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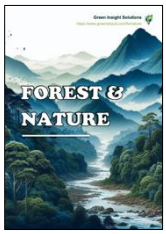

REVIEW ARTICLE

Emerging Trends and Knowledge Structure in Indonesian Forest Management: A Bibliometric Analysis

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ABSTRACT

Indonesia's tropical forests are central to global climate mitigation, biodiversity conservation, and the livelihoods of forest-dependent communities. However, forest management research in Indonesia remains fragmented and insufficiently synthesized, constraining its contribution to coherent scientific development and evidence-based policy. This study addresses this gap by systematically mapping research trends and knowledge structures in Indonesian forest management studies from 1986 to 2025. A total of 756 publications indexed in Scopus under the keywords "Forest Management" and "Indonesia" were analyzed using descriptive bibliometrics and science-mapping techniques, including co-authorship and co-citation analysis with VOSviewer. Research output increased markedly after 2015, with more than 80 articles published between 2021 and 2024. Keyword co-occurrence analysis identified five principal thematic clusters: ecological–silvicultural research; climate change and carbon dynamics; governance and community forestry; spatial and regional analysis; and geographically focused case studies. Overlay visualization reveals a temporal shift from early emphases on logging, timber production, and tropical forest ecology to mid-period attention on deforestation, carbon accounting, and Reducing Emissions from Deforestation and Forest Degradation (REDD), and more recently toward governance-oriented themes such as community forestry, participation, and policy implementation after 2018. The knowledge structure is influenced by a limited number of prominent authors and institutions, supported by strong international collaboration networks, and increasingly framed within sustainable and adaptive forest management, community-based approaches, and social–ecological systems perspectives. Despite thematic progress, significant gaps remain, including limited longitudinal policy impact evaluation, weak integration of socio-ecological and spatial analyses, underrepresentation of regions such as Papua, and insufficient development of operational forest management models. This study offers the first multidimensional synthesis of Indonesian forest management research and underscores the need for integrated, community-responsive strategies to strengthen future policy and practice.

1. Introduction

Forest management in Indonesia has become a critical issue both nationally and internationally, given that Indonesia is home to one of the largest tropical forests in the world, covering approximately 94 million ha (Amri and Ningrum, 2025). Maintaining biodiversity, mitigating global climate change, and guaranteeing the availability of ecosystem products are crucial for forest areas (Nugroho et al., 2022). Forests have many benefits, not only as a source of timber and raw materials, but also as carbon sinks, sources of clean water, habitats for biodiversity, and a fundamental part of the lives of local communities. The data collected proves that the challenges posed by deforestation, land degradation, mining, conservation for plantations, and economic pressures require appropriate methods for managing

forests that should be more integrated and adaptive, as well as scientifically supported by collected data to prove that the challenges that arise require very appropriate methods in managing forests so that they can be much better (Nugroho et al., 2022).

It is crucial to have a comprehensive overview of the development of the scientific literature on forest management in Indonesia, covering topics, researcher collaborations, and research directions. However, systematic efforts to describe this knowledge development using bibliometric methodologies are still very limited. In fact, this kind of mapping is crucial in shaping research objectives, policies, and management (Hussain et al., 2024; Luther et al., 2020; Wang et al., 2020). At the same time, the increasing number of forestry-related studies in Indonesia shows that ecological and regulatory phenomena are becoming increasingly complex. The decline in natural forest cover is a significant problem that has been monitored over the long term by organizations such as Forest Watch Indonesia (Dwiyahreni et al., 2021). In addition, international research shows that Indonesia is currently experiencing the highest rate of tropical deforestation in recent decades (Austin et al., 2019).

In response, Indonesia's social forestry program continues to expand, with a projected coverage of approximately 5.3 million ha by 2023. The program focuses on increasing local communities' role in forest management to promote sustainable practices and improve livelihoods through shared resource management. Data shows that this program has covered 6,625,137 ha with 8,317 units as of July 2023 (Supriyanto et al., 2024). However, academic research evaluating the effectiveness of this policy has not increased consistently with the policy's quantitative expansion and the area under control. Although ecosystem restoration and landscape rehabilitation programs are growing rapidly, research on their implementation, long-term impacts, and socio-ecological consequences remains minimal. This confirms that academic knowledge, particularly systematic and comparative analysis, remains lacking despite the growing policy issues. This condition underscores the need for bibliometric analysis as a tool for systematically mapping the evolution of Indonesian forestry research.

A clear research gap exists in that there has been no comprehensive bibliometric analysis delineating new trends and knowledge frameworks in forest management research in Indonesia across the dimensions of ecology, policy, restoration, socio-economics, and technology. Unlike conventional literature reviews, which tend to be qualitative and subjective in their coverage of specific topics, bibliometric analysis offers the advantage of objectively mapping the architecture of knowledge through network visualization and citation analysis, revealing hidden patterns that conventional narrative methods cannot identify. The absence of this systematic mapping is not only an academic shortcomingbut also limits policymakers' and forest managers' ability to understand research trends and set evidence-based research goals for the future. This study conducted a bibliometric analysis using the Scopus database to provide an overview of research progress, collaboration patterns, and conceptual and geographical gaps. This study is expected to enrich the literature on science mapping in tropical forestry, assist in setting research targets, enhance institutional relationships, and facilitate adaptive, data-driven forest management policies in Indonesia, while bridging the gap between local and global research.

Therefore, this study conducted a bibliometric analysis using the Scopus database for the period 2000 to 2024. This study aims to provide an overview of research progress, collaboration patterns, and conceptual and geographical gaps. This research is urgently needed given global concerns about climate change, tropical deforestation, and biodiversity loss. The results of this research are expected to enrich the scientific mapping literature in tropical forestry, assist in setting research targets, improve institutional relationships, and facilitate adaptive, data-driven forest management policies in Indonesia, while bridging the gap between local and global research.

2. Materials and Methods

2.1. Research Design

This study uses a bibliometric study design to analyze literature on forestry administration in Indonesia. This technique was chosen for its ability to perform quantitative analysis of publication patterns, inter-theme relationships, collaboration networks, and historical developments in knowledge. The research procedure was developed in accordance with the scientific identification protocols by Aria and Cuccurullo (2017) and Donthu et al. (2021), which emphasize transparency, replication, and traceability at every analytical stage. This study utilizes VOSviewer software for data visualization and

a globally indexed scientific journal database. All data, analysis algorithms, and research protocols are made publicly available to facilitate future replication. The research questions in this study are designed to answer the following:

RQ1: What are the emerging research trends in Indonesian forest management studies based on scientific publications during the period 1980–2025?

RQ2: How is the knowledge structure in Indonesian forest management research formed through patterns of co-authorship, co-citation, and co-word analysis?

RQ3: What research gaps can be identified from the mapping of these trends and knowledge structures, and what are the implications for developing the Indonesian forest management research agenda?

The selection of the time frame from 1980 to 2025 aims to capture the long-term evolution and paradigm shift dynamics in forest governance in Indonesia, from the era of intensive timber exploitation to the shift towards community-based forest management and global climate change mitigation. This period covers important milestones in national and international forestry policy, enabling a comprehensive analysis of how academic research has responded to regulations and ecological phenomena over more than four decades.

2.2. Materials and Tools of the Study

This research involves a bibliometric analysis of scientific publication metadata. The primary database analyzed is Scopus, the largest international publication database relevant to forestry and environmental sciences. The geographical focus remains Indonesia. Therefore, all analyzed publications must include the keywords “Forest Management” AND “Indonesia” in their titles, abstracts, or keywords. The publication metadata (title, abstract, keywords, affiliation, references, and citations) are sourced from Scopus and processed using VOSviewer 1.6.x, Microsoft Excel, and Google Sheets. VOSviewer 1.6.x was used for network analysis, specifically co-authorship, co-word, and co-citation mapping, while Microsoft Excel and Google Sheets were used for initial data cleaning and preparation.

2.3. Sampling and Data Selection

2.3.1. Inclusion criteria

Publications must satisfy the following requirements:

a. Indexing: Must be indexed in the Scopus database.
b. Keywords: Must contain the keywords related to forest management in Indonesia, specifically “Forest Management” AND "Indonesia” (searched in the Title, Abstract, or Keywords fields).
c. Document Type: Must be in the form of (research articles, review articles, conference papers, books, or book chapters).
d. Time Period: The analysis period spans from 1986 to 2025 to capture the long-term evolution of the research field.
e. Subject Areas: Limited to relevant academic disciplines (e.g., Environmental Science, Agricultural and Biological Sciences, Social Sciences, Earth and Planetary Sciences, Economics, etc.).

2.3.2. Rationality and limitations of keyword selection

The selection of the specific keywords “Forest Management“ AND “Indonesia“ was intended to ensure that the research focus remained on the core topic of forest administration and governance within Indonesia’s geographic scope. The use of the Boolean operator “AND” was intended to filter results to display only literature directly linking management practices to the local context of Indonesia. However, this approach has certain limitations. The use of overly specific keywords may overlook relevant studies that use alternative terminology but convey similar meanings, such as “forestry governance, “timber management, “ or “silviculture, “ even if the phrase “forest management” is not explicitly mentioned in the title or abstract. In addition, searches focused on English-language literature in Scopus may potentially lead to underrepresentation of high-quality local documents published in Indonesian but not yet indexed in this global database.

2.3.3. Scopus query result

The resulting query used in the Scopus database is as follows:
(TITLE-ABS-KEY ("Forest Management") AND TITLE-ABS-KEY ("Indonesia")) AND PUBYEAR > 1985 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "AGRI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "EART") OR LIMIT-TO (SUBJAREA , "BIOC") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "ENER") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "MEDI") OR LIMIT-TO (SUBJAREA , "PSYC")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "bk"))

2.4. Measurement Methods

The measurements are conducted using the following bibliometric analyses: Descriptive bibliometrics and science mapping analysis. This initial phase entails quantitative summaries of the data: the number of publications per year, the most productive journal sources, the most productive authors, affiliations, the country of origin of the research, and the most cited publications. Next science outlining analysis, the analysis by means of out this stage stands as conducted by means of: Co-authorship analysis, outlining the network of author collaboration, co-occurrence of keywords (identifying dominant themes and emerging topics), co-citation analysis (linking the intellectual structure of the research field), bibliographic coupling (examining the thematic proximity between articles), and thematic evolution analysis (tracing the modify in themes gradually).

3. Results and Discussion

3.1. Emerging Research Trends in Indonesian Forest Management Studies

A metadata analysis of the Scopus database since 1986 shows dynamic developments in forest management research in Indonesia. As illustrated in **Fig. 1**, the expansion of literature became increasingly apparent after 2025. This sharp increase peaked from 2021 to 2024, when the volume of publications exceeded 80 per year. **Fig. 1** not only shows quantitative growth but also analytically represents the scientific community's response to changes in forestry policy and increasing pressure from global climate commitments.

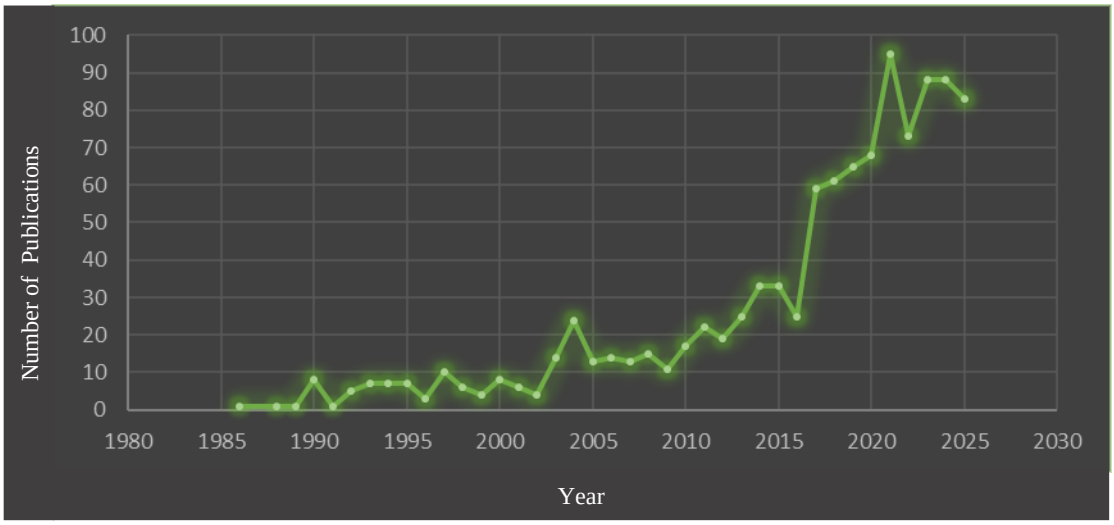

Fig. 1. Research trends in Indonesian forest management studies.

Historically, the main focus of forestry research in Indonesia has been on traditional ecological studies, such as vegetation inventory, forest stand dynamics, and biodiversity conservation. However, since the mid-2010s, there has been a paradigm shift towards a more management-oriented

interdisciplinary approach. This transformation signifies that forests are no longer viewed solely as biological entities, but rather as spaces for policy contestation involving institutional frameworks, the role of Forest Management Units (KPH), and the impact of national programs such as Social Forestry. Along with this thematic shift, the use of modern technologies such as remote sensing, geographic information systems (GIS), and machine learning has become increasingly dominant in the literature. These technologies have served as catalysts, improving the accuracy of deforestation monitoring, carbon stock calculations, and spatial-temporal analysis. The integration of these technologies marks a shift in research from purely observational to predictive and evaluative approaches, which is crucial for evidence-based policy.

A deeper analysis of this trend reveals that a strengthening socio-ecological perspective also drives the increase in publications. The focus on community involvement in forest management, including agroforestry and the utilization of non-timber forest products (NTFPs), reflects academic efforts to respond to global criticism regarding deforestation and climate justice. The dominance of governance and community involvement themes indicates that current knowledge production is heavily influenced by the need to balance ecological integrity with social welfare. Overall, current trends indicate that forest management in Indonesia continues to evolve toward a collaborative and multidisciplinary model. This transition provides a more solid scientific basis for the development of adaptive policies capable of responding simultaneously to the complexity of socio-economic and ecological issues in Indonesia.

The epistemology of Indonesian forest management research has undergone a considerable shift, as evidenced by an examination of publication trends. The increase in publications after 2015 represents a paradigm shift from traditional ecological research to adaptive governance and socio-ecological approaches, alongside greater volume. This shift is consistent with the notion that global interdisciplinary research patterns evolve in response to ecological constraints and shifts in policy regimes (Baatz et al., 2024). The growing focus on social forestry, forest governance, and Indonesia's social forestry policy indicates that the academic community continues to respond to both domestic and international policy processes. It is not unexpected that governance themes are becoming more prevalent, as this aligns with (Supriyanto et al., 2024).

The growing focus on social forestry, forest governance, and social forestry policy in Indonesia shows that the academic community is simultaneously responding to domestic and international policy processes. It is not surprising that the theme of governance has become increasingly common, as this aligns with (Supriyanto et al., 2024), which demonstrates that long-term resource sustainability is more effectively achieved through local institutions and rules collectively established by users, rather than relying solely on centralized state control or pure privatization. These findings provide scientific validation for the shift in Indonesian research, which now emphasizes the roles of communities and collaborative governance structures in successful forest management.

Additionally, a move toward a data-driven environmental research paradigm is evident in the growing use of technologies such as machine learning, GIS, and remote sensing. According to the global deforestation monitoring literature (Braslavska, 2025), integrating these technologies enhances scientific capacity to detect changes in land cover and carbon emissions. The use of spatial technology in Indonesia appears to be a response to more intensive monitoring requirements related to deforestation, making research there more than just observational; it is also predictive and evaluative. In line with socio-ecological research, expand the study's scopeby acknowledging local communities as important players in resource management (Tilot et al., 2022).

Therefore, research trends in Indonesia show a shift toward multiscalar forest management, establishing ecology, policy, community, and technology as essential elements in the forest management. Therefore, research trends in Indonesia show a clear shift towards multiscale forest management, with ecology, policy, community, and technology now recognized as essential elements. These findings confirm the results of the bibliometric analysis in this study, which show that this cross-disciplinary integration is not merely a technical trend but a strategic evolution in response to increasingly complex forest governance challenges. By combining high-precision monitoring with the involvement of local actors, the structure of research knowledge in Indonesia is now moving towards a more holistic management model capable of adapting quickly to environmental and social changes.

3.2. Knowledge Structure in Indonesian Forest Management Research

3.2.1. Knowledge structure based on author, affiliation, and country

Scopus-Analyze-Author data show that the knowledge framework in forest management research in Indonesia is heavily influenced by a core group of authors whose productivity far exceeds that of other authors. Authors such as Nurrochmat, D.R. (24 publications), and Maryudi, A. (17 publications) occupy central positions in this scientific network (**Fig. 2**). Their positions signify their status as key intellectual authorities in forest monitoring, forestry policy, and community-based governance. In addition, the involvement of foreign authors, such as Putz, F.E. (11 articles), strengthens Indonesia's forestry research network on the global stage, demonstrating the integration of local expertise with international perspectives.

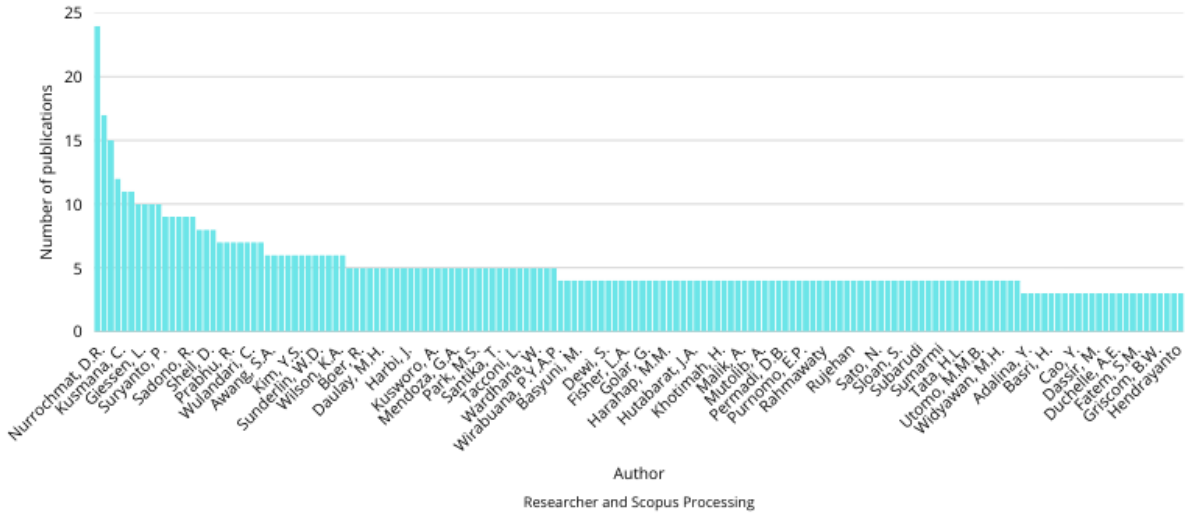

Fig. 2. Distribution of publications by authors.

Fig. 2 illustrates the highly skewed yet structured distribution of author productivity. This pattern is consistent with Lotka's Law, which states that a small number of authors produce the majority of articles in this field, thereby forming a sustainable and robust knowledge cluster. Analytically, this indicates that the methodological direction and thematic development of forest management research in Indonesia are strongly influenced by the thinking and expertise of these key figures, who serve as the principal drivers in the national scientific discourse (Ngo and Mahdi, 2017). In addition to the role of individuals, research strength is also centered on the dominance of certain educational institutions and research organizations. IPB University and Gadjah Mada University lead this affiliate network, further confirming their positions as centers of excellence in national forestry research.

Fig. 3 shows the dominance of publications by institutions such as IPB University, UGM, CIFOR-ICRAF, and BRIN. Interpretation of this data reveals that these organizations are at the forefront of promoting Sustainable Forest Management (SFM) and social forestry. Over the past 20 years, these institutions have not only conducted field research but also provided direct scientific support for national policy initiatives through in-depth analysis that bridges academic theory with practical application. On a global scale, international collaboration has been a fundamental element in expanding the scope of Indonesian research, involving countries with long traditions in ecosystem-based forest management and climate orientation (Cetera, 2022; Firdaus et al., 2022).

Fig. 4 illustrates the distribution of publications by country, where intensive cooperation with the United States, Japan, the United Kingdom, and Australia facilitates the integration of global perspectives into the local context. This is evident in studies on REDD+, carbon management, and forest restoration. Analytically, this country-level network not only reveals patterns of collaboration but also shows the process of exchanging, adapting, and applying global forest management theories to the local Indonesian environment.

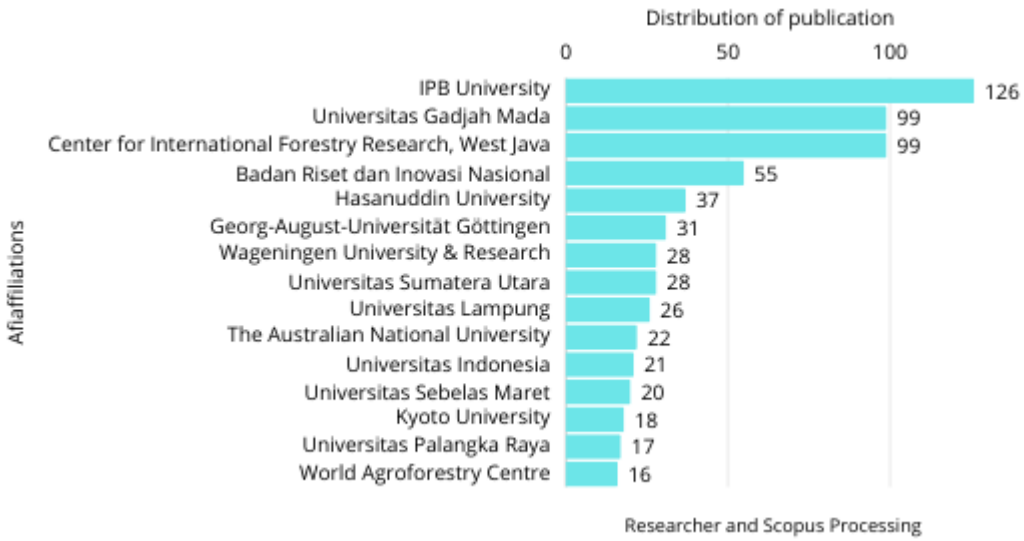

Fig. 3. Top 10 Distribution of publications by affiliation.

Overall, these affiliations and productivity patterns confirm that research in Indonesia is undergoing a real conceptual transition. The field is evolving from traditional approaches focused on timber and silviculture towards a more holistic paradigm (Acosta-Muñoz et al., 2024). The concept of Sustainable Forest Management (SFM) now aims to balance ecological integrity, social equity, and economic viability (Nugroho et al., 2022). This is evident from the main topics of the study, which cover land rights, institutional arrangements, and public participation, reviewed from the perspective of sustainability rather than mere production.

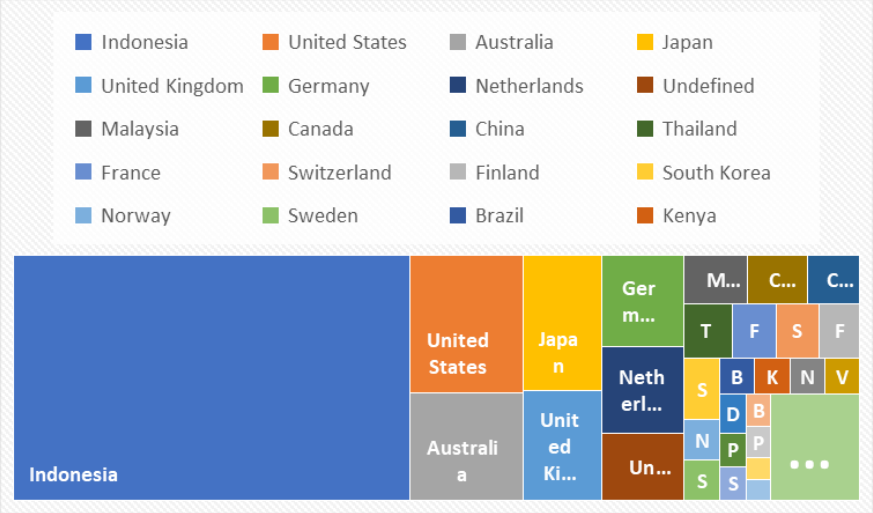

Fig. 4. Distribution of publications by country.

The development of research themes also shows the impact of Adaptive Forest Management (AFM) and ecosystem-based methodologies that view forests as dynamic systems requiring flexibility (Nocentini et al., 2021). The integration of advanced tools such as remote sensing, GIS, and spatial modeling into carbon stock monitoring indicates that Indonesian research is now more focused on designing methods that can adapt to environmental and regulatory changes (Raso et al., 2019; Schoenefeld et al., 2019).

A strong emphasis on social forestry and local participation highlights the importance of the Community-Based Forest Management (CBFM) framework and the Social-Ecological Systems (SES) theory. From this perspective, forests are no longer seen merely as biophysical entities, but as integrated systems shaped by social actors, institutions, and local knowledge (Sanz-Hernández, 2021). The revealed knowledge structure reflects the transition from centralized state forest governance to a collaborative co-

management structure that recognizes local capacity, in line with the principles of resilience and connectivity in natural resource management (Lodge et al., 2024). The most cited articles are presented in **Table 1**.

Table 1. Mose cited articles

Authors	Year	Tittle	Source	Cited
Gaveau et al. (2009)	2009	Evaluating whether protected areas reduce tropical deforestation in Sumatra	Journal of Biogeography	239
Hartanto et al. (2003)	2003	Factors affecting runoff and soil erosion: Plot-level soil loss monitoring for assessing the sustainability of forest management	Forest Ecology and Management	234
Wollenberg et al. (2000)	2000	Using scenarios to make decisions about the future: Anticipatory learning for the adaptive co-management of community forests	Landscape and Urban Planning	216
Mendoza and Prabhu (2000)	2000	Multiple criteria decision-making approaches to assessing forest sustainability using criteria and indicators: A case study	Forest Ecology and Management	190
Sunderlin et al. (2014)	2014	How are REDD+ Proponents Addressing Tenure Problems? Evidence from Brazil, Cameroon, Tanzania, Indonesia, and Vietnam	World Development	184
Estrada et al. (2018)	2018	Primates in peril: The significance of Brazil, Madagascar, Indonesia and the Democratic Republic of the Congo for global primate conservation	Peerj	152

3.3. Research Gaps and Theoretical and Practical Implications

3.3.1. VOSviewer analysis: network and overlay visualization

The VOSviewer visualization reveals the thematic structure of forest management research in Indonesia, which is divided into several major clusters (**Table 2**). Each cluster represents a distinct yet interconnected research focus within a dense network. The largest cluster, colored blue, is centered on keywords such as forest management, Indonesia, forestry policy, community forestry, and social forestry (**Fig. 5**). The red cluster indicates that over the past two decades, research has focused on forest management issues, the role of communities, and forestry legislation. Terms such as deforestation, climate change, environmental management, carbon, REDD+, and land-use change are dominant in this cluster. This cluster indicates that issues of deforestation and emission mitigation are central research areas with global impact.

Table 2. Cluster network and overlay visualization

Cluster	Item	Total
Cluster 1 (Blue)	Article, biomass, carbon, carbon emission, carbon sequestration, climate change, conservation, deforestation, ecosystem service, emission control, environmental management, environmental policy, environmental protection, forest, forest conservation, land use change, nature conservation, REDD+, reforestation, restoration ecology	27 items
Cluster 2 (Red)	Borneo, certification, East Kalimantan, ecology, forest dynamics, forestry, harvesting, illegal logging, Kalimantan, logging, rain forest, silviculture, sustainable development, sustainable forest management, sustainable forestry, timber, tropical forest, tropics	21 items
Cluster 3 (Green)	Agroforestry, community forestry, conservation management, decision making, forest management, forest resource, forestry policy, governance approach, indigenous population, Indonesia, livelihood, local participation, participatory approach, plantation, plantation forestry, policy implementation, social forestry, stakeholder, sustainability	20 items
Cluster 4 (Purple)	Developing country, Greater Sunda Island, Java, mangrove, remote sensing, Sumatra, Sunda Isles	7 items
Cluster 5 (Yellow)	Asia, decentralization, Eurasia, Southeast Asia	4 items

Meanwhile, the green cluster highlights ecological and sustainability themes, including tropical forests, biodiversity, restoration ecology, sustainable forest management, logging, and timber. This indicates a strong focus on conservation, forest utilization, and the ecologicalimpactsts of forest activities. The purple cluster highlights spatial and geographical dimensions, with keywords such as 'Southeast Asia', 'Asia', and 'illegal logging', indicating that Indonesian forest management is. Finally, the yellow cluster contains terms such as 'Greater Sunda Islands', 'Sunda Islands', and 'Java', indicating a thematic research focus on geography and regions. The high number of links between keywords, as indicated by the dense network, demonstrates that research on forest management in Indonesia functions as multidisciplinary, interconnected, and evolving across political, social, environmental, and technological scales.

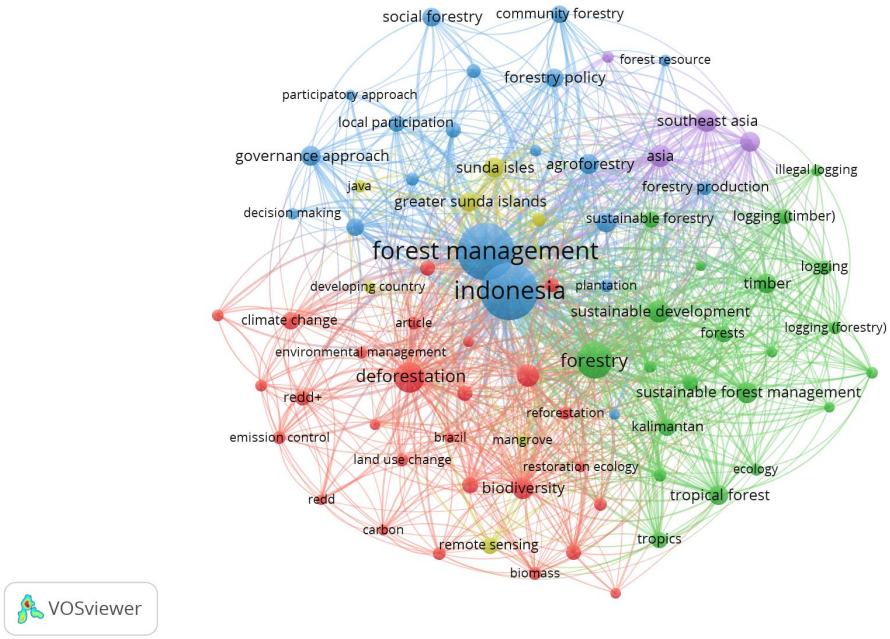

Fig. 5. Network visualization.

The overlay visualization map highlights how research themes in Indonesian forest management have transformed over time, displaying keywords based on average publication year (**Fig. 6**). Using a color gradient from purple (older topics, circa 2012–2014) to bright yellow (newer topics, starting in 2018), this map clearly illustrates the field's thematic evolution.

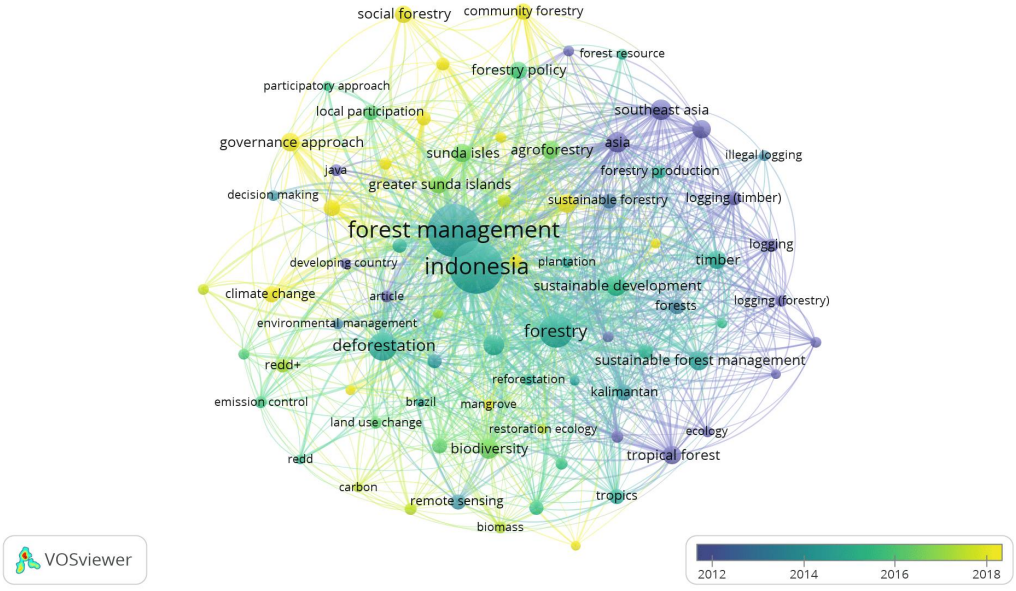

Fig. 6. Overlay visualization.

In the early stages, most research focused on ecological and conservation issues, for instance, tropical forests, plantations, logging, timber, and illegal logging. These terms remain shown in blue and light blue, indicating that they stood as the most popular before 2014. Attention gradually shifted to issues related to deforestation and climate change. Terms such as deforestation, carbon, land-use change (REDD+), and environmental management began to emerge in the green space. This is indicated by an increase in the number of studies conducted between 2015 and 2017, when global concerns about climate change and forest fires in Indonesia attracted more attention than in other countries.

In recent years (2018–2022), terms such as community plantations, social plantations, participatory approaches, governance approaches, local participation, and agroforestry have emerged. This signals a substantial shift towards plantation management research that focuses on government and communities. This trend remains in line with shifts in national policy, particularly the expansion of the Social Forestry Program and the decentralization of forestry, which encourage research adopting a socio-ecological perspective. Overall, terms such as remote monitoring, biodiversity, and restoration ecology are highlighted in light green, indicating that there is still much research on forest monitoring tech and data-driven restoration efforts.

Overall, the overlay visualization indicates that forest management research in Indonesia is shifting from an orientation dominated by ecological and resource aspects to a more policy-relevant, interdisciplinary approach that emphasizes adaptive governance, community participation, technological monitoring, and ecosystem restoration. The growth of this group is similar to changes in national policy, especially the Social Forestry program and the decentralization of forestry. However, a significant research vacuum arises from the insufficient emphasis on the long-term consequences of these therapies. Many studies examine how policies are made, implemented, and involve people. Still, fewer examine the long-term effects, co-management dynamics, resilience-building, or adaptive cycles in social-ecological systems. In essence, governance research explains how policies work but offers fewer insights into whether they deliver lasting ecological, social, or institutional benefits, a critical gap in Indonesian CBFM and SES research. Temporal patterns shown in the overlay visualization further illustrate the field's evolution. Initial studies (2012–2014) focused on silviculture and forest usage, transitioning to deforestation and climate-related concerns from 2015 to 2017. Recent research (2018–2022) is increasingly focusing on governance, involvement, and restoration. This change is part of a bigger shift from getting resources to fighting climate change and, more recently, to governing socio-ecological systems. However, it also reveals a gap: recent studies on governance are often poorly connected to older studies on ecology and climate. Only a small number of users use a single analytical framework to integrate ecological indicators (e.g., carbon stocks, biodiversity, or stand quality) with governance indicators (e.g., institutional legitimacy, participation efficacy, or tenure security). SFM, AFM, CBFM, and SES theories all argue that ecological, social, and economic issues should be addressed simultaneously. This lack of integration goes against those theories. Consequently, Indonesian forest management research continues to evolve in topic silos rather than within a comprehensive integrated management framework.

The spatial and geographical clusters are increasingly focusing on regional settings, especially in Sumatra, Kalimantan, and the Greater Sunda Islands. Key ideas related to landscape methods, such as connectedness, ecological corridors, watershed-scale planning, and cross-boundary governance, are still mostly missing, nevertheless. Considering the degree of habitat fragmentation and land-use transformation in Indonesia, this indicates a considerable deficiency, suggesting that spatial research has yet to translate landscape principles into implementable management solutions. Theoretically, this data indicates that forest monitoring research in Indonesia mostly employs the SFM, AFM, and CBFM, and SES frameworks; however, integration between these frameworks remains inadequate and has not produced a unique, context-specific theoretical system. The complex forest governance issues in Indonesia, including social forestry, overlapping property rights, forest fires, peatland restoration, and forest-based livelihoods, offer substantial opportunities to develop a more robust theoretical framework. In such a context, ideas, for instance, the "Indonesian Adaptive Co-Management model" or the "Hybrid SFM–CBFM Model for Multi-Stakeholder Landscapes" may emerge. Bibliometric studies not only outline contemporary knowledge but also highlight opportunities to improve forest management theory in line with Indonesia's socio-ecological context.

These findings possess considerable practical implications. First, we need to go beyond research that identifies problems and conduct studies that provide real solutions for management. This means

developing community-based forest planning models, multi-criteria optimization tools that account for carbon storage, biodiversity, and local livelihoods, and data-driven long-term recommendations for managing forest fires. Second, findings from governance research must be translated into practical tools, including integrated monitoring systems, collaborative frameworks between Forest Management Units (KPH) and forest settlements, and definitive criteria for assessing the effectiveness of social forestry initiatives. Third, remote monitoring and machine learning are often used for monitoring. Still, they can also be used in decision reinforcement systems that actively assist managers in decision-making and promote fully adaptive forest management. Fourth, research at the landscape level needs to be improved so it can be applied in real life, for instance, through habitat connectivity studies, spatial planning scenarios grounded in ecology, and governance systems that operate across administrative boundaries.

Theoretically, this data indicates that forest management research in Indonesia mostly employs the SFM, AFM, CBFM, and SES frameworks; however, integration among these frameworks remains inadequate and has not produced a unique, context-specific theoretical model. The complex forest governance issues in Indonesia, including social forestry, overlapping property rights, forest fires, peatland restoration, and forest-based livelihoods, offer principal opportunities for developing a more robust theoretical framework. Without this context, ideas, for instance, the “Indonesian Adaptive Co-Management Framework” or the “Hybrid SFM–CBFM Model for Multi-Stakeholder Landscapes,” may emerge. Bibliometric studies not only portray existing knowledge but also highlight opportunities to improve forest management theory in line with Indonesia's socio-ecological context.

These findings contain key practical implications. First, we need to go beyond research that merely identifies problems and conduct studies that provide real solutions for management. This means developing community-based forest planning models, multi-criteria optimization tools that account for carbon storage, biodiversity, and local livelihoods, and data-driven long-term recommendations for managing forest fires. Second, findings from governance research must be translated into practical tools, including integrated monitoring systems, collaborative frameworks between Forest Management Units (KPH) and forest settlements, and definitive criteria for assessing the effectiveness of social forestry initiatives. Third, remote monitoring and machine learning are often employed for monitoring. Still, they can also be used in decision-support systems that actively assist managers in decision-making and promote fully adaptive forest management. Fourth, research at the landscape level needs to be improved so that it can be applied in real life, for instance, in habitat connectivity studies, spatial planning scenarios based on ecology, and governance systems that operate across administrative boundaries. Fourth, forestry research in Indonesia is still unevenly distributed across the country. Much research has been conducted in Java and Sumatra, but Papua and Kalimantan, which feature the highest rates of deforestation and the most diverse ecosystems, have not been adequately explored. This unevenness makes it difficult to formulate forestry policies grounded in data and that reflect the conditions across the entire country. Fifth, research on forest restoration and regeneration remains largely based on small, specific examples, and insufficient effort has been made to identify general, useful lessons. Global restoration research, on the other hand, requires a landscape-scale framework that combines ecological, social, and economic elements (Mani Rai and Kumar Dhakal, 2024). Therefore, it remains essential to expand research to comprise multi-location and multiscale methodologies. From a theoretical perspective, these results emphasize the necessity for an adaptive governance framework that comprehensively integrates policy processes, technical instruments, and ecological dynamics, as depicted in adaptive co-governance theory (Butler et al., 2024). In practical terms, this study provides a solid empirical basis for determining the focus of future research, improving the distribution of research resources, and formulating forestry policies that better address deforestation, climate change, and other complex socio-ecological issues.

4. Conclusion

Theoretically, this data demonstrates that forest management research in Indonesia mostly employs the SFM, AFM, CBFM, and SES frameworks; however, integration among these frameworks remains inadequate and has not produced a unique, context-specific theoretical model. The complex forest governance issues in Indonesia, including social forestry, overlapping property rights, forest fires, peatland restoration, and forest-based livelihoods, offer substantial opportunities to develop a more robust theoretical framework. In this context, ideas, for instance, the “Indonesian Adaptive Co-

Management Framework" or the "Hybrid SFM–CBFM Model for Multi-Stakeholder Landscapes," may emerge. Bibliometric studies not only portray existing knowledge but also highlight opportunities to improve forest management theory in line with Indonesia's socio-ecological context. These findings contain principal practical implications. First, we need to go beyond research that merely identifies problems and conduct studies that provide real solutions for management. This means developing community-based forest planning models, multi-criteria optimization tools that account for carbon storage, biodiversity, and local livelihoods, and data-driven long-term recommendations for managing forest fires. Second, findings from governance research must be translated into practical tools, including integrated monitoring systems, collaborative frameworks between Forest Management Units (KPH) and forest settlements, and definitive criteria for assessing the effectiveness of social forestry initiatives. Third, remote monitoring and machine learning are often used for monitoring, but they can also be used in decision-support systems that actively assist managers in decision-making and promote fully adaptive forest management. Fourth, research at the landscape level needs to be improved so that it can be applied in real life, for instance habitat connectivity studies, spatial planning scenarios based on ecology, and governance systems that operate across administrative boundaries. Third, forestry research in Indonesia remains unevenly distributed across the country. Much research has been conducted in Java and Sumatra, but Papua and Kalimantan, which possess the highest rates of deforestation and the most diverse ecosystems, have not been adequately explored. This unevenness makes it difficult to formulate forestry policies grounded in data and that reflect the conditions across the entire country. Fourth, research on forest restoration and regeneration is still largely based on small, specific examples, and insufficient data have been generated to identify general, useful lessons. Global restoration research, on the other hand, requires a landscape-scale framework that combines ecological, social, and economic components. Therefore, it is essential to expand research to include multi-location and multiscale methodologies. From a theoretical perspective, these results underscore the need for an adaptive governance framework that integrates policy processes, technical instruments, and ecological dynamics, as depicted in adaptive co-governance theory. To enter text, click or press here. In practical terms, this study provides a solid empirical basis for determining the focus of future research, improving the distribution of research resources, and formulating forestry policies that better address deforestation, climate change, and other complex socio-ecological issues.

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