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Environmental Management System (EMS): Trends and Research Patterns from a Bibliometric Perspective

Ajeng Nurhaliza
UIN Sunan Gunung Djati Bandung, Indonesia
ajengnurhaliza121@gmail.com

Abstract

This study aims to explore the development trends and research collaboration patterns in the field of Environmental Management Systems (EMS) using a bibliometric analysis approach. EMS plays a crucial role in supporting sustainable environmental governance and has gained increasing attention in the global academic community over the past decade. The study uses quantitative methods through bibliometric analysis with data obtained from the Dimensions database, focusing on publications from 2021 to mid-2025. A total of 236 relevant publications were analyzed using VOSviewer software to map publication trends, country and institutional collaboration networks, co-authorship patterns, and keyword co-occurrences. The results reveal a significant increase in EMS-related research publications starting from 2021, peaking in 2024. Indonesia emerged as a central actor in EMS research networks, both in terms of publication volume and collaboration strength. Institutions such as the Bandung Institute of Technology and Padjadjaran University were identified as major contributors. Furthermore, the analysis of co-occurring keywords indicates a shift in research focus from structural and technical aspects of EMS towards issues related to policy, implementation challenges, and the role of technology. This study concludes that EMS has evolved into a dynamic and multidisciplinary research area with growing global interest. The strengthening of collaborative networks among researchers, institutions, and countries is pivotal in enhancing the quality and impact of EMS-related research. These findings offer strategic insights for academics, practitioners, and policymakers to optimize research networks and support more effective and sustainable EMS implementations.

Keywords: *EMS, Bibliometric Analysis, Sustainability, Research Collaboration, VOSviewer*

1. INTRODUCTION

In the era of globalization and climate change, environmental management has become a crucial agenda for various sectors, especially industry and government. One approach that has been widely adopted to address this challenge is Environmental Management Systems (EMS). EMS is a structured management system designed to assist organizations in identifying, monitoring and controlling the environmental impacts of their activities in a sustainable manner (Sira, 2024). Through the implementation of EMS, organizations can not only improve their environmental performance, but also strengthen operational efficiency and economic competitiveness (World Bank, 2022 in Jayaraman et al., 2024).

As the complexity of environmental challenges increases (Kusumastuti, et al., 2025), the need for collaborative research in the field of EMS becomes more urgent. Such collaboration not only accelerates the diffusion of knowledge and innovation, but also strengthens institutional and technical capacity to respond to global environmental dynamics. Research by Zhang et al. (2024) highlighted that inter-researcher and inter-organizational collaboration within EMS networks can promote the development of companies' dynamic capabilities and improve sustainability performance. This is in line with the urgency to strengthen synergies across disciplines and regions to expand the scope and effectiveness of EMS implementation.

Bibliometric analysis is an increasingly popular method used to assess the development of science through quantitative scientific publication data. It utilizes mathematical and statistical techniques to map trends, collaboration patterns and the impact of research in a particular field

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(Mu'yidarrahmatillah et al., 2024). With bibliometric analysis, researchers can identify key themes, collaboration networks between authors or institutions, and the evolution of research topics systematically and objectively. In recent years, there has been an increase in the popularity of research interests related to the Environmental Management System. Based on the search results on web dimensions, the increasing popularity of research related to the Environmental Management System can be seen in the following figure:

Graph 1. The increase in the number of Augmented Reality publications per year (2016-2025)
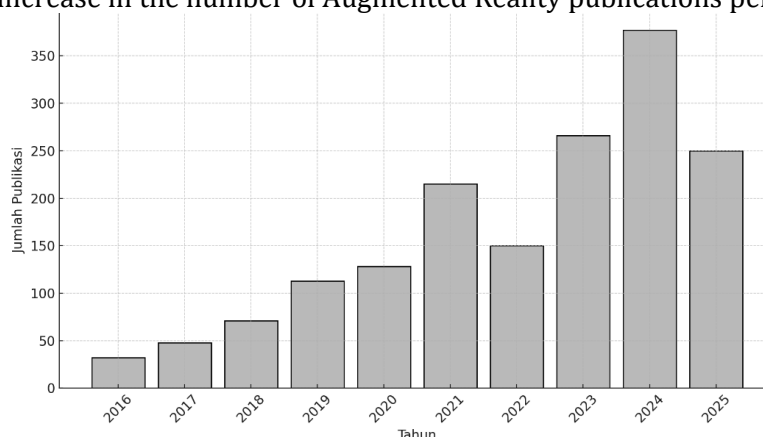
Source: Dimensions Database (2025)

The line graph above displays the trend in the number of annual scientific publications related to the topic of Environmental Management Systems (EMS) from 2016 to 2025. It shows a dynamic growth pattern and illustrates the evolution of research interest in EMS over the past decade. At the beginning of the period (2016-2018), the number of publications is still relatively low and stable, indicating that this topic is not yet a major concern among researchers. However, from 2019 to 2021, there is a significant increase that marks the initial phase of growth in research interest in EMS, possibly triggered by the increasing urgency of climate change issues, the push for environmental regulation, and the development of standards such as ISO 14001.

There is a slight decline in 2022, but the trend picks up again in 2023 and peaks in 2024 with the highest number of publications. This reflects that EMS is becoming an important theme in global academic discourse and environmental policy. Although in 2025 there is a noticeable decline as it is only halfway through the period until July, the number of publications remains high, indicating that EMS is still a relevant and growing topic. Issues of sustainability and environmental management continue to receive widespread attention in the scientific community. Several previous studies have used bibliometric approaches to understand the development of research in various environmental fields. For example, Mu'yidarrahmatillah et al. (2024) conducted a literature mapping of environmental literacy from 1971 to 2024 and found a significant increase in the number of publications as well as international collaborations, indicating greater attention to sustainability issues. Another study by Judijanto, Fajariana, and Duha (2024) analyzed the role of environmental innovation in sustainable development through bibliometrics, revealing trends and citation patterns that show the importance of innovation in the global environmental context. In addition, Putri et al. (2023) examined the development of green accounting research with a bibliometric approach, which helped identify research gaps and opportunities for future development of more specific studies.

While EMS has been a widely researched topic - particularly in relation to ISO 14001 standards, green innovation and green technology adoption - there is limited research that comprehensively examines patterns of research collaboration (Boiral, 2018; Jayaraman et al., 2024). Previous bibliometric studies tend to focus on topic or keyword analysis, without explaining in depth how the structure and intensity of inter-agency and cross-country collaborations contribute to the scientific impact and practice of EMS, particularly in developing countries. Furthermore, the integration of advanced technologies such as Artificial Intelligence (AI) and blockchain in EMS systems is gaining attention,

but there is a lack of studies on how collaborative networks support the adoption of these technologies (Sira, 2024).

Therefore, there is a need for a more in-depth and up-to-date analysis, especially one that integrates aspects of research collaboration and scientific impact in the field of Environmental Management Systems (EMS). An updated bibliometric analysis can provide a holistic picture of how EMS research is evolving, who are the main actors in the collaborative network, and how the research results contribute to sustainable environmental management practices. A major research gap lies in the lack of bibliometric analyses that explore the relationship between research collaboration networks, technology development and overall EMS performance. This is all the more important given the need for a holistic understanding of the dynamics of scientific collaboration that can drive the transformation of innovation-based environments (Zhang et al., 2024).

To address these challenges, this study uses Network Embeddedness theory as an analytical framework. This theory explains that the quality and structure of relationships in the network, both structural (who is connected to whom) and relational (quality of trust and closeness), affect the organization's capability to access resources and generate innovation (Zhang et al., 2024). With this approach, the study can uncover the strategic role of embeddedness in strengthening the effectiveness of EMS research collaboration.

The urgency of this research is based on the importance of mapping and analyzing EMS research collaboration networks bibliometrically with the latest data coverage until July 2025. Through this approach, the research aims to identify publications on Environmental Management Systems (EMS) and describe the characteristics of the research. Bibliometric analysis is used in this study to explore the characteristics of publications in the field of Environmental Management Systems (EMS) as well as to understand research trends in this field.

The results of this study are expected to provide strategic insights for academics, environmental practitioners, and policy makers in designing and optimizing more inclusive and results-oriented EMS research collaborations. Thus, the contribution of this research is not only academic, but also practical in encouraging more adaptive, innovative and sustainable EMS implementation in the future.

2. METHOD

This study uses a quantitative approach using bibliometric methods to analyze trends, collaboration patterns, and research impact in the field of Environmental Management Systems (EMS). The bibliometric method was chosen because it is able to process scientific publication data systematically and quantitatively, thus providing an objective picture of the development of science and research collaboration networks (El Hmieche et al., 2024). This approach also allows visualization of collaboration networks and main keywords using special software. The data source in this study was obtained from the Dimensions database, a bibliometric platform released by Digital Science in 2018. Dimensions provides access to various types of scientific literature collections, including journal articles, books, conference documents, and integrated citation data. The publication time span analyzed was from 2021 to 2025 to get an overview of research developments over the past 5 years. The sample in this study is 236 publications from the dimensions database obtained with the keyword " Environmental Management Systems ". As shown in the table below:

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Table 1. Number and percentage of Environmental Management Systems publications (2021-2025)

No.	Year of Publication	Number of Publications	Percentage (%)
1.	2025	38	16,10
2.	2024	66	27,97
3.	2023	60	25,42
4.	2022	29	12,29
5.	2021	43	18,22
		236	100.00

Source: Dimensions database processed by researchers

Data analysis was conducted using VOSviewer software, which is capable of displaying network visualization, time trend (overlay visualization), and topic density (density visualization). The indicators are the number of publications, the number of citations, and the total link strength between the objects displayed. This approach allows a detailed and structured mapping of Environmental Management Systems.

The research procedure began with searching and collecting publication metadata in Dimensions using predefined keywords. Once the data was collected, cleaning was performed to remove duplicates and irrelevant publications. Next, the data was analyzed using VOSviewer to visualize collaboration networks between authors, institutions, and countries, as well as dominant keyword occurrence patterns. The results of this analysis were then interpreted to identify research trends, gaps, and potential directions for research development. Using the Dimensions database, this research provides a comprehensive and up-to-date picture of the digital government research landscape in the face of disruption, while providing strategic recommendations for the development of digital government science and practice.

3. RESULT AND DISCUSSION

In presenting the results of bibliometric analysis, it is done in a deductive way or starting from general findings to more specific findings, such as: country bibliographic pairs, Institute bibliographic pairs, journal bibliographic pairs, publication bibliographic pairs, author bibliographic pairs, and co-occurrence of author keywords, so that readers follow the information provided from general to more specific information.

**Figure 1.** Publication development Environmental Management Systems 2020-2025

Source: https://www.dimensions.ai/ (2025)

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Based on Figure 1, the development of publications related to Environmental Management Systems (EMS) shows a significant trend in the last decade. In 2021 there was a sharp spike in the number of publications, signaling an increased interest of academics and researchers in environmental management issues. Despite a slight decline in 2022, the number of publications again increased in 2023 and peaked in 2024. This surge can be attributed to the increasing global awareness of sustainability as well as technological developments that support the efficiency of environmental management systems, such as the use of artificial intelligence and blockchain.

In 2025, the number of publications appears to decrease, but this data is provisional as the current year has not yet been fully completed. Overall, there were 428 citations with an average of 1.81 citations per publication, indicating that research in EMS is gaining traction in the scientific community. The increase in the number of publications and citations reflects the urgency of this topic in responding to global environmental issues and the great potential of EMS as a strategic tool to support sustainable development. This graph also shows the need for further analysis of the direction and quality of research collaborations that contribute to strengthening EMS practices in various sectors.

Figure 2. Network visualization of country bibliographic pairs
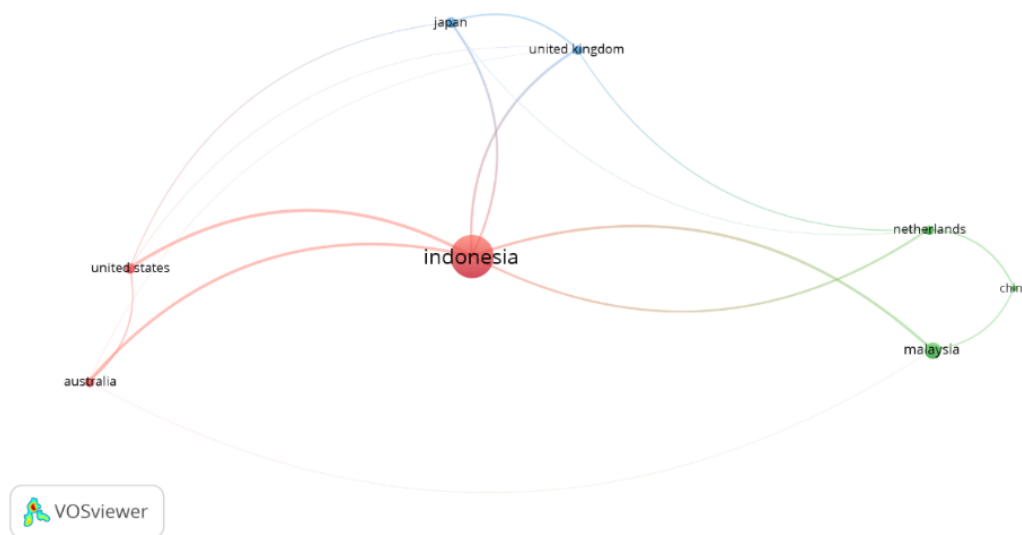
Source: Vosviewer (2025)

The country bibliographic pairs can be seen in the figure above which is displayed with a network visualization. We used a threshold at this stage, where the minimum number of publications for a country is 2. Of the 26 countries, 9 met the threshold. In terms of total link strength, Indonesia ranks first with 953 total link strength, 224 citations and 96 publications. Then, in second place is the United State with 283 total link strength, 14 citations and 6 publications. Furthermore, to display other countries, researchers will sort as follows, the first number is the number of publications, the second number is the number of citations and the third number is the total link strength. The countries are; Australia (5, 106, 242), United Kingdom (5, 50, 241), Japan (6, 15, 204), Malaysia (14, 4, 203), Netherlands (5, 17, 200), China (2, 0, 96), Poland (2, 9, 0).

In Figure 2 above, there are different colors that show the division of clusters or different groups where the groups are based on the intensity of the relationship with each other. In the first or largest cluster are Indonesia, Australia and the United States. The second cluster is China, Malaysia and the Netherland. The third cluster is Japan and the United Kingdom.

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**Figure 3.** Overlay visualization of institutional bibliographic pairs

Source: Vosviewer (2025)

The bibliographic pairs of Institutes are shown in Figure 3 displayed with an overlay visualization. We used a threshold at this stage, where the minimum number of publications from an Institute is 4 publications that have been cited by at least 3. Out of 186 institutions, only 9 met the threshold. We ranked the institutions based on total link strength, where Bandung Institute of Technology ranks first with 131 total link strength, 5 citations and 4 publications. This is followed by Padjadjaran Unuversity with 117 total link strength, 14 citations and 9 publications. Furthermore, consecutively shown in the first number is the total link strength, in the second number is the number of citations and in the third number is the number of publications, IPB University (95, 9, 6), National research and Innovation Agency (94, 7, 9), State University of Semarang (92, 5, 4), University of Indonesia (33, 23, 9), Gadjah Mada University (30, 13, 4), University Of Brawijaya (29, 23, 8), University of Auckland (New Zealand) (56, 6, 3), Brigham Young University (United States) (54, 48, 3), Airlangga University (1, 21.4).

From the picture above there are several colors, ranging from blue, green, to yellow, where yellow indicates the latest publication. Bandung Institute of Technology and State University of Semarang are the latest publications related to Environmental Management Systems.

Figure 4. Density visualization of journal bibliography pairs
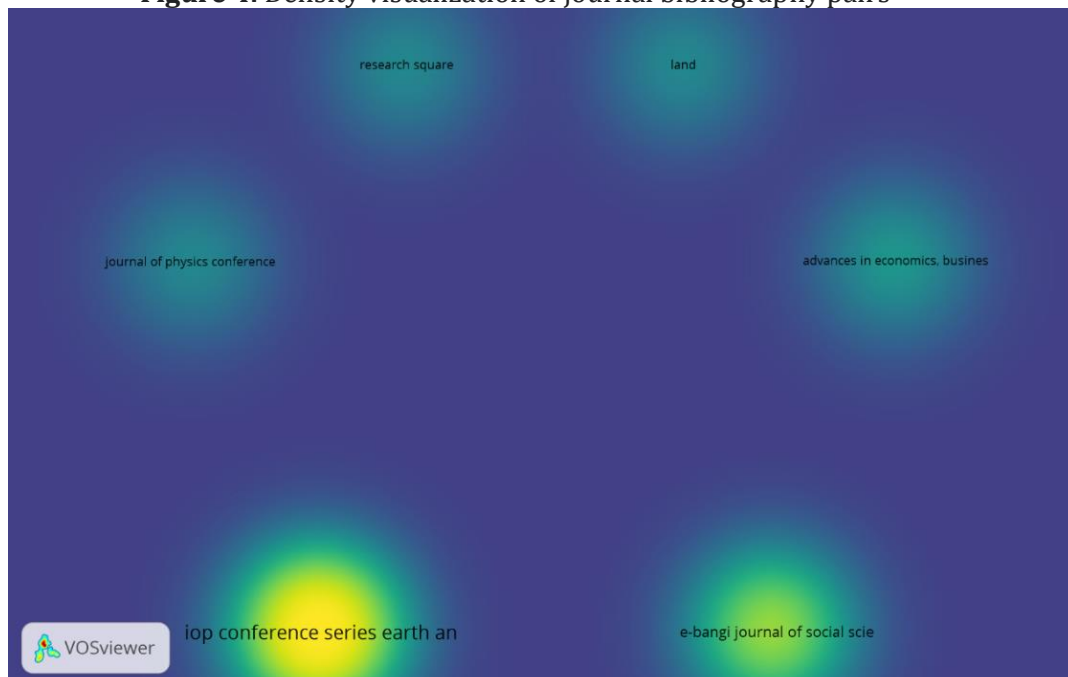
Source: Vosviewer (2025)

The journal bibliography pairs shown in Figure 4 are displayed with Density Visualization. The yellow color indicates the density of a journal. A color that changes to a solid yellow color indicates more publications in the journal in question. Researchers used a threshold at this stage, namely the minimum number of publications of a journal is 2 publications that have been cited as much as 2. Of the 174 journals, only 8 journals met the threshold. The Iop Converence Series Earth journal tops the list with 1 total link strength, 30 citations and 32 publications, followed by E-Bang Journal of Social Science, Sustainabiliy, JPUD - Journal of Early Childhood Education, Advences Economics Business, Land, Journal of Physics Conference Series and Research Square.
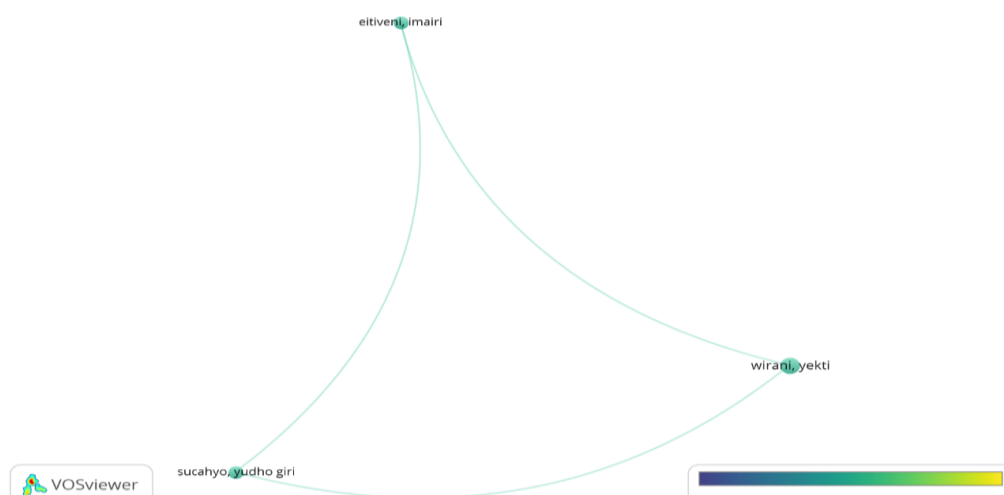
Figure 5. Network visualization of publication bibliographic pairs

Source: Vosviewer (2025

The bibliographic pairs of publications shown in Figure 5 are displayed with network visualization. We used a threshold at this stage, which is the minimum number of citations of a publication is 12. Out of 236 publications, only 6 publications meet the threshold. Warren (2021) ranks first with 64 citations, in second place is Nasyiah (2024) with 30 citations, then successively, Hunggul (2023), Nindhia (2021), Harianja (2023) and Pramono (2023).

**Figure 6.** Overlay visualization of author bibliographic pairs

Source: Vosviewer (2025)

The author bibliography pairs shown in Figure 6 are displayed with overlay visualization. We used a threshold at this stage, where the minimum number of publications of an author is 2 publications and 5 citations. Out of 811 publications, only 6 authors met the threshold. Wirani, Yekti ranks first with 416 total link strength, 8 citations, and 3 publications, in second place is Eitivani, Imairi with 416 total link strength, 8 citations, and 2 publications, then in a row, Sucahyo, Yudho Giri, then Soewarno, Noorlailie, and Sutarsa, Annisa Ayu Putri, and finally there is Tjahjai, Bambang.

In the picture above, the data is displayed with overlay visualization, there are several colors such as blue, green and yellow. The color shows the time information of the Winaro Yekti Ilham Muhammad, Eitivani Imairi, and Sucahyo, Yudho Giri articles with related authors published. The blue color indicates that the new article was published around 2023.

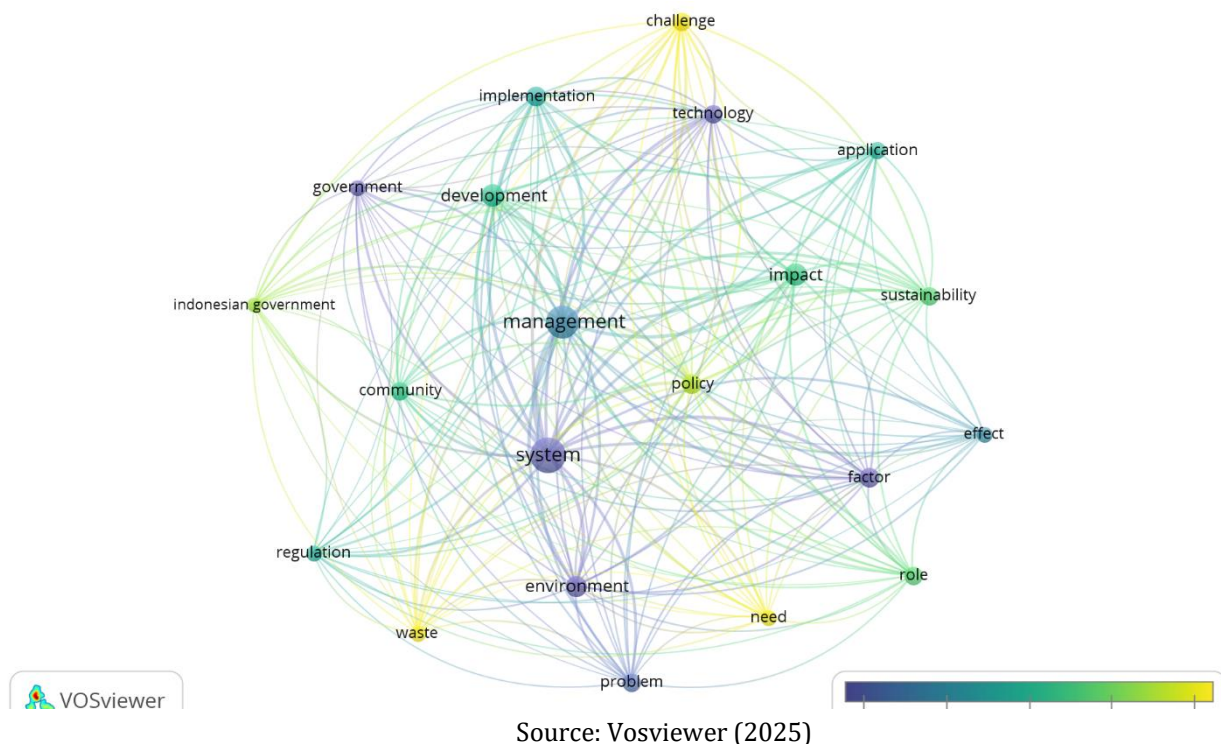**Figure 7.** Network visualization of co-occurrence of author keywords
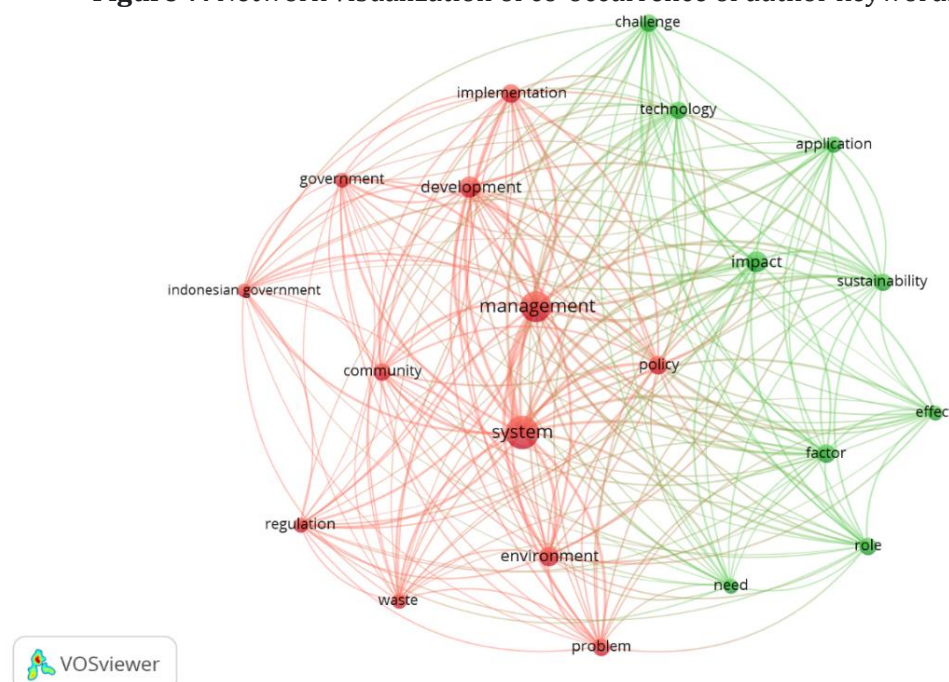
Source: Vosviewer (2025)

The figure above shows the network visualization of the co-occurrence of the author's keywords. Researchers used a threshold at this stage, namely the minimum number of co-occurrences is 26 out of 15339 keywords, 21 keywords that meet the threshold. System ranks first with 207 occurrences of and 3.23 relevance, in second place is the keyword Management, then in a row namely Indonesian Government, Waste, Regulation, Environment, Challenge, Government, Effect, Development, Policy, Technology, Impact, Sustainability, Aplication, Implementation, Factor, Need, Problem, Role and Community.

In Figure 7 above, there are several colors that show clusters of keywords that are often associated with one another. The first or largest cluster is red, namely Community, Development, Environment, Government, Implementation, Indonesian Government, Management, Policy, Problem, Regulation, System and Waste. Furthermore, researchers display data with overlay visualization as shown below:

Figure 8. Overlay visualization of co-occurrence of the author's keywords

Source: Vosviewer (2025)

Figure 8 above shows the co-occurrence data of the author's keywords with overlay visualization. The colors on the network show the average occurrence time of keywords, with a color spectrum from dark blue (2021) to bright yellow (2025). Keywords such as system, environment and factor tend to appear earlier (marked in blue and purple), indicating that the initial focus of EMS research is still centered on conceptual and structural aspects. Meanwhile, keywords such as challenge, policy, need and waste appear in lighter colors (yellow to green), indicating more recent research trends in the later years. This indicates a shift in research focus towards policy issues, technology needs and the challenges of implementing EMS on the ground. The keywords management, development and implementation are in the middle of the color spectrum, indicating their consistent use throughout the period. The keyword indonesian government also appears, signaling a growing interest in the local context and the role of government in supporting EMS implementation. Overall, this visualization reflects the dynamic development of the topic of EMS, which is increasingly complex and adaptive to contemporary environmental issues. This means that this is a gap that the authors, readers and researchers in this field can pursue further.

4. CONCLUSION

This study shows that the number of publications on Environmental Management Systems (EMS) has increased significantly in the last five years, reflecting the increasing global attention to sustainable environmental management issues. This development has been accompanied by a diversification of topics and approaches used in research, ranging from the integration of new technologies to the involvement of local actors such as governments and educational institutions. The bibliometric analysis also confirms that Indonesia is one of the strong centers of EMS research collaboration in the global network, in terms of number of publications, link strength, and institutional contributions.

Furthermore, the research revealed that co-occurring keywords indicate a shift in focus from technical and conceptual aspects towards policy issues, implementation challenges and the need for contextualized solutions. The overlay visualization shows the temporal dynamics of EMS topics as they continue to evolve and adapt to the challenges of the times. Collaborative networks between countries, institutions, authors and publications are an important factor in expanding the impact of EMS research

and accelerating the adoption of innovations in the field. This conclusion emphasizes the importance of strengthening strategic and sustainable research collaboration networks to promote the effective implementation of EMS as an instrument of environmentally sound development.

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