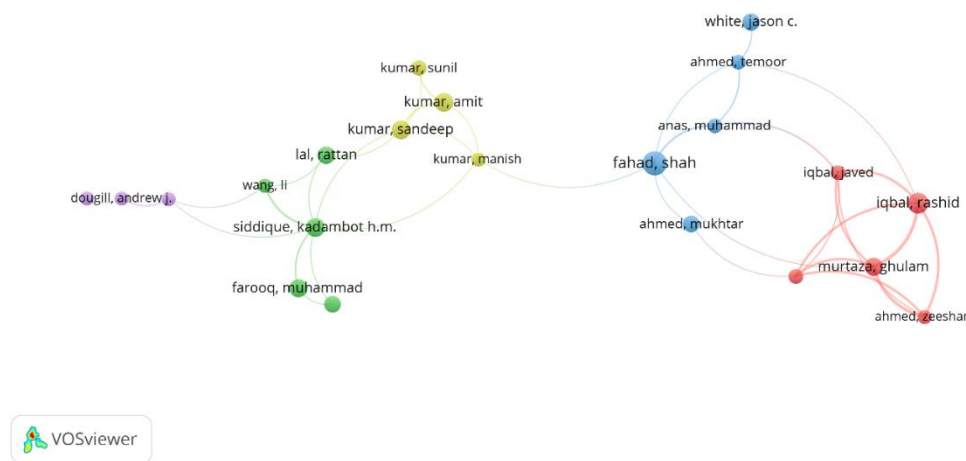


Figure 1. Author Visualization

Source: Data Analysis

The right side of the network consists of a predominantly red-blue collaboration area which is made up of a group of authors including Fahad Shah, Iqbal Rashid, as well as other collaborators who are involved in this kind of research work. On the other hand, the clusters towards the left side of the network include other authors like Kumar, Siddique, and Lal, forming more collaboration groups. Some connecting paths exist between the different clusters, representing interdisciplinary knowledge sharing and integration of different fields of study. There are some individual nodes on the edge of the graph, which indicate the possibility of enhancing international collaboration efforts in future research endeavors.

The institutional collaboration network visualization demonstrates the pattern of cooperation among organizations involved in agricultural resilience research and reveals a relatively concentrated yet interconnected knowledge structure. The size of the nodes reflects institutional influence based on publication output and collaboration intensity, while the connecting lines indicate the strength of collaborative relationships between institutions. Among all institutions, University of Chinese Academy appears as the most prominent and central actor, shown by its larger node size and multiple direct links to surrounding institutions. This indicates that the institution serves as a major research hub and plays an important role in

facilitating scientific exchange and knowledge dissemination within the agricultural resilience domain.

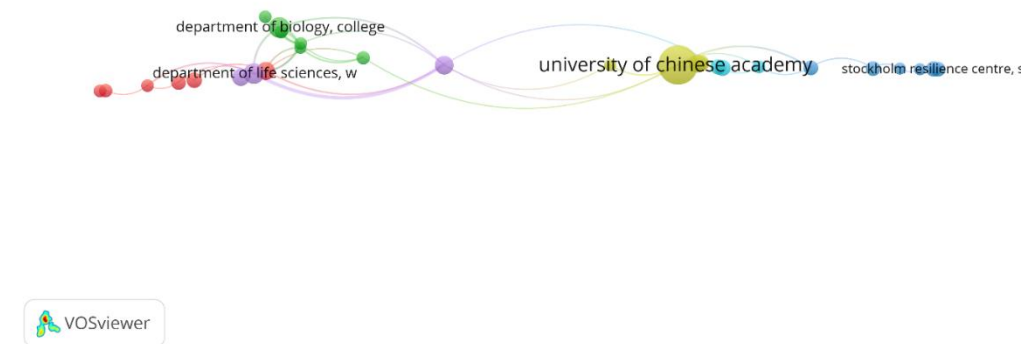


Figure 2. Institution Visualization

Source: Data Analysis

The network further depicts the presence of a number of institutional clusters within each of which are various collaborative communities. The institutions of Department of Biology, College, Department of Life Sciences, and Stockholm Resilience Centre, among others, are all linked based on the degree of their interactions, thereby depicting that agriculture resilience is increasingly becoming a field that draws from multi-disciplines and involves collaboration across various institutions. This is further evident based on the bridging links within the clusters, where it can be argued that some institutions have been acting as bridges connecting various research communities and, in so doing, bringing together varied perspectives from sustainable development, ecology, agricultural adaptation, and resilience research fields.

The country collaboration network illustrates the global structure of research cooperation in agricultural resilience studies and reveals a highly interconnected international research landscape. Node size represents the relative contribution and collaboration intensity of each country, while the connecting lines indicate the strength of collaborative relationships. The visualization shows that the United States, China, and India occupy the most central positions and have the largest nodes, indicating that these countries serve as dominant contributors and major hubs in the development of agricultural resilience scholarship. Their extensive network connections suggest a strong capacity to influence research agendas and facilitate international knowledge exchange across regions.

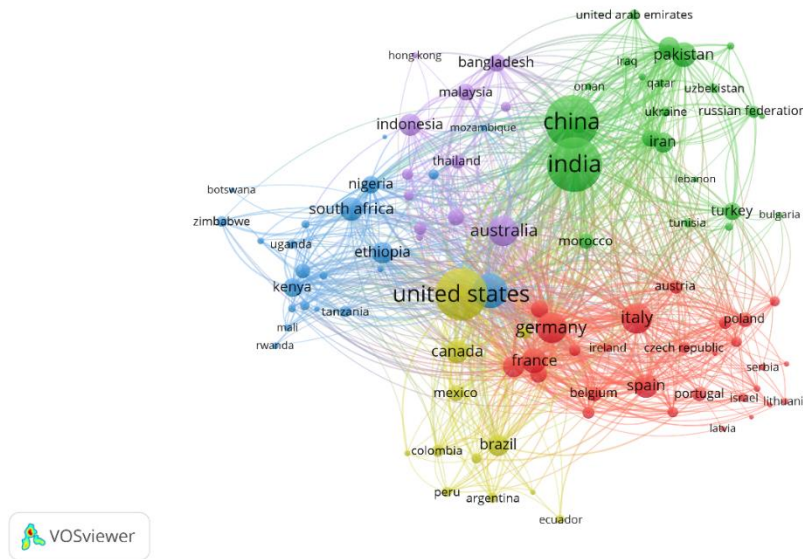


Figure 3. Country Visualization
 Source: Data Analysis

Several collaboration clusters emerge within the network, reflecting geographic and thematic patterns of cooperation. The green cluster is strongly centered around China and India and extends to countries such as Pakistan, Iran, Turkey, and the Russian Federation, indicating active collaboration within Asia and surrounding regions. The red cluster is dominated by European countries including Germany, Italy, France, Spain, and Poland, forming a dense network of intra-

regional scientific interaction. Meanwhile, the blue cluster highlights collaboration among African countries such as South Africa, Ethiopia, Kenya, Uganda, and Nigeria, suggesting increasing scholarly attention to resilience issues in vulnerable agricultural systems. The yellow cluster, anchored by the United States and connected with countries such as Canada, Brazil, Mexico, and Australia, demonstrates broader intercontinental engagement.

3.2 Citation Analysis

Table 1. Top Cited Literature

Citations	Authors and Year	Title
5067	[5]	Planetary boundaries: Exploring the safe operating space for humanity
3630	[6]	Landscape perspectives on agricultural intensification and biodiversity - Ecosystem service management
2562	[7]	Natural climate solutions
2364	[8]	Managing the health effects of climate change. Lancet and University College London Institute for Global Health Commission
2221	[9]	Safeguarding human health in the Anthropocene epoch: Report of the Rockefeller Foundation-Lancet Commission on planetary health
1642	[10]	Climate-smart agriculture for food security
1590	[11]	Plant growth-promoting rhizobacteria: Context, mechanisms of action, and roadmap to commercialization of biostimulants for sustainable agriculture
1556	[12]	Restoring soil quality to mitigate soil degradation
1450	[13]	Agricultural sustainability: Concepts, principles and evidence
1250	[14]	Genetic strategies for improving crop yields

Source: Scopus 2026

The top-cited literature indicates that agricultural resilience research is strongly grounded in sustainability, climate change, biodiversity, planetary health, and food security debates. The most influential work is [5] on planetary boundaries, showing that agricultural resilience is often framed within the broader concern of maintaining human activity within ecological limits. Highly cited studies by [6], [7], [10], [12], [13] further show that the field is shaped by themes of ecosystem services, climate-smart agriculture, soil restoration, biodiversity conservation, and sustainable intensification. The presence of health-oriented works such as [8] and [9] suggests that agricultural resilience is not only treated as a production issue, but also as part of a wider socio-ecological system linked to human health, environmental stability, and planetary well-being. Meanwhile, more technical contributions on plant growth-

promoting rhizobacteria and genetic strategies for crop yield improvement indicate a growing scientific interest in biological and technological pathways to strengthen agricultural adaptation and productivity under changing environmental conditions.

3.3 Keyword Co-Occurrence

The co-occurrence of the keywords reflects the structural and topical features of agricultural resilience studies, which are formed in the interaction of most often used terms in academic literature. The size of the node shows how many times the term occurs, and the intensity of the connection line demonstrates the intensity of the relationship between the terms. From the visualized data, it is clear that climate change, agriculture, food security, and crops are the main concepts structuring the body of knowledge in this domain.

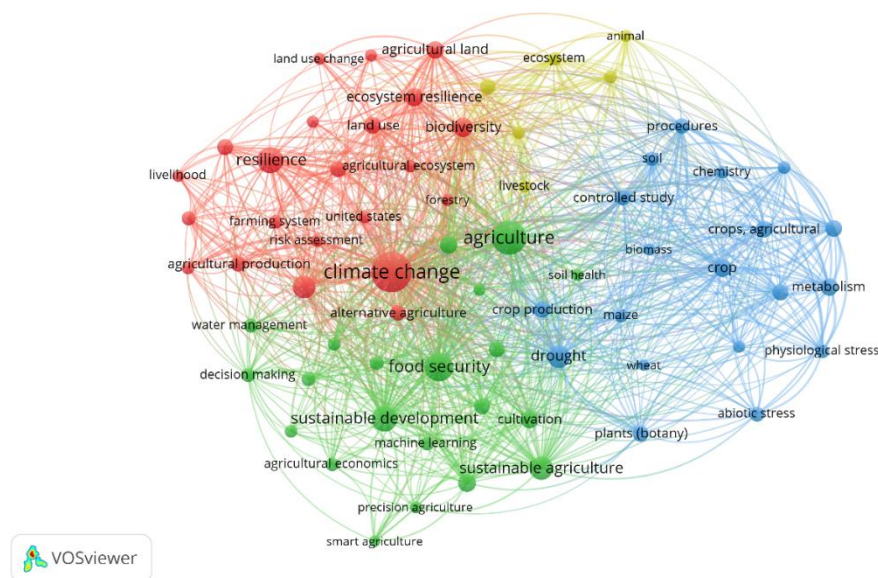


Figure 4. Network Visualization

Source: Data Analysis

The red cluster has a focus on climate change and includes literature which stresses the importance of adaptive processes and resilience in socio-ecological systems. The associated terms such as resilience, ecological resilience, agricultural ecology, land use change, water management, risk assessment, and livelihood reveal the importance of examining resilience from the point of view of

a system. The red cluster thus captures the increasing interest of scholars in examining the reaction of agricultural systems to environmental perturbations. Green cluster is about sustainable agriculture and food system changes where agricultural sustainability, sustainable development, agriculture, and sustainable agriculture form central nodes. Precision agriculture, machine learning,

agricultural economics, and smart agriculture indicate that in the current research works, digital technologies are playing an important role in building strategies for resilience. All these show that conventional methods of developing resilience strategies have been replaced by more sophisticated techniques and technologies in this area.

The blue cluster focuses on the crop-based and physiological aspects of agricultural resilience research. The keywords such as crop, drought, abiotic stress, physiological stress, soil, metabolism, and crop production show great interest in studying how crops cope with environmental stress. From the blue cluster, we can see that resilience studies are not only concerned with policy and management approaches but also with agronomy and plant sciences.

On the other hand, the yellow cluster seems to link ecology and production through ideas like ecosystem, biodiversity, livestock, and animals. The role of this cluster as intermediary implies that the adoption of the ecosystem perspective is important for making connections between the preservation

of the environment and agricultural production. Generally speaking, the network reveals that studies on agricultural resilience have moved away from a narrow scope where agricultural adaptation was central to a more comprehensive perspective that includes aspects such as climate resilience, ecosystems, technology, food security, and sustainable development.

In the above-mentioned visualization, the dynamics of research topics concerning resilience in agriculture for the years 2021-2024 are shown, where the color of the nodes reflects the average year of publication of the keyword in question. Nodes colored dark blue and purple correspond to older research topics, whereas green and yellow keywords signify newer and emerging fields. The graph indicates that initial investigations revolved around ideas such as agricultural resilience, agricultural land, land-use change, ecosystem resilience, and risk assessment, which shows that research focused on the reaction of the agricultural system to external influences and their resilience to maintain its functionality

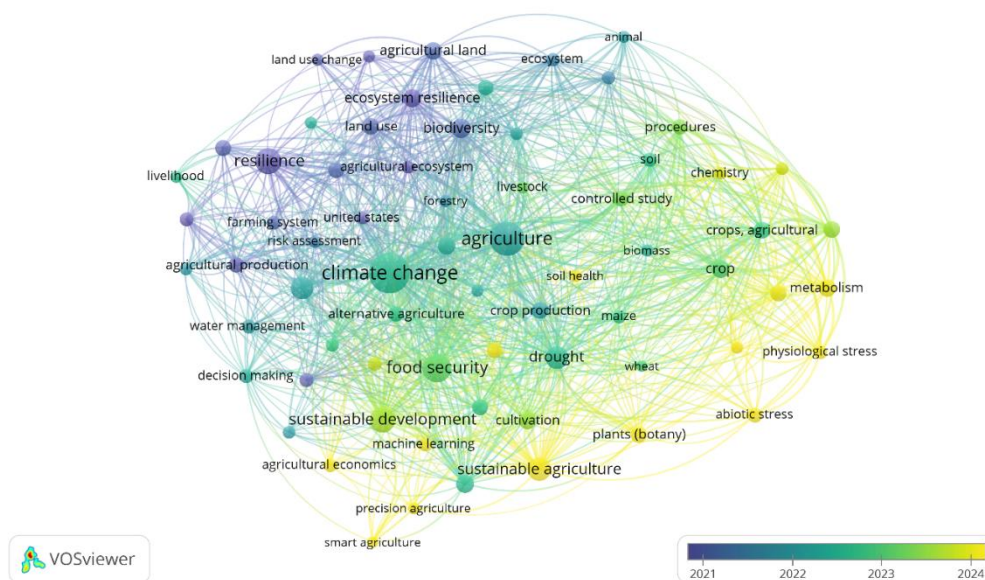


Figure 5. Overlay Visualization
 Source: Data Analysis

As the field evolved, the focus began to revolve around more sustainable and adaptation-based themes, evidenced by the domination of keywords in green colors like

agriculture, climate change, food security, drought, and sustainable development. These keywords are positioned centrally within the network, implying that they were central to

the integration of themes between the environment, economy, and agriculture. This interconnectedness implies that the resilience of agriculture is evolving to go beyond adaptation for the environment and instead be focused on food security and sustainable agriculture production.

The latest trend, represented by the yellow nodes around the year 2024, involves new areas of research focused on technological development and biological adaptation. The keywords "sustainable agriculture," "crop," "physiological stress," "metabolism," "crops," "agricultural," "chemistry," "machine learning," and "precision agriculture" hint at an increasing academic concern about combining technological development with crop science and precision techniques for its management. Such a development demonstrates that current agricultural resilience research tends to shift towards integrated approaches

combining technological intervention, optimization of crops' performance, and sustainability goals.

Density visualization allows us to emphasize the presence of research themes that were discussed most actively in agricultural resilience studies, which are more intense in terms of their connections within the studied area. Based on the obtained results, the most dominant and important research topics for this area can be recognized from their high level of density, shown as brighter yellow spots on the visualization. These topics include climate change, agriculture, food security, and sustainable agriculture. It is evident that the orientation of the existing agricultural resilience studies is linked to the need to consider the ability of the agricultural system to remain productive, sustainable, and ensure food availability under changing environmental conditions.

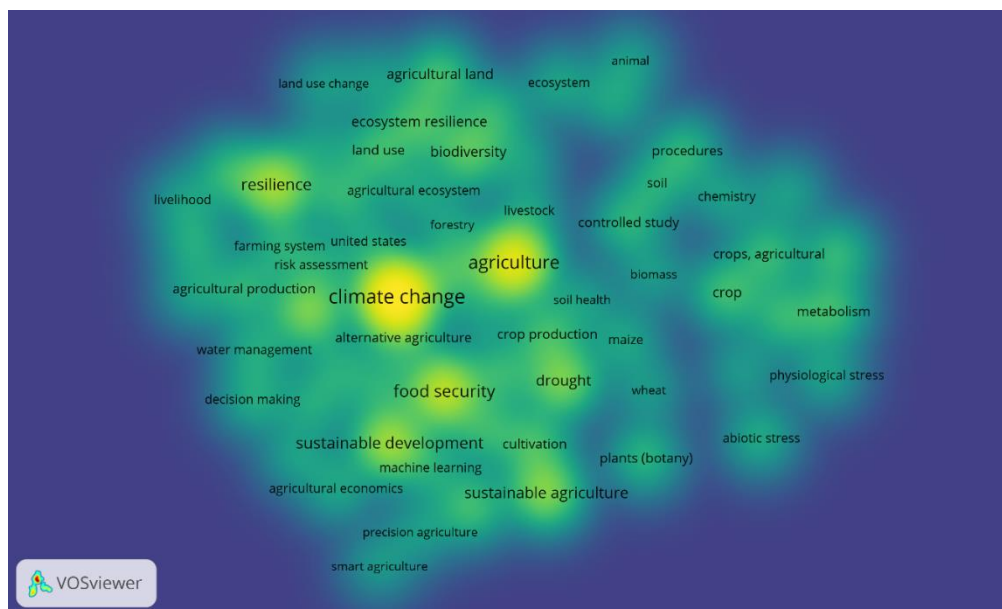


Figure 6. Density Visualization

Source: Data Analysis

Apart from these major themes, the visualization further sheds light on the new and complementary areas of research that have emerged recently. Concepts like machine learning, precision agriculture, smart agriculture, metabolism, physiological stress, and abiotic stress come up in a region characterized by lesser density but higher

connectivity. These concepts hint at technology and crop-level adaptation being key directions in the latest body of knowledge. Moreover, the pattern of keyword density indicates that agricultural resilience, which was once studied only as a climate change problem, has now evolved into a comprehensive area of study, linking

sustainable agriculture, food systems, environmental management, digital agriculture, and agricultural productivity.

4. CONCLUSION

In the current study of bibliometrics, it is possible to trace the evolution of agricultural resilience research between 2012 and 2024 and find out how fast and how much it changed into an increasingly interdisciplinary sphere of science. It is necessary to underline that the results of the study illustrate how this issue became an essential topic for research related to climate change adaptation, sustainable agriculture, food security, ecosystem management, and innovations in technologies. In terms of publication network, one can speak about the presence of an active scientific interaction

among different countries, including the USA, China, and India, as well as other actors who make contributions to the growth of scientific knowledge in this discipline. Keyword mapping, visualization, and density reveal a marked thematic change throughout the literature timeline. The earlier papers largely emphasized resilience, land use, ecosystem resilience, and climate adaptation, whereas more contemporary articles tend to concentrate on sustainable agriculture, food security, resilient crops, and technological advancements including machine learning and precision agriculture. Themes related to physiological stress, crop productivity, and digital agriculture indicate that future resilience in agriculture is likely to take a multidimensional approach involving sustainability, technological progress, and innovative agriculture management practices.

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