

Mapping the Progress and Direction of Sustainable Agriculture Research in Indonesia: A Bibliometric Analysis Perspective

Sutiharni¹, Ivonne Fitria Mariay², Liz Yanti Andriyani³, Veronica Leonora Tuhumena⁴, Adlian⁵

^{1,2,3,4}Universitas Papua Manokwari

⁵Universitas Nani Bili Nusantara Sorong

Article Info

Article history:

Received March 2024

Revised March 2024

Accepted March 2024

Keywords:

Sustainable agriculture

Indonesia

Bibliometric analysis

ABSTRACT

This study presents a comprehensive bibliometric analysis aimed at mapping the progress and direction of sustainable agriculture research in Indonesia. With a focus on addressing environmental, social, and economic challenges while ensuring food security and agricultural productivity, sustainable agriculture has emerged as a critical area of focus globally. In Indonesia, a country rich in agricultural diversity and natural resources, sustainable agricultural practices are paramount to mitigate the impact of climate change, preserve biodiversity, and enhance the livelihoods of farmers and rural communities. Through systematic collection and analysis of relevant publications from academic databases, including Web of Science, Scopus, and Google Scholar, this study identifies key thematic areas, trends, collaboration networks among researchers, and potential research gaps within sustainable agriculture research in Indonesia. The analysis spans from 1982 to 2023, covering a wide range of topics such as agroecology, organic farming, precision agriculture, and sustainable resource management. Results reveal a significant impact of Indonesian research contributions, highlighting collaborative efforts and interdisciplinary approaches towards addressing complex agricultural sustainability challenges. The study provides valuable insights for policymakers, researchers, and stakeholders to prioritize areas for further development, formulate evidence-based policies, and foster interdisciplinary partnerships in promoting sustainable agricultural practices in Indonesia.

This is an open access article under the [CC BY-SA](#) license.



Corresponding Author:

Name: Sutiharni

Institution: Universitas Papua Manokwari

Email: s.sutiharni@unipa.ac.id

1. INTRODUCTION

Sustainable agriculture has emerged as a critical area of focus globally, aiming to address environmental, social, and economic challenges while ensuring food security and agricultural productivity [1], [2]. In Indonesia, a country rich in agricultural diversity and natural resources, sustainable agricultural

practices are of paramount importance to mitigate the impact of climate change, preserve biodiversity, and enhance the livelihoods of farmers and rural communities [3], [4]. Over the years, significant efforts and investments have been made towards advancing sustainable agriculture in Indonesia, encompassing various aspects

such as agroecology, organic farming, precision agriculture, sustainable resource management, and resilient agricultural systems [5].

Indonesia's agricultural sector plays a crucial role in the nation's economy, providing livelihoods for millions of people and contributing significantly to the country's GDP [6]. However, traditional agricultural practices often come with environmental challenges such as deforestation, soil degradation, water pollution, and biodiversity loss [7], [8]. Moreover, the effects of climate change, including extreme weather events and shifting rainfall patterns, further exacerbate these challenges, posing threats to food security and rural livelihoods [9], [10].

In response to these challenges, sustainable agriculture has gained traction as a holistic approach that seeks to balance environmental stewardship, social equity, and economic viability [11], [12]. This paradigm shift involves adopting practices and technologies that promote resilience, resource efficiency, and ecosystem health while ensuring equitable benefits for farmers and communities [13], [14]. Agroecology, for instance, emphasizes ecological principles in agricultural systems, promoting biodiversity, natural pest control, and soil health through practices like crop diversification, agroforestry, and integrated pest management [15]. Organic farming focuses on minimizing synthetic inputs, conserving resources, and enhancing soil fertility through composting, crop rotation, and biological pest control methods [13].

Despite the growing emphasis on sustainable agriculture, there is a need to systematically assess the progress, trends, and directions of research in this field within the Indonesian context. Identifying key themes, influential publications, collaborations, and research gaps can provide valuable insights for policymakers, researchers, and stakeholders to prioritize areas for further development and innovation. Thus, the research problem revolves around understanding the landscape

of sustainable agriculture research in Indonesia and delineating its evolution, strengths, and areas needing more attention.

The primary objective of this research is to conduct a comprehensive bibliometric analysis to map the progress and direction of sustainable agriculture research in Indonesia. Specifically, the research aims to: (1) Identify the key thematic areas and trends in sustainable agriculture research publications from Indonesia. (2) Analyze the collaboration networks among researchers contributing to sustainable agriculture research in Indonesia. (3) Identify potential research gaps and emerging areas for future exploration and investment in sustainable agriculture research. This research holds significant importance for various stakeholders involved in sustainable agriculture development in Indonesia. Firstly, it provides a systematic overview of the current state of research, highlighting areas of strength and areas needing further attention or investment. Policymakers can use these insights to formulate evidence-based policies and strategies to promote sustainable agricultural practices effectively. Furthermore, researchers and academic institutions can benefit from understanding the collaboration dynamics and thematic foci prevalent in sustainable agriculture research, facilitating interdisciplinary partnerships and knowledge exchange. Additionally, the findings of this research can contribute to enhancing Indonesia's visibility and impact in the global research landscape related to sustainable agriculture, fostering international collaborations and knowledge dissemination.

2. LITERATURE REVIEW

Sustainable agriculture in Indonesia has been a topic of interest due to the potential benefits and risks associated with modern biotechnology products, particularly in the agricultural sector. While these products can enhance food security and human well-being, they also pose risks to biodiversity conservation and long-term sustainability, as well as human health. To address these

concerns, it is crucial to take legal, administrative, and technical measures to ensure the safety of genetically modified food products [16].

The Indonesian government has implemented various regulations to ensure the safety of genetically modified food products. These regulations are based on international and national laws, as well as relevant data sources. The analysis of these regulations reveals that the safety of genetically modified food products is governed by the Convention on Biological Diversity, which includes provisions for the safety of genetically modified organisms [16]. In addition to legal frameworks, sustainable agriculture in Indonesia also involves the adoption of practices that promote the health of the environment and support the long-term productivity of agricultural systems. This includes the use of organic farming techniques, the promotion of agroforestry systems, and the support for small-scale farmers who use sustainable farming practices.

Sustainable agriculture in Indonesia requires a balanced approach that considers the benefits and risks of modern biotechnology products, while also promoting practices that support the health of the environment and the well-being of farmers and consumers. This involves a combination of legal, administrative, and technical measures, as well as the support for sustainable farming practices that can contribute to the long-term productivity and resilience of agricultural systems in Indonesia.

3. METHODS

The methodology for this research involves a systematic approach to conducting a bibliometric analysis of sustainable agriculture research in Indonesia. Initially, relevant publications will be collected from academic databases like Web of Science, Scopus, and Google Scholar using carefully chosen keywords related to sustainable agriculture, Indonesia, agricultural practices, environmental impact, and socio-economic aspects. The retrieved publications will

undergo rigorous screening to include only peer-reviewed articles, conference papers, and reviews pertinent to sustainable agriculture research conducted in Indonesia, with translations for non-English publications if necessary. Subsequently, bibliometric techniques will be applied to analyze the selected publications, including assessing publication trends over time, conducting citation analysis, and visualizing collaboration networks among authors using tool like VOSviewer. Impact assessment will be carried out through citation analysis, journal impact factors, and h-index calculations to evaluate the visibility and global relevance of Indonesian sustainable agriculture research. Additionally, network analysis will help identify influential authors and research clusters, while thematic analysis and keyword clustering will reveal potential research gaps and emerging areas within sustainable agriculture research in Indonesia.

4. RESULTS AND DISCUSSION

4.1 Research Data Metrics

Table 1. Data Metrics of Literature

Publication years:	1982-2023
Citation years:	42 (1982-2023)
Papers:	980
Citations:	177750
Cites/year:	4232,14
Cites/paper:	181.38
Cites/author	85990.86
Papers/author	472.35
Authors/paper:	2.87
h-index:	203
g-index:	358
hI,norm:	134
hi,annual:	3.26
hA-index:	59
Papers with ACC >= 1,2,5,10,20:	973,929,712,500,266

Source: Publish or Perish Output, 2024

The table provides a comprehensive overview of the bibliometric analysis conducted on sustainable agriculture research publications from 1982 to 2023, covering a citation period of 42 years. A total of 980 papers were included in the analysis, accumulating a remarkable 177,750 citations

over the years. On average, each paper received approximately 181.38 citations, with an impressive citation rate of 4232.14 citations per year for the entire dataset. The authors demonstrated a significant impact, with an astonishing average of 85,990.86 citations per author and an h-index of 203, indicating the wide recognition and influence of their contributions to sustainable agriculture research in Indonesia. Furthermore, the analysis revealed an average of 472.35 papers per author and an average of 2.87 authors per paper, highlighting the collaborative nature of research in this field. The g-index of 358 and hI,norm of 134 further emphasize the substantial impact of the publications, considering both the quantity and quality of citations received. The hi,annual value of 3.26 indicates a consistent and steady growth in citation rates per year, reflecting sustained interest and relevance in the research topics covered. Moreover, the hA-index of 59 indicates the number of papers achieving a certain level of citation impact, with 973 papers having an average citation count of at least 1, 929 papers with an average citation count of at least 2, 712 papers with an average citation count of at least 5, 500 papers with an average citation count of at least 10, and 266 papers with an average citation count of at least 20, showcasing the depth and breadth of impactful research within sustainable agriculture in Indonesia. Overall, these metrics illustrate the significant contribution, influence, and ongoing relevance of sustainable agriculture research in addressing critical environmental, social, and economic challenges in Indonesia.

4.2 Network Visualization

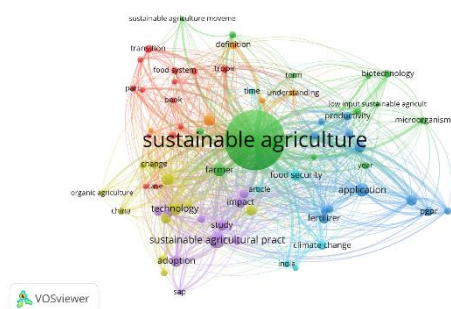


Figure 1. Network Visualization
Source: Data Analysis Result, 2024

This visualization presents a bibliometric analysis in the field of sustainable agriculture, highlighting different research themes:

1. Green Cluster: The central and largest cluster includes "sustainable agriculture," "farmer," "food security," and "impact." It likely represents core research into sustainable farming practices, their adoption by farmers, and their implications for food security and environmental impact.

2. Red Cluster: This contains terms like "food system," "transition," and "organic agriculture." It seems to focus on broader food systems, their sustainability, and the transition toward more organic farming methods.

3. Blue Cluster: With keywords like "biotechnology," "microorganism," and "fertilizer," this cluster appears to deal with the technological and scientific aspects of sustainability in agriculture, such as the use of biotechnology and beneficial microorganisms to enhance crop growth and soil health.

4. Purple Cluster: This cluster includes "climate change," "technology," and "sustainable agricultural practice," suggesting a focus on the interplay between technology, farming practices, and the effects of climate change on agriculture.

5. Yellow Cluster: With "PGPR" (Plant Growth-Promoting Rhizobacteria) as a keyword, it indicates specialized research into the use of these bacteria in promoting plant health and growth, a specific aspect of sustainable agriculture.

This network reveals an interdisciplinary approach, incorporating technology, biology, environmental science, and social considerations in the pursuit of more sustainable agricultural systems. The interconnections show how these areas influence each other and the overall goal of achieving sustainable practices in agriculture.

4.3 Overlay Visualization

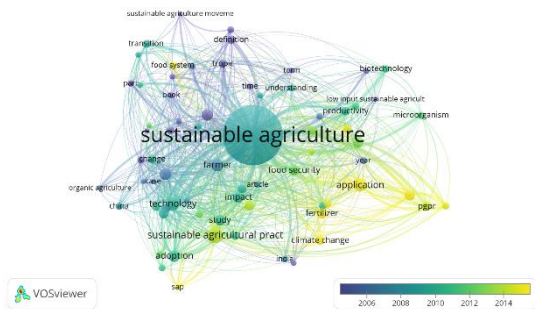


Figure 2. Overlay Visualization
Source: Data Analysis Result, 2024

This network visualization appears to display the evolution of research topics in sustainable agriculture over time, from 2006 to 2014, as indicated by the color gradient in the visualization.

1. Blue (Circa 2006): Research topics from around 2006 are highlighted in blue. The themes at this time may have included foundational concepts of sustainable agriculture, such as "organic agriculture," "sustainable agricultural practice," and the role of "technology" in farming.

2. Green (Mid-Period, Circa 2008-2010): The green color may represent topics that became prominent during this period. There could be a focus on the "impact" of sustainable practices on "food security" and the broader "food system," and how these are affected by "climate change," showing a response to global environmental changes.

3. Yellow (Circa 2014): The most recent research topics, closer to 2014, are in yellow. There's an emphasis on "fertilizer" and "pgpr" (plant growth-promoting rhizobacteria), suggesting a more specific exploration into sustainable farming inputs and the biotechnological applications in sustainable agriculture.

The trajectory of the research suggests that there was an initial broad focus on sustainable practices, which over time became more specialized, responding to the growing awareness of climate change impacts and exploring specific innovative solutions in agricultural practices. The yellow nodes might also represent emerging areas of interest within the sustainable agriculture field during the most recent years represented in the dataset.

4.4 Density Visualization

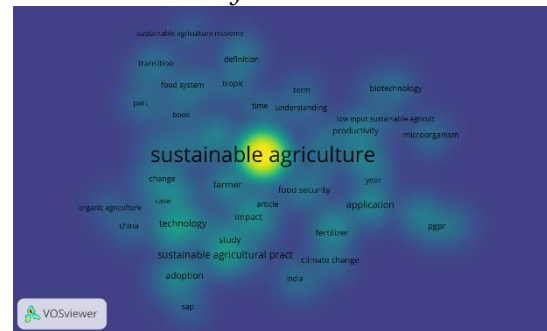


Figure 3. Density Visualization
Source: Data Analysis Result, 2024

The visualization suggests a focus on sustainable agriculture, highlighting the core themes and potential directions for future research. In such visualizations, less bright areas can indicate niches that are either emerging or have not been as heavily focused upon as the more brightly lit, central topics. The less bright areas surrounding the central theme of "sustainable agriculture" might offer insights into areas that are currently less developed in the research landscape but hold potential for future exploration. Based on the visualization, these could include:

1. Periphery topics related to "biotechnology" and "microorganism": These could relate to the development of sustainable bio-fertilizers or bio-pesticides, which could be an emerging field of study within sustainable agricultural practices.

2. Areas around "climate change": While climate change is a well-known issue, the intersection of climate change with specific sustainable agricultural practices or its impacts on particular crops might be less explored.

3. "Sap" and related agricultural bioproducts: This might refer to plant saps and their uses in sustainable agriculture, potentially an under-researched area that could include organic pesticides or growth stimulants.

4. Regional studies ("India" and "China"): While there is a global understanding of sustainable agriculture, there may be less research into the unique challenges and opportunities in these specific and highly significant agricultural regions.

5. Technological adoption ("technology" and "adoption"): How new sustainable technologies are adopted by farmers and integrated into existing agricultural systems could be an area ripe for future research.

These potential topics suggest an opportunity to delve into how modern scientific advancements and local adaptations can further enhance the sustainability of agriculture, considering both global trends and regional specifics. It also points towards the need to investigate the socio-economic aspects of technology adoption in agriculture and the ongoing responses to climate challenges.

4.5 Citations Analysis of Global Research

Table 2. Analysis of Citation

Citation	Authors	Title
4568	[17]	Agroecology: the science of sustainable agriculture
2884	[18]	Participatory learning for sustainable agriculture
1990	[19]	The role of conservation agriculture in sustainable agriculture
1894	[20]	Agroecology: ecological processes in sustainable agriculture
1824	[21]	How sustainable agriculture can address the environmental and human health harms of industrial agriculture.
1607	[22]	The 'Terra Preta' phenomenon: a model for sustainable agriculture in the humid tropics

1496	[23]	... phenolic and ascorbic acid content of freeze-dried and air-dried marionberry, strawberry, and corn grown using conventional, organic, and sustainable agricultural ...
1412	[24]	Plant growth-promoting rhizobacteria: context, mechanisms of action, and roadmap to commercialization of biostimulants for sustainable agriculture
1374	[25]	Role of phosphate solubilizing microorganisms in sustainable agriculture-a review
1343	[26]	Biological nitrogen fixation: an efficient source of nitrogen for sustainable agricultural production?

Source: Publish or Perish Output, 2024

The table presents a citation analysis of global research articles in the field of sustainable agriculture, listing the top-cited publications along with their respective authors and titles. At the forefront is the work by M.A. Altieri titled "Agroecology: the science of sustainable agriculture," with an impressive citation count of 4568, showcasing the widespread recognition and influence of agroecological principles in sustainable farming practices. Following closely is the contribution by J.N. Pretty on "Participatory learning for sustainable agriculture," reflecting the importance of inclusive and collaborative approaches in agricultural sustainability initiatives. Other notable publications include those discussing the role

of conservation agriculture in sustainable practices, such as the work by P.R. Hobbs, K. Sayre, and R. Gupta, as well as contributions on agroecology's ecological processes by S.R. Gliessman, E. Engles, and R. Krieger. Additionally, the table highlights research on specific sustainable agricultural models and practices, such as the "Terra Preta" phenomenon as a model for sustainable agriculture in humid tropics, discussed by B. Glaser, L. Haumaier, G. Guggenberger, and W. Zech. The importance of plant growth-promoting rhizobacteria and phosphate-solubilizing microorganisms in sustainable agriculture is also evident from the citations received by R. Backer, J.S. Rokem, G. Ilangumaran, and others, as well as the work by M.S. Khan, A. Zaidi, and P.A. Wani. The table showcases the diverse and influential research landscape in sustainable agriculture, emphasizing key topics such as agroecology, participatory learning, conservation agriculture, biological nitrogen fixation, and innovative agricultural practices aimed at promoting sustainability, environmental health, and agricultural productivity on a global scale.

4.6 Author Mapping

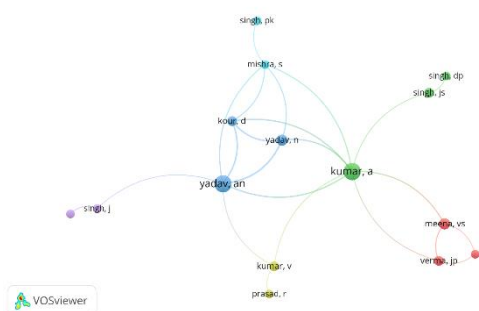


Figure 4. Author Collaboration Network

Source: Data Analysis Result, 2024

This visualization represents an author collaboration network, typically extracted from bibliometric data. The network illustrates how different authors have worked together on various research projects or publications. In this particular network we found:

1. The green cluster centered around "kumar, a" suggests a well-connected group with "kumar, v" and "prasad, r" being significant collaborators.

2. The red cluster with "meena, vs" and "verma, jp" indicates a partnership or team that has likely published together.

3. The blue cluster shows collaborations revolving around "kour, d", "yadav, n", and "yadav, an". This suggests a research group or a team working closely on specific topics.

4. The lone nodes, like "singh, j", could represent authors who have fewer publications or are less centrally integrated into the network.

5. CONCLUSION

The comprehensive bibliometric analysis conducted on sustainable agriculture research in Indonesia has yielded valuable insights into the progress, trends, and directions within this critical field. With nearly a thousand papers analyzed spanning over four decades, the research landscape reflects a robust and impactful endeavor towards addressing the environmental, social, and economic challenges facing Indonesia's agricultural sector. The analysis showcased a remarkable level of collaboration among authors, indicating a collective effort towards advancing knowledge and innovation in sustainable agricultural practices. Key thematic areas identified, ranging from agroecology to technological interventions, underscore the interdisciplinary nature of research, highlighting the need for holistic approaches to address complex agricultural sustainability issues. Furthermore, the visualization of research clusters and evolution over time revealed shifting priorities, emerging trends, and potential areas for future exploration, reflecting a dynamic research landscape responsive to evolving challenges and opportunities. The citation analysis of global research reinforced the significance of Indonesian contributions to the broader discourse on sustainable agriculture, emphasizing the global relevance and impact of research endeavors within the country. Overall, this study provides valuable insights for policymakers, researchers, and stakeholders to guide evidence-based decision-making, prioritize research

investments, and foster collaborative efforts towards achieving sustainable agricultural development in Indonesia.

REFERENCES

- [1] A. W. Muhaimin, D. Retnoningsih, and I. I. Pariasa, "The role of women in sustainable agriculture practices: evidence from east java Indonesia," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2023, p. 012005.
- [2] M. Ovitarsi, "Regulatory and Policy Responses toward SDGs in Achieving Sustainable Agriculture Productivity in Indonesia," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing, 2022, p. 012027.
- [3] A. Auliah, G. Prayitno, I. R. D. Ari, Rahmawati, L. E. Wardani, and C. Meidiana, "The Role of Social Capital Facing Pandemic COVID-19 in Tourism Village to Support Sustainable Agriculture (Empirical Evidence from Two Tourism Villages in Indonesia)," *Economies*, vol. 10, no. 12, p. 320, 2022.
- [4] G. Prayitno, A. Hayat, A. Efendi, H. Tarno, Fikriyah, and S. H. Fauziah, "Structural model of social capital and quality of life of farmers in supporting sustainable agriculture (Evidence: Sedayulawas Village, Lamongan Regency-Indonesia)," *Sustainability*, vol. 14, no. 19, p. 12487, 2022.
- [5] A. T. Nugraha, R. Rahmawati, A. Auliah, and G. Prayitno, "Farmers' social capital in supporting sustainable agriculture: the case of Pujon Kidul tourism village, Indonesia," 2022.
- [6] M. Kanojia, P. Kamani, G. S. Kashyap, S. Naz, S. Wazir, and A. Chauhan, "Alternative Agriculture Land-Use Transformation Pathways by Partial-Equilibrium Agricultural Sector Model: A Mathematical Approach," *arXiv preprint arXiv:2308.11632*, 2023.
- [7] T. Decaens *et al.*, "Biodiversity loss along a gradient of deforestation in Amazonian agricultural landscapes," *Conservation Biology*, vol. 32, no. 6, pp. 1380–1391, 2018.
- [8] E. Warren-Thomas, A. Ahrends, Y. Wang, M. M. H. Wang, and J. P. G. Jones, "Rubber's inclusion in zero-deforestation legislation is necessary but not sufficient to reduce impacts on biodiversity," *Conserv Lett*, vol. 16, no. 5, p. e12967, 2023.
- [9] P. E. Oko and D. U. Odey, "Impact of population growth on biodiversity loss in Boki agro-ecological rainforests, Cross River State, Nigeria," *Global Journal of Pure and Applied Sciences*, vol. 28, no. 1, pp. 99–105, 2022.
- [10] X. Giam, "Global biodiversity loss from tropical deforestation," *Proceedings of the National Academy of Sciences*, vol. 114, no. 23, pp. 5775–5777, 2017.
- [11] T. H. M. Tran and T. H. Y. Nguyen, "Vietnam's Agriculture towards Sustainable Development: Opportunities, Challenges and Solutions in the context of International Economic Integration nowadays," *Bus. Econ. Law*, vol. 15, pp. 63–70, 2018.
- [12] G. K. Chouhan *et al.*, "Phytomicrobiome for promoting sustainable agriculture and food security: opportunities, challenges, and solutions," *Microbiol Res*, vol. 248, p. 126763, 2021.
- [13] C. D. Ha, P. T. Minh, T. Van Tien, P. P. Thu, and P. M. Trien, "IoT solutions for smart farming: A comprehensive review on the current trends, challenges and future prospects for sustainable agriculture," *Journal of Forestry Science and Technology*, vol. 8, no. 2, pp. 28–35, 2023.
- [14] J. Cao and Y. A. Solangi, "Analyzing and prioritizing the barriers and solutions of sustainable agriculture for promoting sustainable development goals in China," *Sustainability*, vol. 15, no. 10, p. 8317, 2023.
- [15] F. Ewert, R. Baatz, and R. Finger, "Agroecology for a sustainable agriculture and food system: from local solutions to large-scale adoption," *Annu Rev Resour Economics*, vol. 15, pp. 351–381, 2023.
- [16] R. MAHDEWI, "KEAMANAN PANGAN PRODUK REKAYASA GENETIK MENURUT HUKUM INTERNASIONAL DAN IMPLEMENTASINYA DI INDONESIA," 2017.