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Bibliometric Analysis of Agricultural Productivity

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ABSTRACT

This study aims to map and analyze the intellectual structure and research trends of agricultural productivity through a bibliometric approach using the Scopus database and VOSviewer visualization techniques. The analysis explores keyword co-occurrence, overlay visualization, and density mapping to identify dominant themes, temporal evolution, and emerging research directions within the field. The findings indicate that agricultural productivity research is shaped by interconnected domains, including agronomic management, plant physiology, environmental sustainability, and digital agriculture technologies. Core themes such as soil fertility, crop production, and sustainable development remain highly influential, reflecting the continued importance of ecological resource management. Temporal analysis reveals a transition from traditional biological and nutrient-based studies toward contemporary topics such as machine learning, precision agriculture, and climate change adaptation. Density patterns further show that while conventional agronomic research still dominates the field, technological innovation is becoming increasingly prominent, signaling a shift toward data-driven agricultural systems. The study highlights the growing need for interdisciplinary integration to address global challenges related to food security, environmental resilience, and sustainable productivity enhancement. These findings provide a comprehensive overview of the evolving research landscape and offer insights for future studies aiming to develop more adaptive and technology-oriented agricultural productivity frameworks.

Keywords: *Agricultural Productivity, Bibliometric Analysis, Sustainable Agriculture, Precision Agriculture, VOSViewer*

1. INTRODUCTION

Agricultural productivity remains a cornerstone of global food security and economic development. The growth in agricultural output is critical not only to meet the increasing demands of a rapidly growing population but also to ensure the sustainability of natural resources [1]. Over the past few decades, advancements in technology, improved crop varieties, and innovative farming techniques have significantly enhanced productivity in various regions. However, the distribution of these advancements is uneven, with disparities between developed and developing countries still persisting. Understanding the trends, challenges, and drivers of agricultural productivity is therefore essential for guiding policy decisions, research priorities, and resource allocation [2].

The concept of agricultural productivity is multifaceted, encompassing both yield per unit area and efficiency in the use of inputs such as labor, fertilizers, and water [3]. Productivity gains are often influenced by several factors including climate change, soil fertility, pest management, and adoption of modern technologies. Consequently, a comprehensive understanding of productivity trends requires systematic synthesis of research outputs across diverse agricultural systems. Traditional reviews often focus on specific crops or regions, limiting their ability to provide a global perspective. Bibliometric analysis, in contrast, offers a systematic and quantitative method to assess patterns of research output, identify influential studies, and map the evolution of scientific knowledge over time [4]. By applying bibliometric tools, researchers can detect emerging themes, collaborative networks, and research gaps that are critical for informed decision-making in agriculture.

Over the past two decades, there has been a notable surge in agricultural research publications, reflecting increased attention to productivity enhancement and food security challenges [5]. This trend is driven by the growing complexity of agricultural systems and the need to integrate cross-disciplinary knowledge, including agronomy, economics, environmental science, and data analytics. Moreover, international initiatives such as the Sustainable Development Goals (SDGs) have reinforced the global focus on sustainable agricultural practices, prompting researchers to explore innovative solutions to maximize productivity while minimizing environmental degradation. Bibliometric studies can capture this evolution in knowledge, revealing shifts in research priorities from mere yield improvement to sustainability, resilience, and resource efficiency.

Despite the substantial body of literature on agricultural productivity, there remains limited understanding of the patterns and dynamics of research contributions across countries, institutions, and disciplines. Certain countries dominate publication outputs, while others remain underrepresented, leading to potential knowledge gaps and imbalances in research influence [6]. Additionally, emerging areas such as precision agriculture, biotechnology, and climate-smart farming practices are increasingly highlighted, yet the extent to which these areas intersect with traditional productivity studies is not fully documented. Bibliometric analysis provides a lens to examine these interactions, offering insights into which topics attract research attention, the collaboration networks that drive innovation, and the citation patterns that indicate influence and knowledge dissemination.

Furthermore, bibliometric analysis allows for identification of influential authors, institutions, and journals in the domain of agricultural productivity. Mapping these contributions helps guide future research by recognizing key thought leaders and high-impact studies, thereby fostering collaboration and knowledge exchange [7]. Such analyses are particularly useful in shaping funding priorities, research agendas, and policy frameworks. For instance, countries aiming to enhance their agricultural productivity can leverage bibliometric findings to identify best practices, promising technologies, and strategic partnerships. In essence, bibliometric studies bridge the gap between raw research outputs and actionable insights, providing a meta-perspective that is crucial for both scientific advancement and practical application.

The application of bibliometric methods in agriculture has also highlighted temporal and thematic trends in the literature. Research topics have evolved from basic agronomic practices to integrated approaches addressing productivity, sustainability, and resilience[8], [9]. Modern bibliometric techniques, such as co-citation analysis, keyword mapping, and network visualization, enable a detailed understanding of how scientific knowledge evolves, which areas are saturated, and which remain underexplored. This capacity to systematically evaluate large volumes of publications positions bibliometric analysis as an essential tool for evidence-based agricultural planning. By quantifying research productivity and identifying influential themes, policymakers and researchers can make informed decisions to enhance agricultural output, address food security challenges, and support sustainable development.

Despite the significant advances in agricultural research, a comprehensive and systematic assessment of global research trends in agricultural productivity remains limited. Many studies focus on specific crops, regions, or technological innovations, often neglecting the broader context of interdisciplinary knowledge accumulation and collaboration patterns. This fragmentation hinders the ability of policymakers, researchers, and institutions to identify gaps, prioritize resources, and foster collaborations that could accelerate productivity improvements. Therefore, there is a need for

a bibliometric study that synthesizes the body of knowledge on agricultural productivity, highlighting research trends, key contributors, thematic foci, and emerging directions. The objective of this study is to conduct a bibliometric analysis of research on agricultural productivity.

2. METHODS

This study employed a bibliometric approach to systematically analyze research on agricultural productivity. Bibliometric analysis is a quantitative method that examines the patterns, trends, and impacts of scientific publications within a specific field [4]. The study focused on peer-reviewed journal articles published over the last two decades, covering both global and regional perspectives. Data were extracted from the Web of Science and Scopus databases, which are widely recognized for their comprehensive coverage of scientific literature. Search queries included keywords such as "agricultural productivity," "crop yield," "food security," and "sustainable agriculture", combined with Boolean operators to ensure both specificity and inclusivity. Only articles written in English were considered, and duplicates were removed to maintain data integrity.

After data collection, bibliometric indicators were employed to assess publication patterns, research trends, and scholarly impact. Keyword co-occurrence and thematic mapping were applied to reveal emerging research topics and interdisciplinary trends, highlighting how the focus of agricultural productivity research has evolved over time. Data visualization tools and bibliometric software were used to enhance the interpretation of results. VOSviewer was employed to create keyword maps allowing for a clear representation of relationships among authors, institutions, and research topics.

3. RESULTS AND DISCUSSION

3.1 Network Visualization

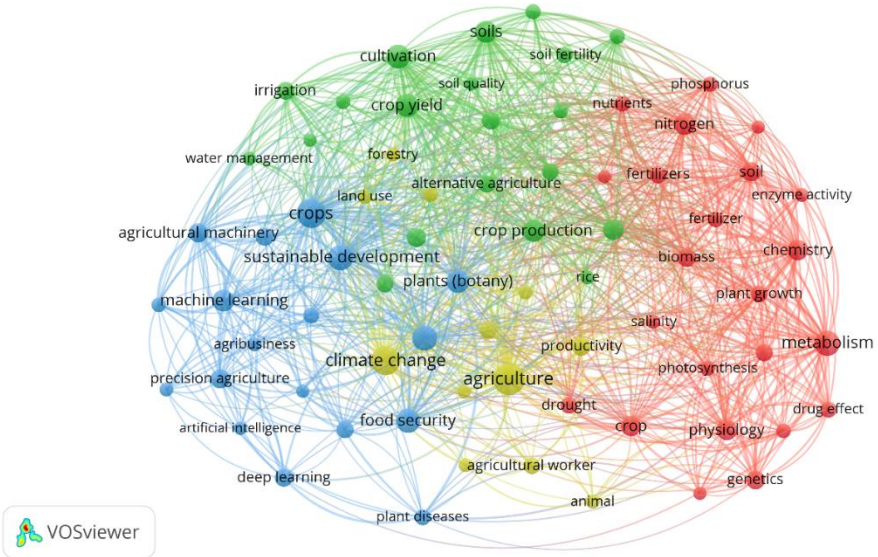

Figure 1. Network Visualization
Source: Data Analysis Result, 2026

Figure 1 reveals that agricultural productivity research is structured into several interconnected thematic clusters, reflecting the multidisciplinary nature of modern agriculture studies. The central position of terms such as agriculture, crop production, and productivity indicates that the literature integrates agronomic science, environmental sustainability, and technological innovation. The dense links among nodes suggest that agricultural productivity is no longer studied as a single agronomic outcome but as a complex system influenced by climate, soil

conditions, technology adoption, and food security concerns. The green cluster highlights agronomic and environmental management themes, including crop yield, soil fertility, cultivation, irrigation, and water management. This cluster reflects traditional productivity research grounded in ecological and land-use perspectives. The strong connections between soil quality and crop production suggest that recent studies emphasize sustainable intensification and resource efficiency. Researchers increasingly frame productivity through ecosystem management, indicating a shift toward regenerative agriculture and long-term soil health rather than purely yield-maximization approaches.

The red cluster represents plant science and biochemical research, including keywords such as metabolism, genetics, physiology, photosynthesis, fertilizers, and nitrogen. This shows that a substantial portion of agricultural productivity literature still relies on experimental plant biology and nutrient management studies. The presence of biomass, enzyme activity, and chemistry suggests a strong focus on molecular and physiological mechanisms that drive crop growth. This cluster indicates that scientific advances in plant metabolism and fertilizer efficiency continue to shape productivity improvements at the biological level. The blue cluster reflects the integration of digital technologies and sustainability issues into agricultural productivity research. Keywords like machine learning, artificial intelligence, precision agriculture, and agricultural machinery illustrate the growing role of smart farming technologies. The linkage between these technological terms and climate change and food security implies that digital innovation is increasingly framed as a solution to global agricultural challenges. This cluster signals an ongoing transition toward data-driven agriculture where predictive analytics and automation contribute to productivity optimization.

The yellow cluster acts as a bridging domain connecting agronomic, environmental, and socio-economic aspects of productivity. Terms such as food security, agricultural worker, drought, and agriculture demonstrate that productivity research is expanding beyond purely technical factors to include resilience, labor dynamics, and climate risks. The central placement of this cluster suggests that future research trends may converge around integrated sustainability frameworks that combine technological innovation, ecological management, and socio-economic resilience to enhance agricultural productivity in a changing global environment.

3.2 Overlay Visualization

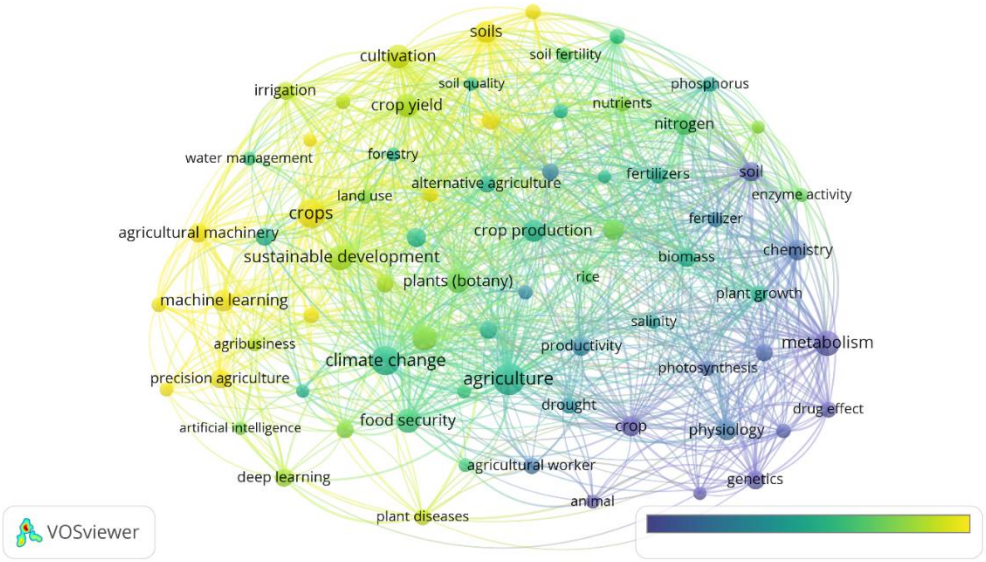

Figure 2. Overlay Visualization
Source: Data Analysis Result, 2026

Figure 2 illustrates the temporal evolution of research themes within agricultural productivity, where color gradients indicate shifts from earlier to more recent topics. Keywords displayed in darker blue tones, such as metabolism, genetics, physiology, and plant growth, represent earlier foundational research largely centered on plant biology and biochemical processes. This suggests that initial scholarly attention in agricultural productivity was strongly rooted in laboratory-based studies that examined physiological mechanisms underlying crop performance and nutrient responses. Moving toward the green spectrum, the literature demonstrates a transition into integrative agronomic and environmental themes. Terms such as crop production, soil fertility, nutrients, climate change, and food security indicate a phase where productivity research expanded beyond plant-level mechanisms into broader ecosystem management and sustainability frameworks. The prominence of these mid-period keywords reflects growing academic awareness of climate risks, soil health, and resource management, showing how agricultural productivity research evolved into a more systems-oriented perspective.

The most recent developments are highlighted by yellow-toned keywords, including machine learning, precision agriculture, agricultural machinery, and cultivation. This pattern signals a clear shift toward digital transformation and smart agriculture approaches, where data analytics and technological innovation are increasingly integrated into productivity optimization. The emergence of these terms suggests that contemporary research directions prioritize automation, predictive modeling, and sustainable intensification strategies, positioning digital agriculture as a key frontier shaping the future of agricultural productivity studies.

3.3 Citation Analysis

Table 1. The Most Impactful Literatures

Citations	Authors and year	Title
5383	[10]	Spreading dead zones and consequences for marine ecosystems
4775	[11]	The Global Land Data Assimilation System
3534	[12]	The contentious nature of soil organic matter
3522	[13]	Europe-wide reduction in primary productivity caused by the heat and drought in 2003
3006	[14]	Going back to the roots: The microbial ecology of the rhizosphere
2579	[15]	Climate change impacts on global food security
2348	[16]	Soil carbon sequestration and land-use change: Processes and potential
2311	[17]	Global fire emissions and the contribution of deforestation, savanna, forest, agricultural, and peat fires (1997-2009)
2297	[18]	Greening of the Earth and its drivers
2182	[19]	Drought and salt tolerance in plants

Source: Scopus, 2025

3.4 Density Visualization

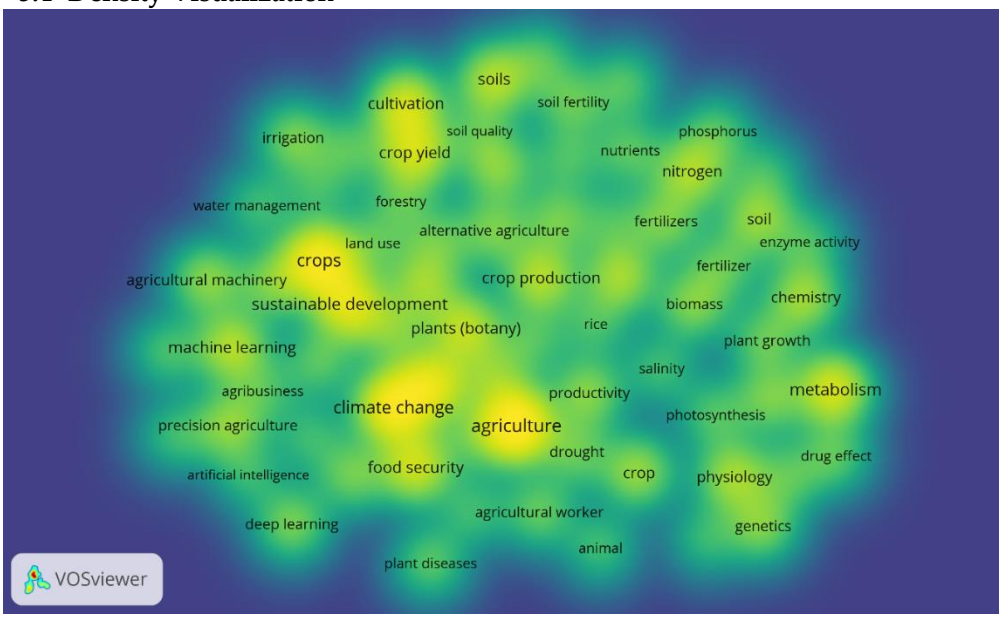

Figure 3. Density Visualization

Source: Data Analysis Result, 2026

Figure 3 highlights the concentration of research topics within agricultural productivity literature, where brighter yellow areas represent highly frequent and strongly connected keywords. The central density around agriculture, crop production, soil fertility, crop yield, and sustainable development indicates that these themes form the core foundation of the field. Their strong presence suggests that most studies continue to focus on improving productivity through agronomic practices, soil management, and sustainability frameworks. The clustering of climate change and food security near the center further reflects the growing integration of environmental challenges and global food system concerns into productivity research. Peripheral yet visible density zones reveal emerging and specialized subthemes. Areas including machine learning, precision agriculture, and artificial intelligence show moderate density, indicating expanding but still developing research interest in digital agriculture technologies. Meanwhile, topics such as metabolism, genetics, and physiology appear as concentrated pockets, emphasizing ongoing contributions from plant science and biochemical studies.

Discussion

The bibliometric mapping of agricultural productivity research reveals a field characterized by strong interdisciplinary integration, where agronomic science, environmental sustainability, plant biology, and digital technology converge to address global food production challenges. The keyword network demonstrates that productivity is no longer examined solely through yield improvement but through a systems-oriented perspective that links soil health, climate resilience, and technological innovation. The central positioning of terms such as agriculture, crop production, soil fertility, and sustainable development indicates that the literature is anchored in efforts to balance productivity growth with ecological sustainability. This reflects a broader academic shift toward sustainable intensification, where improving outputs must align with environmental conservation and long-term resource management.

From a thematic perspective, the cluster structure suggests that agricultural productivity research evolves across three major knowledge domains. The agronomic-environmental cluster highlights the continued importance of irrigation, soil management, and land-use practices, emphasizing how ecosystem services remain fundamental to productivity improvements. Simultaneously, the plant science cluster demonstrates that molecular and physiological research

continues to drive innovation through advances in genetics, metabolism, and nutrient efficiency. These findings indicate that productivity research still relies heavily on biological foundations, reinforcing the role of plant physiology and fertilizer optimization in addressing yield constraints, particularly in regions facing soil degradation or nutrient limitations.

Another key finding emerging from the overlay visualization is the clear temporal transition toward digital agriculture. Recent keywords such as machine learning, precision agriculture, and artificial intelligence reveal a growing scholarly interest in data-driven farming approaches. This trend suggests that contemporary research increasingly explores predictive modeling, automation, and smart machinery to enhance productivity while reducing input inefficiencies. The integration of technological keywords with themes like climate change and food security indicates that digital transformation is not viewed merely as a technological upgrade but as a strategic response to environmental uncertainty and global demand pressures.

The density visualization further supports this interpretation by showing that traditional agronomic themes remain highly concentrated, while technological and interdisciplinary topics form expanding but less dense areas. This pattern implies that the field is currently in a transitional phase, where established agricultural practices still dominate the research landscape, yet emerging technologies are rapidly gaining scholarly attention. The coexistence of dense traditional topics and developing digital themes suggests that future research may increasingly focus on hybrid approaches that combine agronomic knowledge with artificial intelligence and precision farming tools.

CONCLUSION

This bibliometric analysis demonstrates that agricultural productivity research has evolved into a multidisciplinary field integrating agronomic practices, plant science, environmental sustainability, and digital innovation. The findings reveal that traditional themes such as soil fertility, crop yield, and sustainable development remain central, while emerging topics including machine learning, precision agriculture, and artificial intelligence indicate a growing shift toward data-driven farming approaches. Temporal patterns suggest that earlier studies focused on biological and physiological mechanisms, whereas recent research increasingly addresses climate change, food security, and technological transformation. The field is moving toward integrated productivity frameworks that combine ecological resilience, technological advancement, and sustainable resource management, highlighting the need for future studies to bridge scientific innovation with socio-economic and environmental considerations.

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