

A bibliometric analysis of research gaps on ritual plants within ethnobotanical studies in Indonesia

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Abstract. Sudirgayasa IG, Sulisetijono, Mahanal S, Gofur A, Surata IK, Sudiana IM, Maduriana IM. 2025. A bibliometric analysis of research gaps on ritual plants within ethnobotanical studies in Indonesia. *Asian J Ethnobiol* 8: 158–170. Ethnobotany plays a crucial role as a bridge between traditional knowledge and modern science, exploring the deep and long-standing relationship between humans and plants. In Indonesia—a country rich in both biodiversity and cultural diversity—ethnobotany holds a vital place in safeguarding ancestral heritage, such as herbal remedies, traditional rituals, and indigenous agricultural practices. These traditions not only enrich the nation's identity but also offer sustainable alternatives for the future. This analysis aims to map research trends and identify knowledge gaps related to ethnobotany in Indonesia. The findings are expected to serve as a reference for conservation programs that preserve local wisdom throughout the country. This study employed a bibliometric analysis. Scientific publication data were obtained from the Scopus database over the past decade. The keywords used included *ethnobotany*, *ethnobotanic*, *ethnobotanical*, *Indonesia*, *Indonesian*, *ritual*, and *rituals*. Data were analyzed using VOSviewer and Microsoft Excel. The analysis revealed several gaps that need to be addressed. First, the most popular topic in ethnobotanical research in Indonesia over the past decade has been medicinal plants. In contrast, research on ritual plants remains minimal—comprising less than 10% of all ethnobotanical studies—with an average of only two publications per year and a stagnant trend. Second, the digitalization of ethnobotanical data on internet-based platforms is still underdeveloped. The visibility and popularity of ritual plant studies should be enhanced through increased global collaboration, funding support, and sustainable conservation policies. Digitalization efforts should be improved by developing websites, mobile applications, social media platforms, and mapping plant distribution using Geographic Information System (GIS) tools or Google MyMaps. The education system should also be engaged by promoting the integration of ethnobotanical themes and values through both intra-disciplinary and interdisciplinary approaches.

Keywords: Bibliometric analysis, ethnobotanical, gap, Indonesia, ritual plants

Abbreviations: AI: Artificial Intelligence, CSV: Comma Separated Values, VOSviewer: Visualization of Similarities Viewer

INTRODUCTION

Ethnobiology plays a vital role in maintaining harmony between humans and nature by exploring traditional knowledge passed down orally through generations (Albuquerque and Alves 2016). It is not merely the study of how people utilize living organisms around them, but also an exploration of how values, beliefs, and cultural identities are shaped through interactions with the environment. Amid the rapid pace of modernization that often overlooks local wisdom, ethnobiology serves as a bridge connecting the past to the future, uniting science and spirituality within a single narrative of life (Wolverton 2013; Lotero-Velásquez et al. 2024). By understanding ethnobiology, we are not only preserving biodiversity but also nurturing the collective human spirit that has long evolved in tandem with the natural world (Turner et al. 2022; Baghersad et al. 2024). One of the main branches of ethnobiology is ethnobotany, which specifically focuses on the relationship between humans and plants various aspects of life (Albuquerque et al. 2017). This field examines how

various cultures perceive, use, and manage plant resources for food, traditional medicine, construction materials, cultural rituals, and as symbols of belief (Siswanto and Batoro 2019; Singh et al. 2025). Through ethnobotany, we can understand and preserve traditional knowledge while contributing to the conservation of natural resources, especially plants.

As a tropical country, Indonesia possesses abundant biodiversity (Rintelen et al. 2017) alongside a rich cultural heritage. Since ancient times, Indonesian communities have lived in harmony with nature, guided by local wisdom passed down through generations (Kubontubuh 2023). In this context, ethnobotany holds a unique and profound role, reflecting the nation's extraordinary biological and cultural diversity (Hidayat et al. 2018; Afentina et al. 2020; Jannaturrayyan et al. 2020; Rambey et al. 2021). Beneath the canopy of dense tropical forests and within traditionally managed gardens lies a wealth of indigenous knowledge—ranging from medicinal plants and food sources to flora imbued with spiritual significance in ritual ceremonies.

More than a scientific discipline, ethnobotany in Indonesia serves as a medium for preserving local wisdom, reinforcing cultural identity, and sustaining the harmonious relationship between humans and nature. In the face of modernization, ethnobotany reminds us that plants are not merely natural resources, but vital components of the collective consciousness that shapes the holistic and meaningful way of life among the Indonesian people (Marsandi et al. 2025). One important branch of this field is ritual ethnobotany, which explores the role of plants in religious and ceremonial contexts.

Ritual plant ethnobotany plays a crucial role in preserving traditions and conserving the environment in the modern era (Geng et al. 2017). It serves as an effective approach to protecting rare flora with spiritual and ritual significance (Cornelius and Van Wyk 2025). This practice strengthens the cultural identity of indigenous communities, enhances ecological awareness, and maintains the balance between humans and nature amid rapid modernization (Jigme and Yangchen 2022). Furthermore, studies on ritual plant ethnobotany open opportunities for innovation in various fields, including the development of creative industries, cultural tourism, biodiversity conservation, education and research, local economic empowerment, and traditional healing (Quiroz et al. 2016; Rahayu et al. 2023).

However, does the research trend in ritual plant ethnobotany in Indonesia align with expectations? To answer this question, a bibliometric analysis might be useful as an initial step to uncover research patterns, trends, and unexplored knowledge gaps related to ethnobotany in Indonesia. The bibliometric approach provides a comprehensive overview of the most influential research contributions, scientific collaboration networks, and dominant topics within a specific field of study (Manterola et al. 2024; Sharma et al. 2024a). Bibliometric analysis serves not merely as a tool for tracking publication trends, but as a compass for understanding how knowledge about the intricate relationship between humans and plants evolves and gains recognition across the globe (Donthu et al. 2021). It enables researchers to trace intellectual trajectories, uncover underexplored themes, and foster cross-cultural and interdisciplinary collaborations (Ochsner 2021). Bibliometric studies help ensure that traditional knowledge, such as medicinal plant practices or the ritual use of flora, is not only documented but also valued within the global academic landscape. Beyond numbers and citations, bibliometrics in ethnobotany is an effort to preserve the collective human memory of nature, ensuring that this cultural and ecological legacy remains alive and relevant in addressing future challenges. Specifically, this bibliometric analysis aims to: (i) Map the publication trends of ethnobotanical studies in Indonesia, (ii) Identify the most productive journals related to ethnobotanical research in Indonesia, (iii) Identify the most productive affiliations involved in ethnobotanical research in Indonesia, (iv) Identify the most prolific authors contributing to ethnobotanical studies in Indonesia, (v) Identify the most productive countries in the field of ethnobotanical research in Indonesia, (vi) Map the most prominent subject areas within ethnobotanical studies in Indonesia, (vii) Identify

the most active funding sponsors supporting ethnobotanical research in Indonesia, (viii) Highlight the most influential scientific publications on ethnobotany in Indonesia, (ix) Map national and international author collaborations in ethnobotanical research in Indonesia, (x) Identify popular keywords and emerging topics related to ethnobotanical studies in Indonesia, (xi) Provide recommendations and insights to address knowledge gaps in future research.

MATERIALS AND METHODS

Study area

The primary study area of this bibliometric analysis encompasses all ethnobotanical studies conducted in Indonesia. All studies analyzed, whether conducted by Indonesian or international researchers, focus on the utilization of plants by local communities across various regions of Indonesia, ranging from western areas such as Sumatra and Kalimantan to eastern regions such as Maluku and Papua. For comparison, a global-scale ethnobotanical analysis was also conducted to contextualize the trends of ethnobotanical study in Indonesia within the broader international landscape.

Procedures

A bibliometric approach was employed to analyze scientific publications related to ethnobotany in Indonesia. This method was selected in alignment with the study's objective of identifying research trends, scientific collaborations, and popular topics (Donthu et al. 2021; Sharma et al. 2024b). We adopted the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 flow diagram in the data search strategy (Figure 1). Scientific publication data were retrieved from the Scopus database. The data search was conducted using relevant keywords, including ethnobotany, ethnobotanic, ethnobotanical, Indonesia, Indonesian, ritual, and rituals. Additionally, specific filters were applied, such as a 10-year time frame (2015-2025), and types of publications limited to journal articles, conference papers, and review papers (Table 1). The collected data were then exported in Comma-Separated Values (CSV) format for further analysis.

Table 1. Summary of data search strategy

Category	Criteria
Database	Scopus
Search query	((TITLE-ABS-KEY(ethnobotany OR ethnobotanic OR ethnobotanical) AND TITLE-ABS-KEY(indonesia OR indonesian)) AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE,"ar") OR LIMIT-TO (DOCTYPE,"cp") OR LIMIT-TO (DOCTYPE,"re")))
Year of publication	2015- March 2025
Documents type	Article, review, and conference paper
Study area	All study area
Data export format	Comma-Separated Values (CSV)

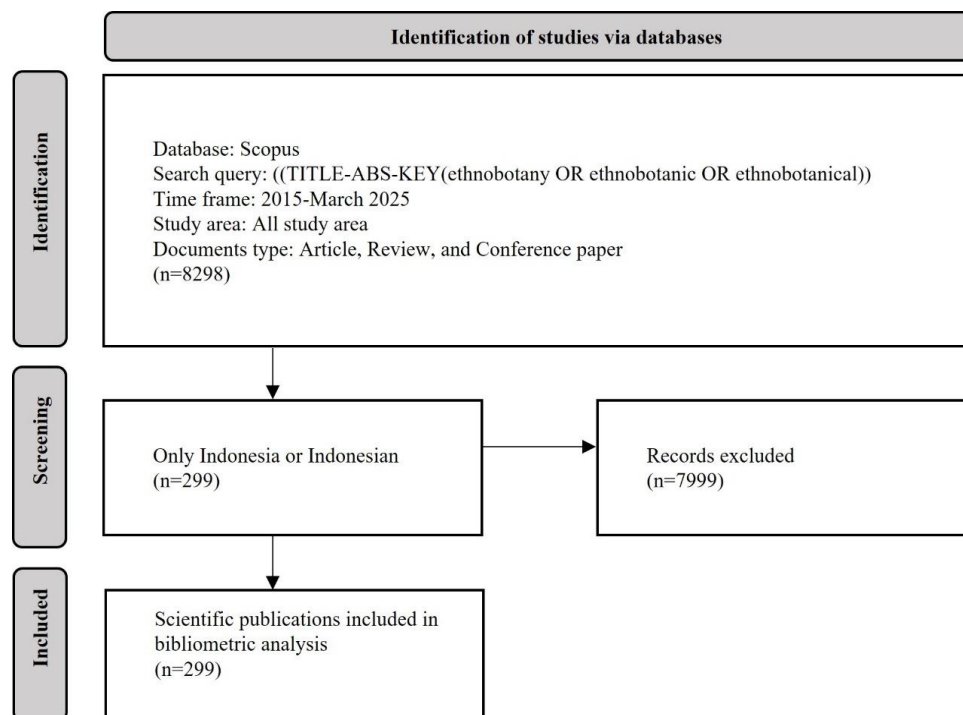


Figure 1. PRISMA flow diagram on the identification and screening of scientific publications

Table 2. Number of scientific publications on ethnobotany in the last decade

Year	Ethnobotany			
	Global	Global ritual	Indonesia	Indonesian ritual
2015	536	15	7	2
2016	571	24	12	1
2017	557	17	18	2
2018	581	15	20	1
2019	698	25	24	3
2020	903	25	38	4
2021	965	22	41	1
2022	983	35	28	2
2023	1095	25	49	3
2024	1179	36	57	5
2025	230	10	5	0
Total	8298	249	299	24
Average	754	23	29	2

Data analysis

The collected scientific publications were analyzed using several key parameters, including publication trends, most productive journals, leading affiliations, top contributing authors, most active research fields, funding sources, patterns of author collaboration, and commonly studied topics. These parameters were employed to identify gaps between research expectations and actual findings, providing a strategic foundation for shaping future directions in ethnobotanical research. The data were processed and analyzed using VOSviewer and Microsoft Excel. VOSviewer was applied to examine author collaboration networks and to visualize frequently occurring keywords. Microsoft Excel was used to organize data, generate tables and graphs, and perform initial data management prior to further analysis in VOSviewer.

RESULTS AND DISCUSSION

Trends in ethnobotany publications in Indonesia

In general, the number of scientific publications related to ethnobotany in Indonesia has shown an increasing trend over the past decade (Table 2; Figure 2). The average number of publications is 29 documents per year, with the highest number recorded in 2024, total 57 documents. However, publications on ritual ethnobotany in Indonesia have remained stagnant, with an average of only two documents per year. This number is significantly lower compared to global ethnobotany publications, which average 754 documents per year.

Most productive journals

The ten most productive journals and conferences publishing scientific research on ethnobotany in Indonesia over the past decade are presented in Figure 3. Two of these journals are classified as Quartile 1 (Q1) according to the Scimago Journal and Country Rank website. The two journals are Ethnobotany Research and Applications and the Journal of Ethnopharmacology. Biodiversitas (Q2) ranks first, with 102 documents. This is followed by IOP Conference Series: Earth and Environmental Science in second place with 29 documents. The third position is held by Ethnobotany Research and Applications with 16 documents.

Information on the most active journals plays a crucial role in mapping the development of scientific knowledge in specific fields such as ethnobotany. By recognizing the most productive journals, researchers can identify key sources frequently cited, understand emerging research trends, and select reputable journals that are most suitable for publishing their work. Moreover, this information is

valuable for fostering strategic scientific collaborations and enhancing the visibility of research outputs at both national and international levels.

Most productive affiliations

The ten most productive affiliations in scientific publications on ethnobotany in Indonesia over the past decade are presented in Figure 4. The National Research and Innovation Agency (Badan Riset dan Inovasi Nasional) ranks first, with 28 publications. The Indonesian Institute of Sciences (LIPI), which is now part of a Research Organization (RO) under the National Research and Innovation Agency (BRIN) ranks second with 26 publications. The third position is shared by Institut Pertanian Bogor and Universitas Padjadjaran, each contributing 24 publications.

This information plays a strategic role in advancing scientific development and fostering research collaboration. This data is useful for identifying leading research institutions in the field, serving as a reference for researchers seeking academic partnerships, pursuing further studies, or initiating joint research projects. Additionally, it aids funding agencies and policymakers in directing research support based on institutional productivity and impact. For students and early-career researchers, highly active affiliations can be an important consideration when selecting institutions for

academic training or professional growth. Furthermore, mapping institutional contributions can help reveal research gaps across regions or organizations, thereby encouraging more equitable development of research capacity in ethnobotany throughout Indonesia.

Most productive authors

The ten most productive authors in scientific publications on ethnobotany in Indonesia over the past decade are presented in Figure 5. Johan Iskandar ranks first, with 22 publications. The second and third positions are held by Marina Silalahi and Adi Bejo Suwardi, each contributing 15 publications.

This information holds strategic value in building a robust and sustainable research ecosystem. By identifying active researchers, we can recognize the individuals driving the advancement of knowledge in this field. This data not only serves as an academic reference but also opens opportunities for collaboration, idea exchange, and cross-generational learning among researchers. For students and early-career researchers, the works of highly productive authors can serve as a rich source of inspiration and learning, while also highlighting emerging research directions and trends. Thus, mapping the most active authors helps foster a more dynamic, interconnected scientific community that is focused on collective progress.

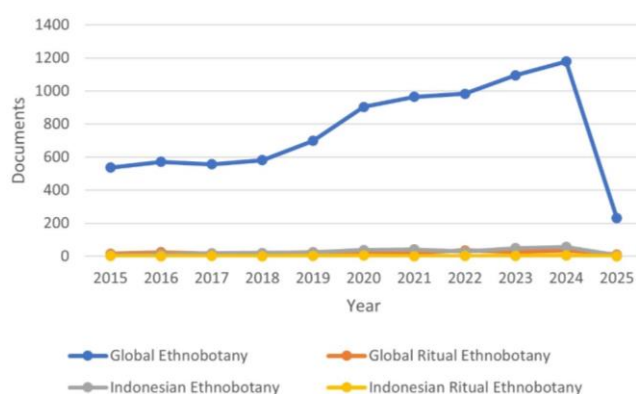


Figure 2. Trend of the number of scientific publications on ethnobotany in the last decade

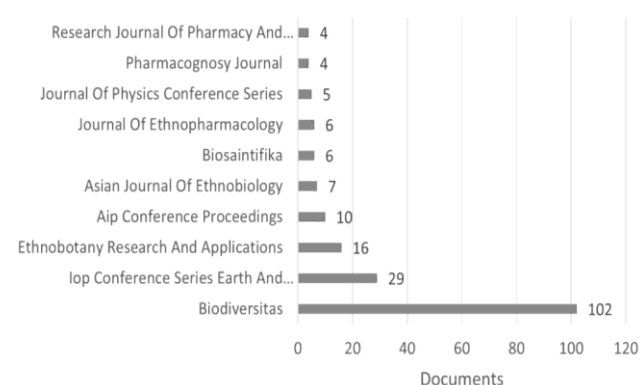


Figure 3. The most productive journals and conferences with scientific publications on ethnobotany in Indonesia in the last decade

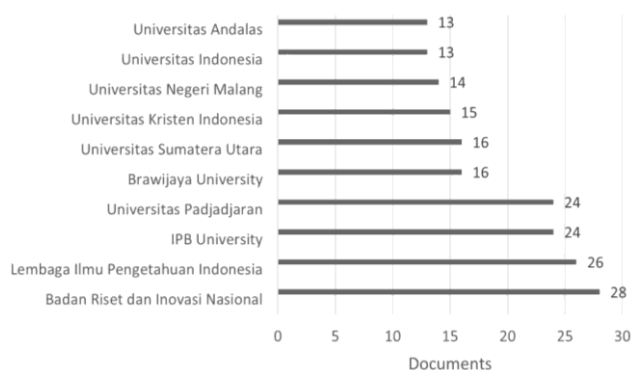


Figure 4. The most productive affiliations in scientific publications on ethnobotany in Indonesia in the last decade

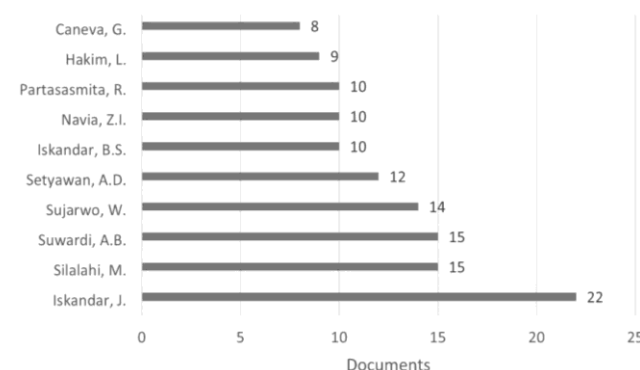


Figure 5. The most productive authors in scientific publications on ethnobotany in Indonesia in the last decade

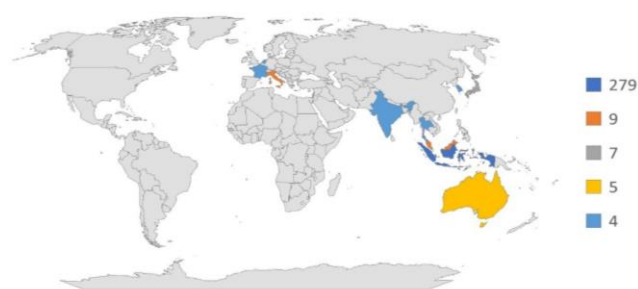


Figure 6. The ten most productive countries in ethnobotanical studies in Indonesia

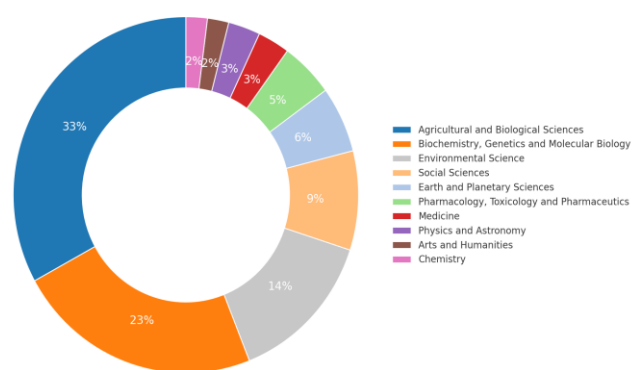


Figure 7. The most prevalent subject areas in scientific publications on ethnobotany in Indonesia in the last decade

Most productive countries

The distribution of the ten most productive countries in ethnobotanical studies in Indonesia is presented in Figure 6. Indonesia ranks first with 279 documents or 84.80%. It is followed by Italy and Malaysia, each with 9 documents or 2.74%. Japan ranks fourth with 7 documents or 2.13%, while Australia is in fifth place with 5 documents or 1.52%. The remaining countries-France, India, Netherlands, South Korea, and Thailand-each contributed 4 documents or 1.22%.

This information plays a crucial role in providing insights into the global dynamics of scientific development. This data allows us to identify leading countries in ethnobotanical study and compare research contributions across nations, which in turn can strengthen international collaborations. By recognizing the countries producing the most publications, we can assess the research strengths and identify areas that may require more attention. Additionally, this information is valuable for governments and funding agencies in shaping policies that support research and in more effectively allocating resources.

Most productive subject area

The ten most productive subject areas in scientific publications on ethnobotany in Indonesia over the past decade are presented in Figure 7. Agricultural and Biological Sciences ranks first, with 186 documents (33%).

Ethnobotanical studies are inherently multidisciplinary, involving various scientific disciplines. A multidisciplinary approach enables a broader and more holistic understanding of human-plant interactions.

This information provides valuable insights into the scope, direction, and interdisciplinary nature of research in ethnobotany. First, it helps identify the academic disciplines that contribute most significantly to ethnobotany. Second, it offers an overview of prevailing research focuses, such as medicinal plant conservation, traditional knowledge, or bioprospecting, which can serve as a reference for formulating research questions or selecting future study topics. Third, this information is useful for designing academic curricula, developing study programs, and establishing research centers aligned with academic and societal needs. Lastly, mapping the most productive subject areas enables greater synergy between disciplines to support the integrated and sustainable preservation of biodiversity and local wisdom.

Funding sponsor

The ten funding sponsors supporting scientific publications on ethnobotany in Indonesia over the past decade are presented in Figure 8. Universitas Padjadjaran ranks first, sponsoring ten documents. The Ministry of Research, Technology, and Higher Education of the Republic of Indonesia (Kementerian Riset Teknologi Dan Pendidikan Tinggi Republik Indonesia) ranks second, having funded nine publications. The third position is held by the Ministero dell'Istruzione, dell'Università e della Ricerca, which supported eight publications. In general, funding for ethnobotanical studies in Indonesia is primarily provided by government institutions through ministries and public universities.

This information plays a key role in guiding the sustainability and strategic direction of scientific inquiry in ethnobotanical studies. First, it allows for the identification of national and international institutions that actively support ethnobotanical studies. Second, this information serves as a practical reference for researchers seeking funding opportunities aligned with their research interests, while also helping them understand each sponsor's priorities and focus areas. Third, insights into funding patterns enable academic institutions and research centers to develop more targeted strategies that align with donor agendas. Furthermore, transparency in funding sources promotes accountability and reinforces ethical standards in scholarly publishing.

Most influential scientific publications

The ten most highly cited publications are presented in Table 3. The top position is held by Jadid et al. (2020) with a total of 102 citations, followed by Ansori et al. (2020) in second place with 96 citations. Rahmat et al. (2021) ranks third with 85 citations. This information highlights the most influential publications related to ethnobotanical research in Indonesia.

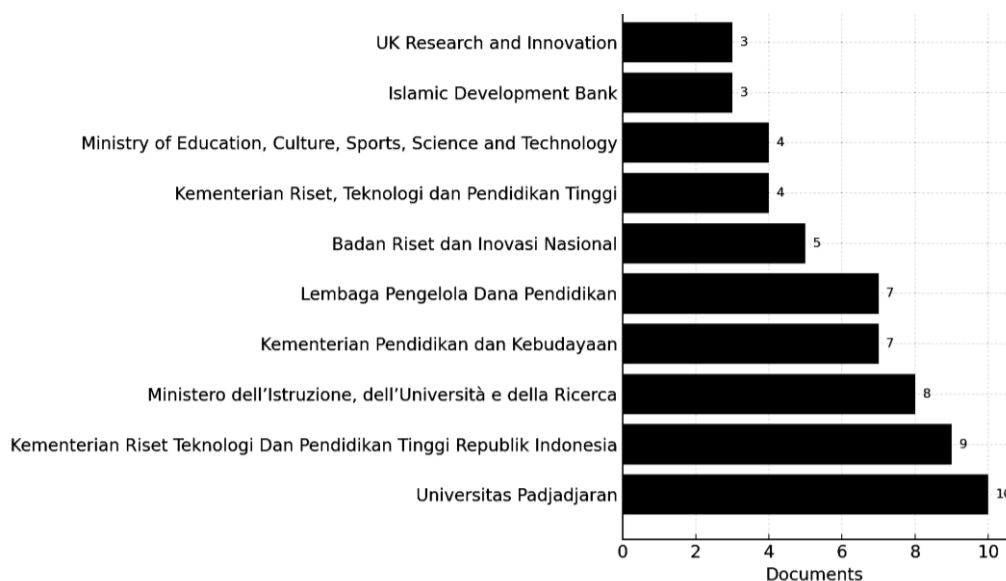


Figure 8. The funding sponsors in scientific publications on ethnobotany in Indonesia in the last decade

Table 3. The ten most influential publications on ethnobotany in Indonesia in the last decade

Rank	Author	Document title	Source	Total citations
1	Jadid et al. (2020)	An ethnobotanical study of medicinal plants used by the Tengger Tribe in Ngadisari Village, Indonesia	PLoS One	102
2	Ansori et al. (2020)	A review on medicinal properties of mangosteen (<i>Garcinia mangostana</i> L.)	Research Journal of Pharmacy and Technology	96
3	Rahmat et al. (2021)	Javanese turmeric (<i>Curcuma xanthorrhiza</i> Roxb.): Ethnobotany, phytochemistry, biotechnology, and pharmacological activities	Evidence-Based Complementary and Alternative Medicine	85
4	Silalahi et al. (2015)	The local knowledge of medicinal plants trader and diversity of medicinal plants in the Kabanjahe traditional market, North Sumatra, Indonesia	Journal of Ethnopharmacology	83
5	Sujarwo et al. (2015)	Ethnobotanical study of Loloh: Traditional herbal drinks from Bali (Indonesia)	Journal of Ethnopharmacology	78
6	Pawera et al. (2020)	Wild food plants and trends in their use: From knowledge and perceptions to drivers of change in West Sumatra, Indonesia	Foods	71
7	Suwardi et al. (2020)	Ethnobotany and conservation of indigenous edible fruit plants in South Aceh, Indonesia	Biodiversitas Journal of Biological Diversity	63
8	Sujarwo et al. (2016)	Ethnobotanical uses of neem (<i>Azadirachta indica</i> A.Juss.; Meliaceae) leaves in Bali (Indonesia) and the Indian subcontinent in relation with historical background and phytochemical properties	Journal of Ethnopharmacology	57
9	Supiandi et al. (2019)	Ethnobotany of traditional medicinal plants used by Dayak Desa Community in Sintang, West Kalimantan, Indonesia	Biodiversitas Journal of Biological Diversity	55
10	Silalahi and Nisyawati (2018)	The ethnobotanical study of edible and medicinal plants in the home garden of Batak Karo Sub-ethnic in North Sumatra, Indonesia	Biodiversitas Journal of Biological Diversity	50
Total				740
Average				74

This information is essential for understanding the core contributions that have shaped the field. Highly cited works often represent foundational studies or critical shifts in theoretical frameworks, methodologies, or empirical findings. For researchers, these publications serve as key references that provide a strong basis for developing well-informed research questions and frameworks. Additionally, identifying

high-impact publications helps scholars recognize prevailing trends and directions in the discipline, enabling them to align their work with current scientific discourse. Such influential studies also foster interdisciplinary dialogue and broaden perspectives on issues related to traditional knowledge, biodiversity conservation, and sustainability at both local and global levels.

National and international author collaboration

The results of the author collaboration network analysis using VOSviewer are presented in Figure 9. National collaborations among authors tend to occur within the same institution. Among the six author clusters, only two clusters

exhibit cross-collaboration. On the other hand, international author collaboration remains limited. The countries most frequently collaborating with Indonesian researchers include Japan, Australia, Italy, and Malaysia (Figure 10).

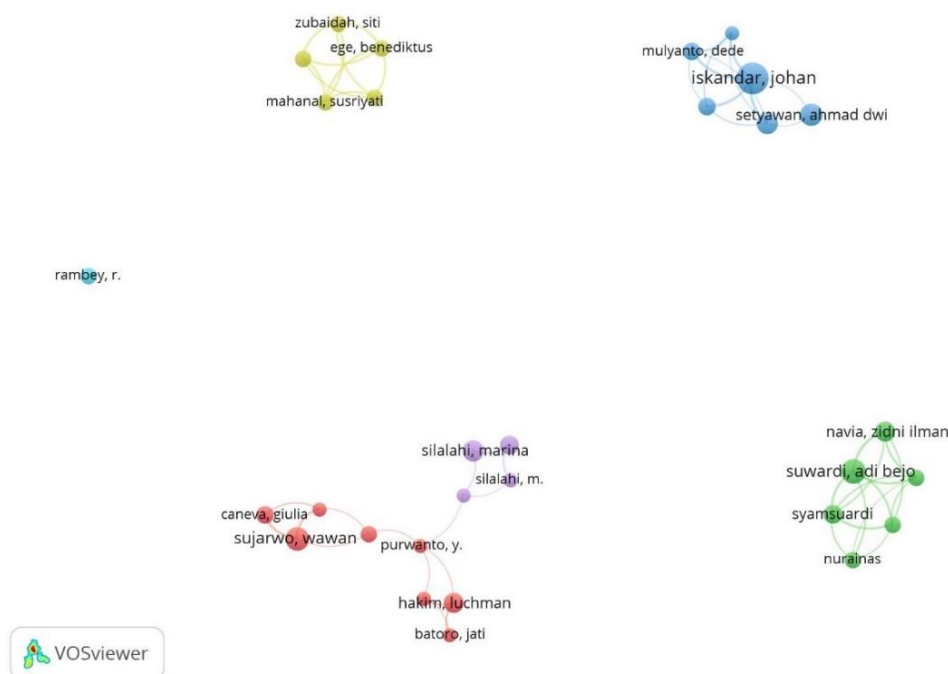


Figure 9. Diagram of collaboration among authors in publications on ethnobotany in Indonesia in the last decade

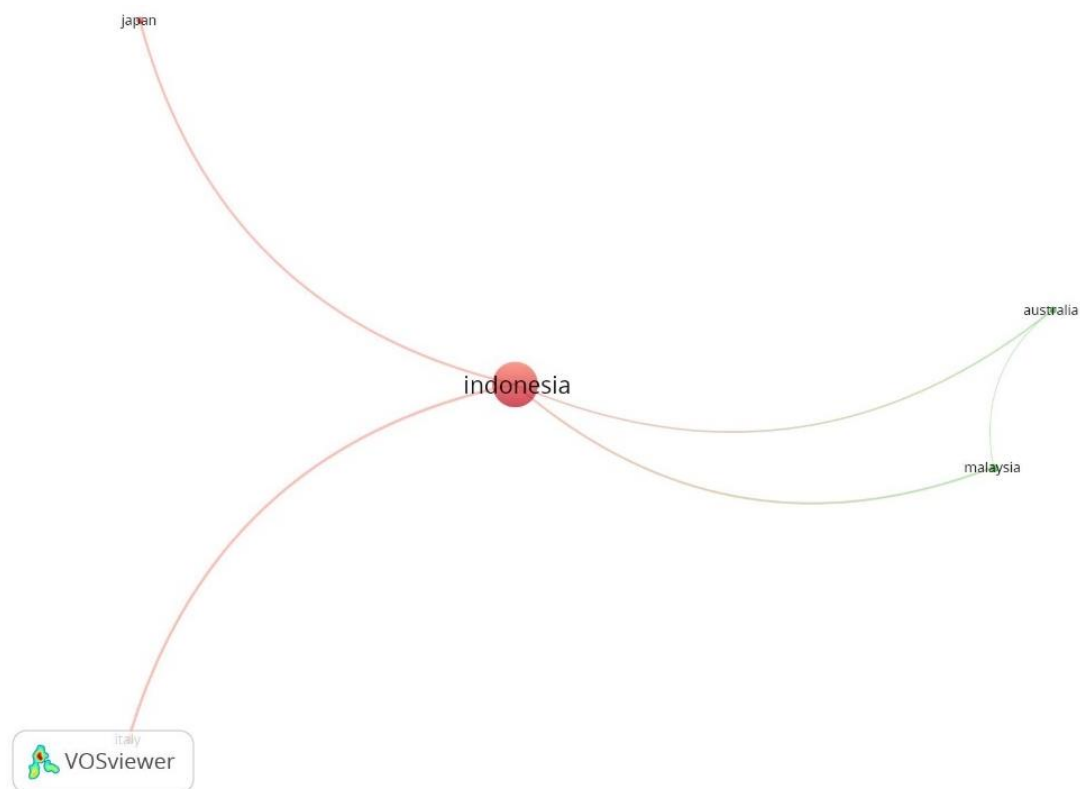


Figure 10. Diagram of collaboration among countries in publications on ethnobotany in Indonesia in the last decade

Keyword analysis and popular topics

The results of keyword analysis using VOSviewer are presented in Figures 11, 12, and 13. Based on the Network Visualization diagram, ethnobotanical research in Indonesia is categorized into three main clusters: ethnoculture, ethnomedicine, and ethnochemistry. The Overlay Visualization diagram indicates that the latest research

topics in Indonesian ethnobotany focus on medicinal plants and local wisdom conservation. Furthermore, according to the Density Visualization diagram, the most extensively studied topic in Indonesian ethnobotany is medicinal plants, as reflected by dominant keywords such as medicinal plants, ethnopharmacology, and traditional medicine.

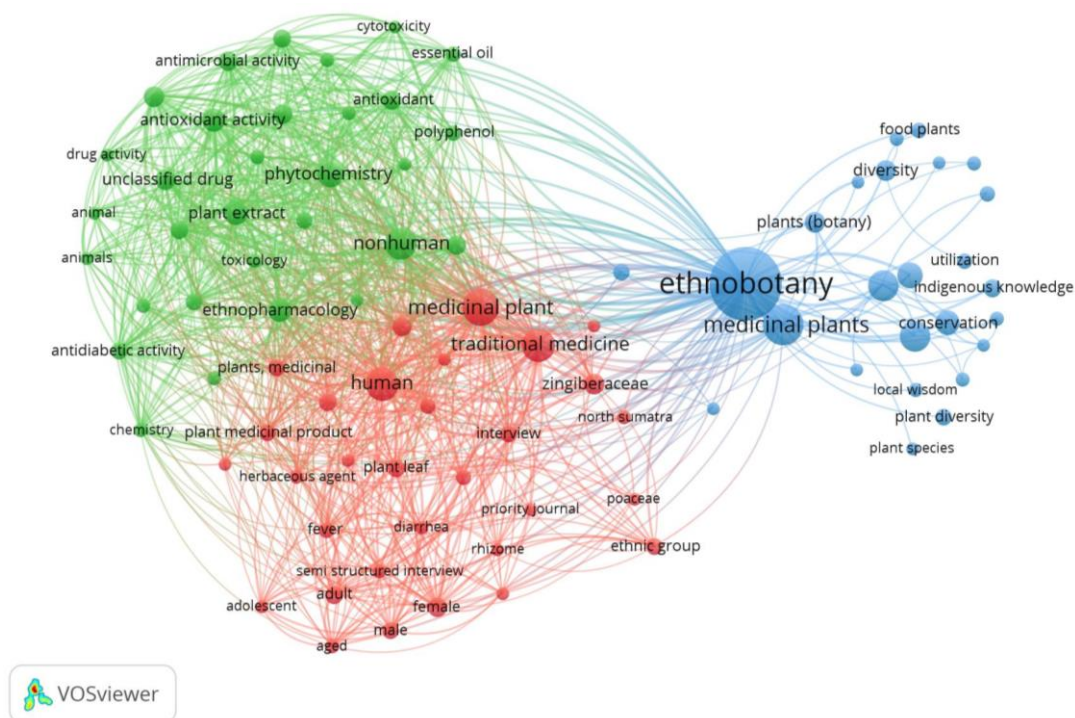


Figure 11. Network visualization of ethnobotanical publications in Indonesia in the last decade

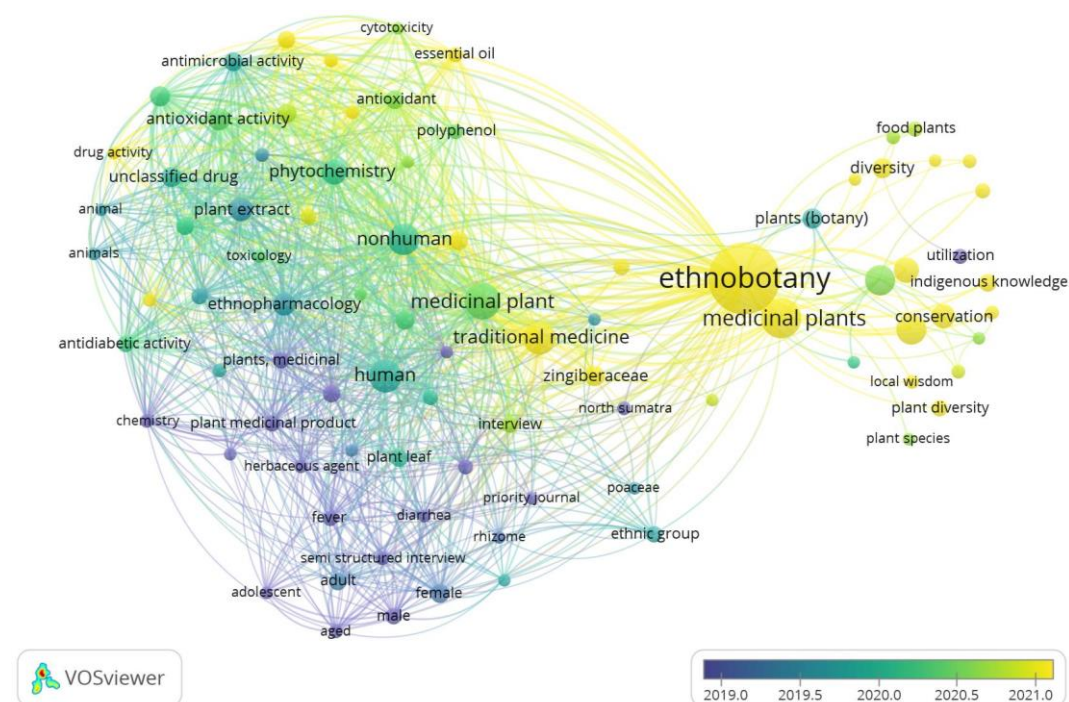


Figure 12. Overlay visualization of ethnobotanical publications in Indonesia in the last decade

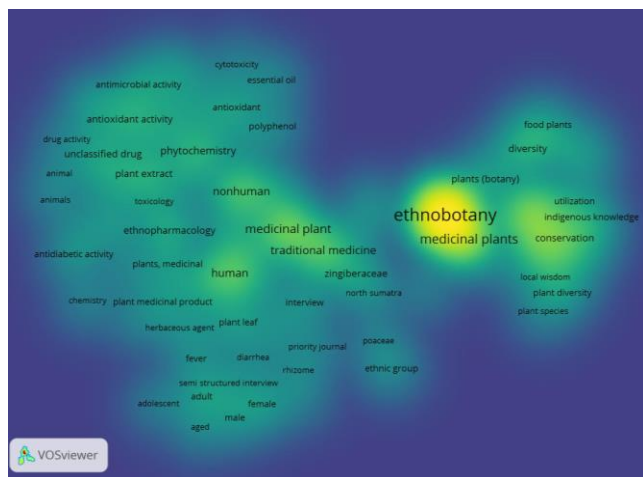


Figure 13. Density visualization of ethnobotanical publications in Indonesia in the last decade

Discussion

The gap in ethnobotanical studies on ritual plants

Research publications on ritual ethnobotany in Indonesia have remained stagnant over the past decade, with an average of only two documents per year. Ethnobotanical studies on medicinal plants are significantly more popular than those on ritual plants, both in Indonesia and globally (Sharma et al. 2024c; Vats et al. 2024). Several factors contribute to this gap. Medicinal plants are widely accepted due to their therapeutic applications, whereas ritual plants are often linked to specific local beliefs, making their use less universally applicable (Staub et al. 2011; Dafni et al. 2020). Some ritual plants are considered sacred, leading to restricted access (Fatur 2020; Tatay and Merino 2023). Additionally, traditional medicinal plants can be developed into modern pharmaceuticals with high economic value (Chotchoongchatchai et al. 2012; Sarin et al. 2014), increasing the likelihood of funding and research proposal acceptance. This disparity also occurs on a global scale. The total number of scientific publications on the ethnobotany of ritual plants in the past decade is only 249 documents, averaging 23 documents per year. This number is significantly lower compared to studies on the ethnobotany of medicinal plants.

This gap poses a dilemma for a biodiversity and culturally-rich country like Indonesia. If this trend continues, it could threaten the preservation of local wisdom related to ritual plants. To address this issue, global-scale research on Indonesia's ritual ethnobotany must be strengthened. This can be achieved through enhanced international collaboration, digital and AI-based technology utilization, interdisciplinary approaches, increased funding support, and sustainable conservation policies (Chaachouaya et al. 2023; Chitakunye et al. 2023; Duche-Pérez et al. 2024).

The challenges in increasing the number of ethnobotanical publications focused on ritual plants in Indonesia are complex and multidimensional. One of the main barriers is the limited documentation of local knowledge, as much of the ritual practices are passed down orally and considered sacred by indigenous communities, making them difficult

for researchers to access (Ritonga et al. 2023). Additionally, ethical issues and cultural sensitivities present significant challenges, as research interventions that are not carried out carefully can be seen as violations of traditional values. Furthermore, there is a shortage of researchers with interdisciplinary expertise, particularly in the combination of botany, anthropology, and ethnography, which results in a lack of studies that can bridge the scientific understanding with the spiritual or symbolic meaning of plant use in rituals (Fatur 2024).

In addition, limitations in funding, access to remote communities, and bureaucratic hurdles in obtaining research permits in indigenous areas also pose obstacles (Magsayo et al. 2024). The absence of a national platform specifically promoting research on ritual plants makes this area less exposed compared to other ethnobotanical subfields, such as medicinal or food plants. Other challenges include limited collaboration among institutions with relevant expertise and field data, as well as suboptimal publication in high-impact international journals due to language barriers and academic writing standards. To overcome these challenges, a collaborative and participatory approach involving local communities as research partners is needed, along with policy support and sustainable funding for research based on local wisdom (Aspan et al. 2023; Lestari et al. 2023).

The approach to studying the ethnobotany of ritual plants needs to shift from an ethnocultural perspective to an ethnoscientific one (Eldeen et al. 2016; Putra 2021). In general, existing studies on the ethnobotany of ritual plants have primarily examined ethnobotanical data from an ethnocultural standpoint, focusing on aspects such as philosophical values, usage, and plant parts utilized. These studies need to be expanded to include perspectives that are more universally accepted. For example, research could explore the phytochemistry of ritual plants, their potential as medicinal plants, their applications as natural fertilizers or pesticides, their role in ethnotourism, their market potential in ethnobotanical commerce, and conservation programs based on local wisdom. By broadening the scope in this manner, the study of the ethnobotany of ritual plants would no longer appear exclusive to specific ethnic or religious groups.

The gap in author collaboration

Indonesia ranks second in the world for biodiversity, following Brazil (Nugroho et al. 2023). This signifies that Indonesia should ideally be a global center for ethnobotanical research (Wilson et al. 2016). However, based on the authors' data regarding authorship, affiliations, countries, and sponsorships, it is evident that Indonesia has largely dominated ethnobotanical studies conducted within the country over the past decade. Collaboration among authors and between countries remains suboptimal, with research predominantly involving institutions within Indonesia. This dominance limits the global visibility and recognition of Indonesia's ethnobotanical research. Therefore, enhancing international collaboration is essential.

Ethnobotanical research collaboration within Indonesia continues to face significant challenges, primarily due to

disparities in infrastructure, resource access, and academic networking across local institutions (Purwaningrum 2016; Ghozi et al. 2023; Harsanto and Wahyuningrat 2024). Many universities and research centers in remote or underdeveloped areas lack sufficient laboratory facilities, digital tools, and skilled human resources, which hinders their ability to engage in collaborative research efforts. Additionally, inter-institutional collaboration is often constrained by bureaucratic procedures, uneven research funding distribution, and the absence of a cohesive national framework that facilitates researcher connectivity. These obstacles not only slow the advancement of ethnobotanical science but also lead to fragmented documentation and understanding of Indonesia's extensive traditional plant knowledge, knowledge that would benefit from integrated, interdisciplinary efforts across regions.

On the international level, collaborations between Indonesian researchers and global partners often encounter additional structural and ethical challenges (Prihatin 2016; White-Jones 2022; Abigail et al. 2023). Despite increasing global interest in Indonesia's biodiversity and indigenous knowledge systems, such collaborations can sometimes be imbalanced, with foreign institutions setting research priorities and leading project directions. Differences in research goals, institutional expectations, and funding structures may hinder equal partnership. Furthermore, language barriers, administrative hurdles in research permitting, and concerns surrounding intellectual property rights often complicate cross-border cooperation. To promote more equitable and impactful global collaboration, there is a pressing need for transparent agreements, co-ownership of research outcomes, and recognition of local expertise and cultural context. Strengthening these aspects will support the development of fair, respectful, and mutually beneficial scientific partnerships.

Improving collaboration can begin by fostering connections among researchers through conferences, discussion forums, and global academic networks (Osiek et al. 2009; Eberle et al. 2017). Funding opportunities should also be expanded beyond national sources to include international organizations such as UNESCO and collaborative research grants. The adoption of digital technology is crucial to facilitating efficient data exchange and communication via online platforms. Additionally, researcher exchange programs should be strengthened to deepen understanding of local knowledge across different regions. Furthermore, publishing in high-impact international journals and adopting a multidisciplinary approach integrating ethnobotany with phytochemistry, ecology, or economics can enhance the global relevance of ethnobotanical research.

The gaps in digital documentation

Keyword analysis using VOSviewer revealed no significant keywords related to internet-based digital documentation. In general, ethnobotanical data collection methods primarily involve interviews, field explorations, and literature reviews. The collected data is typically recorded in the form of tables, graphs, and photographs. However, these methods indicate that data is collected but not necessarily digitized in a centralized, easily accessible

manner. Analog ethnobotanical data presents several limitations, such as storage constraints, difficulties in data access, susceptibility to damage or loss due to environmental factors, unattractive presentation, and inefficient and ineffective information analysis. If this trend continues, local wisdom related to ritual plants in Indonesia may be forgotten and lost. Therefore, digitalization must be implemented immediately. This can be achieved through: website development, mobile applications, social media utilization, and plant distribution mapping using Geographic Information System (GIS) or Google MyMaps (do Nascimento Fernandes de Souza and Hawkins 2020; Chitakunye et al. 2023).

One of the most pressing challenges in the digital documentation of ethnobotanical knowledge lies in the fact that much of the information regarding plant use among Indonesia's Indigenous communities remains oral, deeply embedded in tradition, language, and spiritual practice (Rinto et al. 2023). Field-based studies have shown that this knowledge is rapidly disappearing, driven by a decline in native language use and the shifting lifestyles of younger generations. The situation is further complicated by limited digital infrastructure in remote regions, where internet access, data storage tools, and digitally literate human resources are often scarce (Chitakunye et al. 2023). Ethical concerns also play a significant role, particularly regarding questions of data ownership, appropriate use, and the potential exploitation of knowledge that is sacred or collectively held (Maroyi 2020). Moreover, the absence of national standards for ethnobotanical documentation results in fragmented datasets that are often inaccessible, even to local researchers (Pirintsos et al. 2016).

Despite these challenges, promising solutions are emerging. One of the most effective approaches is the development of participatory digital documentation ecosystems, in which local communities are not merely subjects of study but active agents in recording and managing their own knowledge (Böhlen and Sujarwo 2020). This approach has been piloted in several community-based projects using low-tech tools such as offline mobile apps that enable voice and image-based recording in native languages. Equally important is the design of data storage systems that respect collective rights, using mechanisms like community-based access protocols or customary licensing models. Strengthening collaboration among researchers, technologists, government institutions, and Indigenous communities must be supported by national policies that prioritize the safeguarding of traditional knowledge. In this way, digitalization becomes not only a tool for preservation but also a means of empowerment and recognition for the rich, often hidden, knowledge systems rooted in Indonesia's forests, fields, and cultural rituals.

The role of the education system

Based on the most productive subject areas, it can be concluded that ethnobotanical conservation in Indonesia tends to adopt an ecological approach. This approach needs to be balanced with a socio-cultural approach, for example, through the education system. Education plays a crucial role in preserving local ethnobotanical wisdom by transferring

knowledge to younger generations (Arjaya et al. 2024; Pearnpitak et al. 2024; Marsandi et al. 2025). One of the key disciplines in this effort is biology education. Ethnobotanical themes and values can be integrated into the biology curriculum through two main approaches: intradisciplinary and interdisciplinary. The intradisciplinary approach can be implemented by integrating ethnobotanical themes and values into all biology courses, including genetics, morphology, taxonomy, and ecology. Meanwhile, the interdisciplinary approach involves incorporating ethnobotanical themes and values into various fields of study (Slikkerveer and Gellaerts 2024). Integration of ethnobotanical themes into various fields of study can be implemented through project-based assignments, such as the ethno-market project in economics, the ethno-tourism project in tourism studies, the ethno-policy project in law, and the ethno-cultural heritage project in cultural studies. Integrating ethnobotany into project-based learning provides an interdisciplinary learning experience, connecting students with traditional knowledge and cultural practices related to plant use (Salick 2014; Ramakrishna et al. 2020). This not only enhances learning engagement but also actively contributes to the preservation of local wisdom.

The integration of ethnobotany into primary and secondary school education holds tremendous potential for fostering ecological awareness, cultural understanding, and a strong sense of local identity among students from an early age (Rebello and De Meirelles 2022). However, to avoid falling into rigid, uniform teaching models, more human-centered, contextual, and original approaches are needed. One effective method is the “Ancestral Plant Traces” project, where students investigate the historical use of specific plants within their own families. For instance, they may interview grandparents about the plants used in the past for medicine, food, or rituals, and document these stories through personal narratives enriched with drawings or photographs. This technique not only integrates language and art skills, but also strengthens intergenerational bonds and cultivates pride in cultural heritage.

Data from community-based education initiatives in regions such as South Sulawesi and Central Kalimantan show that students involved in ethnobotany-based learning demonstrated up to a 35% increase in learning motivation, particularly in science and language subjects (Usman et al. 2024). Another underutilized yet impactful technique is the “Schoolyard Plant Safari,” in which students explore their surroundings to identify local or wild plants, investigate their uses through local knowledge and interviews, and present their findings via school podcasts or mini-exhibitions. Rather than treating planting activities as mere assignments, this approach invites students to engage with the deeper meanings and socio-cultural connections of plants in their environment. These techniques are not only original and impactful but also position schools as dynamic spaces for preserving and revitalizing local ecological knowledge in meaningful and innovative ways (Azevedo et al. 2022; Serrano-Jiménez et al. 2025).

Based on the analysis results, several key conclusions can be drawn. First, the trend of scientific publications on

ritual plant ethnobotany in Indonesia over the past decade has remained minimal and stagnant, with medicinal plant ethnobotany continuing to dominate the field. Second, the digitalization of ethnobotanical data remains underdeveloped, limiting access, preservation, and dissemination of knowledge.

To elevate the prominence of ritual plant studies, it is essential to foster stronger global collaboration, increase funding support, and implement sustainable conservation policies. Digitalization efforts should include the development of dedicated websites, mobile applications, social media engagement, and plant distribution mapping using Geographic Information System (GIS) tools or platforms such as Google MyMaps. Furthermore, the education system must contribute by reimagining the integration of ethnobotanical themes and values through both intradisciplinary and interdisciplinary approaches, ensuring the preservation and advancement of local knowledge in a modern context.

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