

Identifying Research Gap in the Digitalization of Ethnobiology for Science Education: A Systematic Literature Review and Bibliometric Mapping

Ahmad Aris Arifin^{1*}, Agus Ramdani^{1,2}, A. Wahab Jufri^{1,2}, Satutik Rahayu³

¹Doctoral Program in Science Education, Postgraduate Program, University of Mataram, West Nusa Tenggara, Indonesia

²Biology Education Study Program, FKIP, University of Mataram, West Nusa Tenggara, Indonesia

³Physics Education Study Program, FKIP, University of Mataram, West Nusa Tenggara, Indonesia

*Corresponding author e-mail: ahmadarisarifin01@gmail.com

Accepted: May 22nd 2026, Approved: May 23rd 2026, Published: May 26th 2026

Abstract— *The Sasak, Samawa, and Mbojo (Sasambo) communities in West Nusa Tenggara, Indonesia, possess rich biocultural knowledge that is closely related to ethnobiological studies. However, the rapid global development of ethnobiology research has not been accompanied by adequate digital approaches for organizing, disseminating, and utilizing ethnobiological knowledge in science education. This study aims to identify the research gap in ethnobiology digitalization for science education through bibliometric mapping and a systematic literature review (SLR). Bibliometric data were retrieved from the Dimensions AI database using the keyword ethnobiology in publication titles and abstracts, resulting in 1,094 documents published between 1937 and 2025. The data were analyzed using VOSviewer to map publication trends, term networks, and thematic structures in global ethnobiology research. The extraction process identified 3,187 terms, which were filtered to 148 based on occurrence thresholds and further refined to 82 representative terms. The SLR stage followed the PRISMA framework and synthesized 30 Scopus-indexed journal articles relevant to ethnobiology, digitalization, and science education. The findings indicate that ethnobiology research is still dominated by themes related to biodiversity, traditional knowledge, local communities, and health, while educational studies mainly emphasize pedagogical integration and digitalization studies focus on preservation and access. Their intersection in the form of digitally structured ethnobiology resources for science education remains underexplored. These results confirm a clear research gap and provide a conceptual basis for future initiatives, including the possible development of the Ethnobiology-SASAMBO Digital Portal.*

Keywords— Ethnobiology Digitalization, Science Education, Research Gap, Systematic Literature Review, Bibliometric Mapping.
How to Cite— Arifin, A.A., Ramdani, A., Jufri, A.W., & Rahayu, S. (2026). Identifying Research Gap in the Digitalization of Ethnobiology for Science Education: A Systematic Literature Review and Bibliometric Mapping. *International Journal of Contextual Science Education*, 4(2), 47-65. <https://doi.org/10.29303/ijcse.v4i2.1591>

1. Introduction

Ethnobiology is an interdisciplinary field that examines the complex relationships among humans, living organisms, and the environment within local cultural contexts, including knowledge systems, resource-use practices, and traditional biotic classifications that develop in communities [1]. Ethnobiological studies play an important role in supporting biodiversity conservation, as traditional ecological knowledge has been shown to contribute to the sustainability of natural resource management [2] [3]. In more recent developments, ethnobiology has also been positioned as a bridge between modern science and local wisdom in responding to global environmental crises and as a foundation for the development of culture-based education. Thus, this field is not only descriptive but also transformative in the context of sustainable development [4].

Over the past few decades, ethnobiology has experienced rapid growth in line with increasing global recognition of the importance of local and Indigenous knowledge in understanding human–environment relationships. Contemporary studies emphasize that ethnobiological knowledge is not merely a record of traditional practices, but a dynamic system that reflects ecological adaptation, cultural identity, and biocultural resilience [5] [6]. Ethnobiology also plays a critical role in bridging local knowledge with modern science while strengthening the human–nature relationship within a framework of cultural sustainability [7] [8]. In science education, the integration of Indigenous and local knowledge is increasingly recognized as an approach that can

make science learning more relevant, contextual, and meaningful for students. The use of learning resources based on Indigenous knowledge enables students to understand science through experiences and local wisdom that are closely connected to their daily lives. This integration not only enriches learning content, but also serves as a means of preserving local values that reflect a harmonious relationship between humans and nature. Ethnobiology-based learning has been shown to foster positive attitudes toward science, enhance cultural awareness, and support the development of scientific identity rooted in local values [9] [10] [11].

At the same time, the development of information technology has created a new paradigm for the preservation, management, and utilization of local knowledge. The digitalization of cultural knowledge enables data that were previously preserved only through oral traditions or scattered records to be archived, organized, and accessed systematically across generations [12] [13]. Emphasizes the importance of digital transformation as a key instrument for safeguarding local knowledge threatened by modernization and cultural homogenization [14]. In this context, digitalization is not merely an effort of documentation, but a strategic approach to ensuring that such knowledge remains alive, reusable, and functional within contemporary scientific, cultural, and educational contexts [15] [16]. This is highly relevant to science education, as digital learning environments increasingly influence access to learning resources, knowledge organization, and student engagement [17] [18].

In Indonesia, various cultural repositories and digital initiatives have been developed to preserve cultural heritage. However, many cultural digitalization initiatives in Indonesia, such as Data Pokok Kebudayaan (DAPOBUD) and Perpustakaan Digital Budaya Indonesia (PDBI) [19] [20], still tend to be descriptive and oriented toward passive preservation because the available information remains at the level of documentation. Both platforms have not yet provided pedagogical reconstruction that allows direct integration into learning, and therefore cannot be optimally utilized as learning resources. In the context of ethnobiology for science education, this condition indicates that the digitalization of cultural knowledge has not been fully directed toward educational, contextual, and instructionally relevant knowledge organization. As a result, ethnobiological knowledge rich in scientific and biocultural value is still rarely available in the form of structured digital learning resources ready for use in science education.

At the global level, platforms such as D-PLACE (*Database of Places, Language, Culture, and Environment*), developed by Kirby demonstrate how cultural, linguistic, ecological, and geographic information can be systematically connected for comparative analysis [21]. Such initiatives are important because they show that digital platforms can move beyond static storage toward broader knowledge organization and accessibility. However, in the context of ethnobiology for science education, significant limitations remain. Much of the available information is still presented at the level of documentation and preservation, with limited pedagogical reconstruction for learning purposes. Moreover, the existing literature has not yet clearly shown how ethnobiological knowledge can be digitally organized, educationally reconstructed, and presented as a contextual science learning resource. This gap becomes even more apparent in the context of the Sasambo communities, whose ethnobiological knowledge is rich in biocultural value but is still underrepresented in structured digital learning resources.

From the perspective of science education, this issue is not merely a matter of technological availability, but also of conceptual and pedagogical alignment. A digital ethnobiology learning resource will only be meaningful when local knowledge is not positioned as passive cultural information, but rather as knowledge that can be educationally reconstructed into learning material that is relevant, contextual, and scientifically meaningful. Therefore, the main issue of this study is not immediately whether a digital portal needs to be developed, but whether the existing body of research has sufficiently addressed the digitalization of ethnobiology as a resource for science education. This is where the main research gap lies: although ethnobiology, Indigenous knowledge, and digital transformation have each developed as important fields of scholarship, their intersection in the form of structured digital ethnobiology resources for science education remains relatively underexplored.

Based on this context, this study is designed to identify the research gap in the digitalization of ethnobiology for science education through a systematic literature review and bibliometric mapping. Rather than beginning from the assumption that a digital portal is definitely needed, this study first examines global publication trends, thematic patterns, and the extent to which digitalization has been integrated into ethnobiology research relevant to education. By identifying what has been studied, what remains overlooked, and how ethnobiological knowledge has been positioned in digital and educational contexts, this study seeks to provide a clearer conceptual and empirical basis for further development. Therefore, the findings of this study are expected to provide a scientific rationale for discussing the possible development of the Ethnobiology-SASAMBO Digital Portal as a follow-up response to the identified gap, rather than as the initial premise of the study.

2. Method

This study employed a mixed-review design combining bibliometric mapping and a systematic literature review (SLR) to identify research gaps in ethnobiology digitalization for science education. This approach was selected to provide both a quantitative overview of global ethnobiology research trends and a qualitative synthesis of studies relevant to the intersection of ethnobiology, digitalization, and science education.

The bibliometric data were obtained from the Dimensions AI database. The search was conducted using the keyword *ethnobiology*, limited to publication titles and abstracts to ensure the relevance of the retrieved documents. The publication period covered 1937–2025, resulting in 1,094 scientific publications. All retrieved data were exported in CSV format and analyzed using VOSviewer. The bibliometric analysis focused on publication trends, document types, author collaboration, and term co-occurrence patterns to map the thematic structure of global ethnobiology research. The initial extraction process identified 3,187 terms. These terms were then filtered using an occurrence threshold, resulting in 148 terms that met the minimum frequency criteria. A further relevance-based filtering process yielded 82 representative terms, which were used to generate network, density, and overlay visualizations. This analysis was intended to identify major research clusters and to examine the extent to which themes related to digitalization and science education appeared in the ethnobiology literature.

The SLR stage was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, including identification, screening, eligibility, and inclusion stages. The literature search was carried out through Dimensions AI using the keywords *ethnobiology* and *digital portal*, followed by relevance screening based on the focus of the study. The inclusion criteria comprised journal articles indexed in Scopus, full-text availability, relevance to ethnobiology, digitalization, or science education, and explicit discussion of local or Indigenous knowledge, digital platforms, learning resources, or knowledge organization. Articles that did not meet these criteria, were not indexed in Scopus, or were not sufficiently relevant to the purpose of the study were excluded. Based on this process, 30 Scopus-indexed journal articles were selected for in-depth review.

The selected articles were analyzed thematically to identify major patterns across the reviewed studies. The analysis focused on three interconnected domains: (1) ethnobiology and local or Indigenous knowledge, (2) digitalization and knowledge management, and (3) science education and contextual learning resources. Through this thematic synthesis, the study examined how previous research has addressed each of these domains and to what extent their intersection has been explored. Meanwhile, the bibliometric findings were used to contextualize the broader development of ethnobiology research at the global level. The results of both analyses were then integrated to identify the research gap, particularly the limited development of digitally structured ethnobiology resources for science education. This integrated analysis also provided a conceptual basis for considering future initiatives, including the possible development of the Ethnobiology-SASAMBO Digital Portal.

3. Result and Discussion

The results are presented clearly and concisely in accordance with the main objective of this study, namely to identify the research gap in the digitalization of ethnobiology for science education. This Results and Discussion section is organized using two main approaches: bibliometric mapping and a systematic literature review (SLR). Bibliometric analysis based on data retrieved from Dimensions AI is used to map publication trends, document types, and the global development of ethnobiology research, while the SLR is employed to examine in greater depth the thematic characteristics, research directions, patterns of knowledge dissemination, and the extent to which digitalization has been integrated into ethnobiological studies with relevance to education. The findings from these two approaches are then integrated to identify research patterns, underexplored themes, and gaps in the digitalization of ethnobiology, particularly in relation to its function as a contextual resource for science education. Thus, this discussion not only presents quantitative patterns of research development but also provides a conceptual and empirical basis for understanding the current state of the field and for considering future initiatives, including the possible development of a digital Ethnobiology–SASAMBO portal as a follow-up response to the identified gap.

Global Trends in Ethnobiology Research

The dynamics of scientific publications using the keyword *ethnobiology* in titles and abstracts during the period 1937–2025 illustrate how the development of ethnobiological studies has progressed gradually over time. The data retrieved from Dimensions AI provide an overview of the early phase of growth, which was still very limited, up to the period when research productivity increased significantly, particularly in the last decade. The year-to-year pattern of changes in the number of publications serves as an initial basis for examining the direction of growth, research intensity, and the stability of ethnobiology's development as a global scientific discipline.

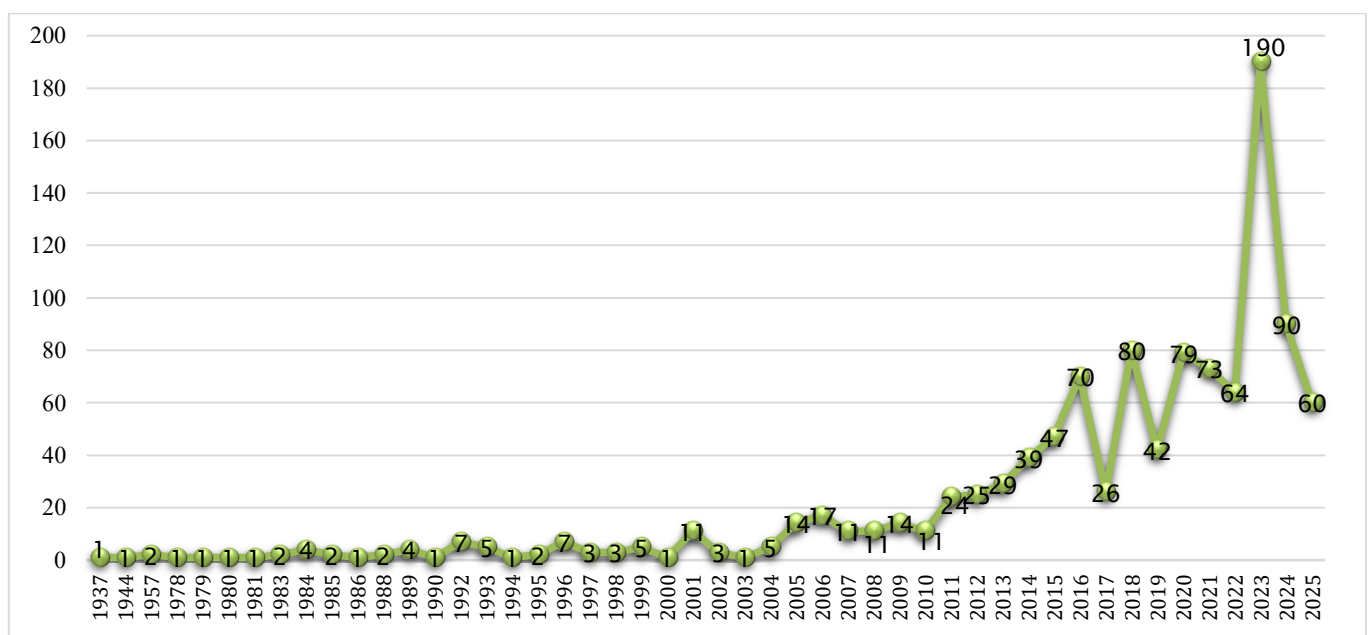


Figure 1. Publication Dynamics Using the Keyword *Ethnobiology* Based on Title and Abstract for the Period 1937–2025 (Data Source: Dimensions AI)

Based on the search results obtained from Dimensions AI using the keyword *ethnobiology* limited to titles and abstracts, a total of 1,094 documents were identified for the period 1937–2025. The curve presented represents the last 10 years (2016–2025) and shows a fluctuating dynamic with an overall upward trend. In 2016, 70 publications were recorded, followed by a sharp decline in 2017 to 26 publications. However, the number increased significantly in 2018 to 80 publications. In 2019, the output declined again to 42 publications, then rose in 2020 to 79 publications, followed by a slight decrease in 2021 (73 publications) and 2022 (64 publications). The most pronounced surge occurred in 2023 with 190 publications, representing the highest peak in the last decade, before declining again in 2024 (90 publications) and 2025 (60 publications). This pattern indicates that ethnobiology research productivity over the past decade has been dynamic but generally exhibits a strong growth trend, particularly marked by the substantial post-pandemic surge in 2023. This trend is consistent with previous bibliometric studies showing that ethnobiology has experienced rapid growth since the early 2000s, in line with increasing global attention to local knowledge, biodiversity, and sustainability issues. For example, [22] reported a significant increase in ethnobiology publications in Latin America and emphasized that the discipline has evolved from a marginal field into a well-established scientific domain. A similar pattern was also identified in a global analysis of ethnoentomology by Andrade, which showed that scientific output increased sharply after 2000 and peaked in the last decade, driven by international collaboration and interdisciplinary approaches [23]. In addition, a bibliometric study on ethnobotany in education and conservation by Marsandi confirmed that publications related to traditional knowledge and ethnobiology increased significantly during the period 1997–2024, with the strongest acceleration occurring in the last 10 years [24]. Thus, the surges and fluctuations observed in the publication curve derived from Dimensions AI are not anomalous but rather reflect the global pattern of ethnobiology's development as an increasingly relevant discipline in the context of biodiversity conservation, sustainability, and the integration of local knowledge into modern science.

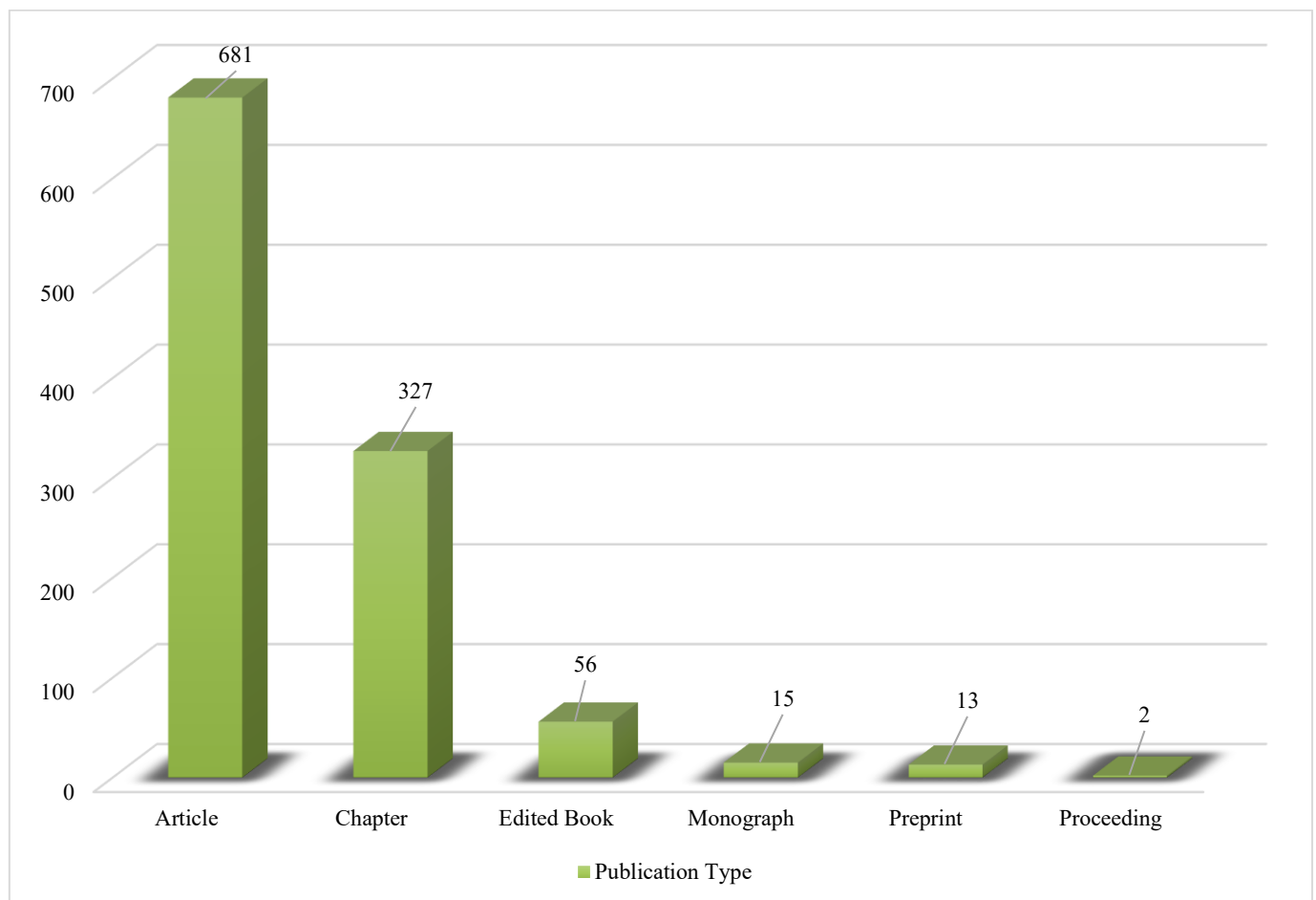


Figure 2. Publication Type (Data Source: Dimensions AI)

Based on Figure 2, which presents the distribution of publication types using the keyword *ethnobiology* from the Dimensions AI search, journal articles are shown to be the most dominant form of publication with a total of 681 documents, followed by book chapters with 327 documents. In contrast, edited books account for only 56 documents, monographs 15 documents, preprints 13 documents, and conference proceedings only 2 documents. The dominance of journal articles indicates that global scholarly communication in the field of ethnobiology still relies heavily on journals as the primary medium for the dissemination of research findings. This pattern is consistent with the general characteristics of modern scientific publishing, which position journal articles as the main channel for knowledge validation through the peer-review mechanism [25] [26]. In addition, the relatively high number of book chapters suggests that ethnobiological studies also develop strongly in the form of collective works and thematic syntheses, which are commonly used to summarize research findings across regions and disciplines. The low number of monographs and conference proceedings reflects that

ethnobiological studies are rarely published as large-scale single-authored works or in conference forums, but are instead directed toward indexed publications with international readership. This distribution pattern is also consistent with the findings of Reyes-García, who stated that the global growth of ethnobiology is primarily driven by the increase in journal article publications rather than books or proceedings, thus reinforcing the position of journals as the main backbone of the development of contemporary ethnobiology as a discipline [27] [28] [29].

Table 1. Top 40 Ethnobiology Researchers Based on Number of Publications According to Dimensions AI Data

Name	Organization, Country	Publications	Citations	Citations mean
Rainer Willi Bussmann	Ilia State University, Georgia	112	438	3.91
Ulysses Paulino De Albuquerque	Federal University of Pernambuco, Brazil	109	2,149	19.72
Olim Kaxxarovich Khojimatov	Academy of Sciences Republic of Uzbekistan, Uzbekistan	98	135	1.38
Washington Soares Ferreira Júnior	Universidade de Pernambuco, Brazil	43	649	15.09
Andrea Pieroni	University of Gastronomic Sciences, Italy	34	1,010	29.71
Yusufjon Gafforov	New Uzbekistan University, Uzbekistan	29	35	1.21
Sylvie Rapior	Centre d'Écologie Fonctionnelle et Évolutive, France	27	33	1.22
Patrícia Muniz De De Medeiros	Federal University of Alagoas, Brazil	26	418	16.08
Manzura Yarasheva	Academy of Sciences Republic of Uzbekistan, Uzbekistan	23	31	1.35
Rômulo Romeu Da Nóbrega Alves	State University of Paraíba, Brazil	23	849	36.91
Michal Tomšovský	Mendel University in Brno, Czechia	20	25	1.25
Maria Franco Trindade Medeiros	Federal University of Rio de Janeiro, Brazil	20	184	9.20
Milena J Rašeta	University of Novi Sad, Serbia	19	22	1.16
Ana Haydeé Ladio	National University of Comahue, Argentina	18	381	21.17
Taline Cristina Da Silva	Universidade Estadual de Alagoas, Brazil	16	267	16.69
Timur V Abduraupov	Academy of Sciences Republic of Uzbekistan, Uzbekistan	16	1	0.06
Gustavo Taboada Soldati	Universidade Federal de Juiz de Fora, Brazil	14	242	17.29
Natalia Hanazaki	Universidade Federal de Santa Catarina, Brazil	13	259	19.92
Ingvar Svanberg	Uppsala University, Sweden	13	165	12.69
Marcelo Alves Ramos	Universidade de Pernambuco, Brazil	13	550	42.31
Ina Vandebroek	University of the West Indies at Mona, Jamaica	13	476	36.62
David Ludwig	Wageningen University & Research, Netherlands	12	482	40.17
André Luiz Borba Do Do Nascimento	Federal University of Maranhão, Brazil	12	230	19.17
Risoneide Henriques Da Silva	Federal University of Pernambuco, Brazil	11	170	15.45
Renata Sōukand	Ca' Foscari University of Venice, Italy	11	157	14.27
Steve Wolverton	University of North Texas, United States	9	227	25.22
Dahdouh-Guebas Dahdouh-Guebas	Université Libre de Bruxelles, Belgium	9	998	110.89
Victoria E Reyes-García	Autonomous University of Barcelona, Spain	9	121	13.44
Gary Paul Nabhan	University of Arizona, United States	9	104	11.56
Joelson Moreno Brito De Moura	Federal University of Pernambuco, Brazil	8	53	6.63
Eraldo Medeiros Costa Costa-Neto	State University of Feira de Santana, Brazil	8	83	10.38
Flávia Rosa Santoro	National University of Córdoba, Argentina	8	178	22.25
Alejandro Casas	National Autonomous University of Mexico, Mexico	8	118	14.75
Rafael Ricardo Vasconcelos Da Da Silva	Federal University of Alagoas, Brazil	8	157	19.63
Eugene S Hunn	University of Washington, United States	7	262	37.43
Chelsey Geralda D Armstrong	Simon Fraser University, Canada	7	177	25.29
Thiago Goncalves Gonçalves-Souza	University of Michigan-Ann Arbor, United States	7	164	23.43
Geilsa Costa Santos Baptista	State University of Feira de Santana, Brazil	7	62	8.86
Dana S Lepofsky	Simon Fraser University, Canada	7	110	15.71
Alvaro Onrubia Fernández-Llamazares	Autonomous University of Barcelona, Spain	7	71	10.14

Author productivity in ethnobiology publications reveals a strong concentration of contributions among a select number of researchers and institutions, particularly from Latin America and Europe. The most prolific author is Rainer Willi Bussmann from Ilia State University, with 112 publications, followed by Ulysses Paulino De Albuquerque from the Federal University of Pernambuco, with 109 publications and a very high total citation count (2,149 citations; average 19.72), indicating not only productivity but also substantial scientific impact. Significant contributions also come from Central Asia, particularly Uzbekistan, through authors such as Olim Kaxxarovich Khojimatov, Manzura

Yarasheva, and Timur V. Abduraupov, who demonstrate high productivity but relatively low average citations, reflecting strong local output with limited global visibility. Conversely, some authors with fewer publications exhibit very high average citations, such as Andrea Pieroni (29.71), Rômulo Romeu da Nóbrega Alves (36.91), Ina Vandebroek (36.62), and David Ludwig (40.17), indicating the substantial intellectual influence of their work. An extreme example is Dahdouh-Guebas, with an average of 110.89 citations per article, highlighting a highly influential contribution despite a relatively limited number of publications. Overall, this pattern demonstrates that the ethnobiology research landscape is shaped not only by publication quantity but also by the quality and impact of the work, with Brazil emerging as a dominant institutional center of ethnobiology research, complemented by significant contributions from Europe, North America, and Central Asia.

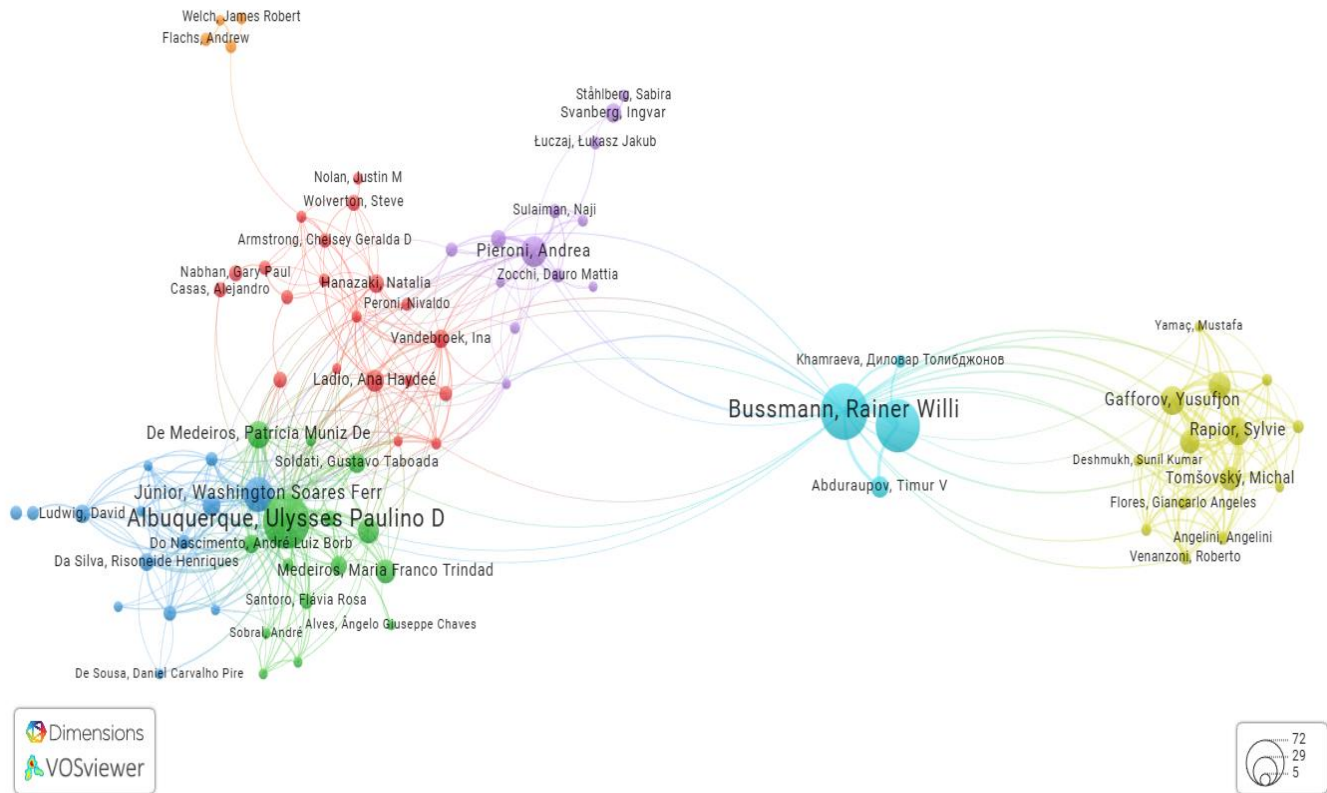


Figure 3. Collaboration Network of Ethnobiology Researchers Based on Bibliometric Analysis (VOSviewer–Dimensions AI)

Bibliometric-based mapping of the ethnobiology researcher network reveals a clustered collaboration structure with several key actors serving as central hubs. The most central author with the highest connectivity is Rainer Willi Bussmann, who functions as the main hub linking researcher clusters from Eastern Europe and Central Asia to broader international networks. Another major cluster is dominated by Latin American researchers centered around Ulysses Paulino De Albuquerque, who is strongly connected with several Brazilian researchers such as Maria Franco Trindade Medeiros, Patrícia Muniz de Medeiros, and Marcelo Alves Ramos, reflecting the strong tradition of ethnobiology research and collaboration in Brazil. The European cluster is represented by close connections between Andrea Pieroni and Ingvar Svanberg, highlighting Europe’s important role in the development of ethnobiological studies on food culture, migration, and cross-regional ethnobotany. Meanwhile, the North American cluster is evident through the collaborative network of researchers such as Steve Wolverton, Eugene S. Hunn, and Ina Vandebroek, who contribute significantly to advancing modern ethnobiology and biocultural conservation approaches. This network structure confirms that global ethnobiology research develops through strong cross-country collaborations, yet knowledge remains concentrated around specific key actors, resulting in asymmetrical collaboration distribution and potential visibility gaps for researchers from regions that are not yet strongly integrated into the global network.

Table 2. Terms Most Frequently Occurring in the Search Based on Frequency and Relevance (VOSviewer)

No	Term	Occurrences	Relevance
1	Ethnobiology	315	0.13
2	Plant	51	0.14
3	Knowledge	46	0.16
4	Study	40	0.18
5	Community	36	0.13
6	Perspective	35	0.17
7	Ethnobotany	34	1.22
8	Ecology	32	0.13

No	Term	Occurrences	Relevance
9	Brazil	30	0.23
10	Management	27	0.17
11	Mexico	26	1.16
12	Research	26	0.12
13	Science	22	0.39
14	Medicinal Plant	22	0.24
15	Person	21	0.14
16	Change	21	0.19
17	Regel	18	6.29
18	Indonesia	18	0.19
19	History	17	0.26
20	Diversity	17	0.21
21	Analysis	17	0.18
22	Contribution	17	0.17
23	Medical Ethnobiology	16	1.46
24	Method	16	0.30
25	Perception	15	0.32
26	Case Study	15	0.18
27	Mountain Regions	14	1.88
28	Ethnoecology	14	0.26
29	Chapter	14	0.25
30	India	14	0.25
31	Nature	14	0.24
32	Chiapas	13	1.51
33	Future	13	0.22
34	Biodiversity	13	0.20
35	Evolutionary Ethnobiology	12	0.81
36	Local Ecological Knowledge	12	0.53
37	Northeastern Brazil	12	0.35
38	Development	12	0.34
39	Society	12	0.29
40	Food	12	0.27
41	Animal	12	0.20
42	Importance	11	0.43
43	Introduction	11	0.41
44	Traditional Knowledge	11	0.23
45	Fisher	10	0.56
46	Northeast Brazil	10	0.36
47	Lamiaceae	9	5.99
48	Ethnobiology Letter	9	0.46
49	Environmental Anthropology	9	0.46
50	Impact	9	0.32
51	Interaction	9	0.26
52	Challenge	9	0.22
53	Health	9	0.18
54	Haitian Zombie	8	1.02
55	Local Community	8	0.53
56	Cultural Significance	7	1.33
57	Indigenous People	7	0.57
58	New York	7	0.52
59	Argentina	7	0.48
60	Biodiversity Conservation	7	0.38
61	Case	7	0.33
62	Nepal	7	0.31
63	Traditional Ecological Knowledge	7	0.28
64	Reflection	7	0.26
65	Indigenous Knowledge	7	0.20
66	Darkness	6	1.21
67	Passage	6	1.21

terms related to digitalization, technology, or digital transformation of ethnobiological knowledge do not appear prominently in the term network. This situation indicates a research gap, namely the limited exploration of how ethnobiological knowledge is documented, managed, or disseminated through digital platforms. Therefore, studies on the digitalization of ethnobiology are important, both in the context of preserving traditional knowledge, enhancing information access, and developing ethnobiological methodologies that are more adaptive to technological advancements.

Ethnobiology-SASAMBO

The term SASAMBO refers to the three main ethnic groups in the West Nusa Tenggara Province of Indonesia: the Sasak of Lombok Island, the Samawa of western Sumbawa Island, and the Mbojo (Bima–Dompu) of eastern Sumbawa Island. These communities possess a rich traditional knowledge system related to the utilization of biological resources, ranging from medicinal plants, local food sources, and traditional agricultural systems to forest management and nature-based health practices. From an ethnobiological perspective, this knowledge represents local ecological knowledge that has been passed down through generations and has proven adaptive to local ecological conditions [30] [31] [32] [33] [34]. Various studies in Lombok and Sumbawa indicate that the Sasak, Samawa, and Mbojo communities have established systems for classifying medicinal plants, traditional processing techniques, and conservation practices based on local wisdom, which remain actively applied in daily life [35] [36].

Ethnobiological studies on the Sasak community, for instance, reveal the use of various local plant species for traditional medicine, cultural rituals, and food, simultaneously contributing to the sustainability of local biodiversity [37]. In the Samawa and Mbojo regions, practices involving medicinal plants, non-timber forest products, and traditional agroforestry systems have also been shown to support community food security and health [38]. However, most SASAMBO ethnobiological knowledge remains scattered across separate scientific publications and has not yet been integrated into a unified data system. Furthermore, knowledge transmission, which still heavily relies on oral tradition, faces significant challenges due to modernization, changing lifestyles, and declining interest among younger generations [39] [40].

In this context, the Ethnobiology-SASAMBO concept is positioned as a systematic effort to integrate, digitize, and preserve the ethnobiological knowledge of the Sasak, Samawa, and Mbojo communities in a single, unified platform. The development of Ethnobiology-SASAMBO is not only oriented toward cultural preservation and biodiversity conservation but also serves as a learning resource grounded in local wisdom, a research data source, and a medium for knowledge dissemination to the broader community. This approach aligns with the view that modern ethnobiology should move toward the integration of local knowledge documentation, biodiversity conservation, and technology-based innovation. Therefore, Ethnobiology-SASAMBO represents a concrete effort to elevate the local biocultural heritage of West Nusa Tenggara into the global scientific ecosystem in a digital format.

The cultural and traditional wealth of SASAMBO (Sasak–Samawa–Mbojo) not only represents the social identity of the West Nusa Tenggara communities but also embodies significant ethnobiological value, as most of their customary practices are rooted in the use of biological resources, the environment, and local ecological knowledge. Beneath this diversity of traditions lies extensive information about plants, animals, ecosystems, and human–nature relationships that have been transmitted across generations. However, much of this richness remains limitedly documented, scattered, and primarily preserved through oral traditions, making it vulnerable to extinction due to modernization and social change. This situation underscores the urgency of digitizing SASAMBO ethnobiological knowledge as a strategic effort for preservation, data integration, and dissemination of knowledge grounded in local wisdom. Among the many traditions that reflect the close relationship between culture and ethnobiology, one example highlighted in this study is the Pedak Api ritual.

The Pedak Api tradition is a ritual performed for a mother and her newborn after the umbilical cord has been severed. It typically takes place on the seventh or ninth day after childbirth. The term *Pedak Api* comes from the Sasak language, where *Pedak* means “to extinguish” and *Api* means “fire,” thus signifying “extinguishing the fire.” Pedak Api carries deep philosophical, religious, and social meanings, playing a vital role in human life, particularly among the Sasak community as the ritual practitioners. Philosophically, Pedak Api represents an effort to honor and value life as a divine gift. The Sasak view life as a blessing from God, which must be treated with gratitude. One way to express this gratitude is through ritual performance, which reflects appreciation for the gift of life. In this context, Pedak Api serves as an expression of gratitude for the blessing of a child’s birth [41] [42] [43] [44].

From a religious perspective, the Pedak Api ritual is grounded in the belief of honoring life in all its forms, including inanimate objects, plants, animals, and humans, as all forms of life originate from God. Understanding and awareness of the origin of life is considered essential knowledge, as without it, human life is viewed as comparable to animal life. Socially, Pedak Api functions as a mediator that reminds humans of their covenant with God. Human civilization, in essence, is an effort to maintain cosmological balance as part of their role as stewards (*khalifah*) on earth. This effort to nurture and harmonize the relationship with nature is expressed through ritual practices, which aim to preserve and sustain mutual respect with the natural environment [45].

In the Pedak Api ritual, the newborn is positioned above a hearth, commonly referred to as *ta eyok* (*diayak*), while being carried by the mother using a cloth wrapped up to her chest (*bekemben*). During the ritual, the baby is rotated nine times above the hearth smoke. According to the *belian* (ritual practitioner), placing the baby on the *ta eyok* nine times is intended to provide warmth to the infant’s body, described locally as *areq saq anget awak ne sengak ye masih odak*, meaning “to warm the baby’s body while it is still weak.” In this context, *odak* indicates that the newborn’s body or physiological systems are still fragile or not fully developed. Newborns have very little subcutaneous fat and an immature thermoregulatory system, making them highly susceptible to environmental temperature changes. The subcutaneous fat layer, located beneath the skin, functions as a natural thermal insulator, helping to maintain body temperature [46]. However, in newborns, this layer is extremely thin, making it less effective at retaining heat. Additionally, the thermoregulatory system of newborns is not yet fully developed [47]. The hypothalamus, which serves as the brain’s central temperature regulator, is still maturing and does not respond efficiently to temperature changes. This

physiological immaturity makes newborns especially vulnerable to fluctuations in environmental temperature [48].

Maintaining or warming a newborn's body is crucial for their health. Newborns are particularly vulnerable to fluctuations in body temperature because their thermoregulatory system is not yet fully developed. In the context of the Pedak Api ritual, the infant is positioned above a hearth, allowing heat transfer to occur through radiation. During the ritual, the hearth—or heat source, typically from burning dried peat (*kambut* or *bobok*)—is ignited to produce warmth. This heat radiates throughout the surrounding space, and the baby is carefully placed near the hearth and rotated several times above it, ensuring that the infant receives the radiant heat evenly. This method of warming through radiation helps maintain the newborn's body temperature and prevents the risk of hypothermia.



Figure 7. Sequence of the Pedak Api tradition: Preparation of Sembeq (a1, a2, a3); turmeric and coconut water for bekejames (b); Teken (bracelet) with turmeric, garlic, and jeringau accessories (c); Pedak Api fireplace (d); Pedak Api procession (e1, e2); Sembeq procession (f); bracelet installation (g); naming ceremony (h); and andang-andang (i).

Hypothermia can occur when the body is exposed to cold temperatures, causing the blood vessels to constrict, a process known as vasoconstriction. This response helps the body maintain a stable core temperature. Vasoconstriction narrows the blood vessels in the skin and extremities, such as the hands and feet, thereby reducing blood flow to these areas. The primary purpose of this adjustment is to minimize heat loss through the skin and keep vital organs warm during cold exposure. Conversely, when the body is exposed to heat—such as near the hearth during the Pedak Api ritual—the blood vessels undergo vasodilation or widening. This process allows greater blood flow to the skin, helping the body dissipate excess heat. Vasodilation also assists in cooling the body when it becomes too warm and is an essential mechanism for maintaining thermal balance. These vascular adjustments are part of a complex thermoregulatory system that enables the body to adapt to environmental temperature changes and maintain thermal homeostasis, which is critical for physiological balance [49].

The correlation between the Pedak Api ritual and the biological mechanisms of thermoregulation in newborns clearly demonstrates that SASAMBO local traditions hold not only significant cultural and social value but also a substantial body of empirical and functional biological knowledge that has been developed and refined over generations. However, this complex and nuanced ethnobiological knowledge continues to be transmitted primarily through oral tradition, supplemented only by limited visual documentation and scattered academic publications that have yet to be systematically integrated. Consequently, the intricate biological, ecological, and scientific significance embedded in traditions such as Pedak Api is at risk of being oversimplified, misinterpreted, or entirely lost if it

is perceived solely as a ceremonial or cultural performance without understanding its underlying functional mechanisms. This situation strongly emphasizes the critical urgency of developing the Ethnobiology-SASAMBO digital portal as a comprehensive platform capable of systematically recording not only the detailed ritual practices but also the associated biological data, the materials utilized, ecological principles, and their health-related functions. By utilizing such a digital portal, SASAMBO ethnobiological knowledge can be sustainably archived, made accessible across multiple generations, and widely employed as an educational resource, a research database, and a strategic instrument for preserving invaluable biocultural heritage that remains highly vulnerable to loss due to ongoing social changes, modernization, and the erosion of traditional knowledge transmission.

Synthesis of Scopus-Indexed Studies Relevant to Ethnobiology Digitalization for Science Education

Based on the systematic literature review conducted in this study, 30 Scopus-indexed journal articles relevant to the focus of this research, namely the digitalization of ethnobiology for science education, were selected. These articles were chosen because they represent three interconnected domains, namely ethnobiology and local or Indigenous knowledge, digitalization and knowledge organization, and science education and contextual learning resources. The following table presents a synthesis of the selected articles, including the authors' names, article titles, general findings, and the identified research gaps. This presentation is intended to provide a comprehensive overview of the current state of the literature while highlighting the research gap at the intersection of ethnobiology, digitalization, and science education.

Table 3. Synthesis of Scopus-Indexed Articles on Ethnobiology Digitalization for Science Education

No	Full Author Names	Article Title	General Findings	Research Gap
1	Robby Zidny; Jesper Sjöström; Ingo Eilks	A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability	Shows that Indigenous knowledge can enrich science education for sustainability both epistemologically and pedagogically.	Does not discuss ethnobiology digitalization, digital portals, or digitally structured learning resources for science education.
2	Robby Zidny; S. Solfarina; Ratna Sari Siti Aisyah; Ingo Eilks	Exploring Indigenous Science to Identify Contents and Contexts for Science Learning in Order to Promote Education for Sustainable Development	Demonstrates that Indigenous science can provide relevant content and contexts for meaningful science learning.	Has not yet transformed ethnobiological knowledge into structured digital resources for science education.
3	Qingna Jin	Supporting Indigenous Students in Science and STEM Education: A Systematic Review	Reports that culturally responsive programs can improve participation and learning among Indigenous students in science and STEM.	Focuses on educational programs, not on digital ethnobiology resources or portal-based learning environments.
4	Julio César Tovar-Gálvez	Intercultural Teaching Practices for Science Education to Support Teachers in Culturally Diverse Classrooms	Offers intercultural teaching practices that help connect scientific and traditional knowledge in diverse classrooms.	Emphasizes pedagogy rather than the digitalization of ethnobiological knowledge for science education.
5	Julio César Tovar-Gálvez	Bringing Cultural Inclusion to the Classroom through Intercultural Teaching Practices for Science Education (ITPSE) and Guiding Tools	Provides practical tools for cultural inclusion in science education through intercultural pedagogy.	Does not develop digital ethnobiology resources, databases, or portals for contextual science learning.
6	Kamal Prasad Koirala	Ethno Science Practice as Indigenous Wisdom: Challenges to Braiding with Western-Based School Science Curriculum	Highlights challenges in braiding ethnosience with Western school science curricula.	Identifies epistemic integration issues, but not digital organization of ethnobiological knowledge for learning.
7	Stephany RunningHawk Johnson	The Importance of Learning with/on/from Land and Place While Honoring Reciprocity in Indigenous Science Education	Emphasizes land- and place-based learning and reciprocity in Indigenous science education.	Does not explain how place-based ethnobiological knowledge can be reconstructed into digital learning resources.
8	Sinethemba Mdleleni; Kenneth Mlungisi Ngcoza	Using Topic Specific Pedagogical Content Knowledge to Study Indigenous Knowledge Integration in Grade 11 Physical Science Lessons: Teachers' Perspectives	Shows that teachers value Indigenous knowledge integration but face implementation challenges in classroom practice.	Addresses teachers' perspectives, not digital ethnobiology or technology-supported contextual science resources.
9	Birgitte Mari Midtervoll Lange; Julie Marie Pedersen; ...	Integrating Coastal Sámi Traditional Knowledge in Science Education: Challenges, Approaches, and the Path Forward	Shows that integrating Coastal Sámi traditional knowledge in science education is promising but conceptually and practically challenging.	Relevant to science education, yet it does not develop digital ethnobiology infrastructure or portal-based resources.
10	Umar A. Adam; Franklin U.	Testing the Potency of Ethnosience Instruction on Biology Students'	Finds that ethnosience-based instruction can improve biology	Supports classroom value of ethnosience, but not

No	Full Author Names	Article Title	General Findings	Research Gap
	Onowugbeda; Nur Islami; Kehinde G. Ogolo	Critical Thinking Ability	students' critical thinking.	digital delivery or structured ethnobiology repositories.
11	Thumah Mapulanga; Loyiso Currell Jita	A Systematic Review of Studies Using the Topic-Specific Pedagogical Content Knowledge Framework in Science Education	Shows that topic-specific pedagogical content knowledge is useful for improving the quality of science teaching.	Useful pedagogically, but not specific to ethnobiology digitalization or contextual digital resource development.
12	Yared Nigussie Demssie; Harm J. A. Biemans; ...	Combining Indigenous Knowledge and Modern Education to Foster Sustainability Competencies: Towards a Set of Learning Design Principles	Develops learning design principles for combining Indigenous knowledge and modern education to foster sustainability competencies.	Strong on learning design, but does not extend to digital ethnobiology resources for science education.
13	Dennis N. Ocholla	The Complex Marriage: Interfacing Open Science and Open Indigenous Knowledge	Discusses how open science can interface with open Indigenous knowledge and why this matters for knowledge justice.	Focuses on open knowledge and governance rather than ethnobiology and science education resource design.
14	Adeyinka Tella; Esther Oluwayemi Jatto; Yusuf Ayodeji Ajani	Preserving Indigenous Knowledge: Leveraging Digital Technology and Artificial Intelligence	Shows that digital technologies and AI can support documentation, preservation, and dissemination of Indigenous knowledge.	Closely related to digitalization, but not specific to ethnobiology or pedagogical use in science education.
15	De Graft Johnson Dei; Monica Mensah Danquah	Mirrors of Knowledge and Indigenous Knowledge Management	Explains the role of libraries, archives, and information systems in managing Indigenous knowledge.	Focuses on knowledge management, not on ethnobiology digitalization for science teaching and learning.
16	Patricia Badendorst; Muvhulawa Matumba; Mousin Omarsaib	Libraries as Agents of Decolonisation: Exploring the Integration of Indigenous Languages into Library Services in South African Public Higher Education Libraries	Shows that libraries can play a decolonizing role by integrating Indigenous languages into academic services.	Relevant to access and decolonization, but not specifically to ethnobiology or science education digital resources.
17	Sonja E. Bosch; Marissa Griesel	Exploring the Documentation and Preservation of African Indigenous Knowledge in a Digital Lexical Database	Demonstrates that digital lexical databases can document and preserve Indigenous knowledge effectively.	Provides a digital model, but it is not targeted at ethnobiology-based science learning.
18	Maneesha Perera; Rajith Vidanaarachchi; ...	Indigenous Peoples and Artificial Intelligence: A Systematic Review and Future Directions	Reviews opportunities and risks of AI in relation to Indigenous knowledge systems and data governance.	Important for AI and digital governance, but not focused on ethnobiology or science education contexts.
19	Răzvan Gabriel Boboc; Elena Băutu; Florin Gîrbacia; ...	Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications	Shows that augmented reality can enhance cultural heritage visualization and user engagement.	Relevant as enabling technology, but not yet applied to ethnobiology for contextual science education.
20	Luan Victor Brandão dos Santos; Daniel Pereira Monteiro; ...	The Traditional Knowledge About the Biodiversity of Edible Brazilian Fruits and Their Pollinators: An Integrative Review	Builds a conceptual evidence base on local biodiversity knowledge through an integrative review.	Shows potential for data building, but not for pedagogically reconstructed digital ethnobiology resources.
21	Johnson Andrade Junior; Paulo Roberto Ramalho Silva; ...	Ethnoentomology (1952–2024): Scientific Production, Emerging Trends and Research Gaps	Maps the growth, themes, and collaboration patterns in ethnoentomology as a subfield of ethnobiology.	Strengthens understanding of subfield development, but not of digitalization for science education.
22	Georgina Pérez-Rodríguez; Carlos Alberto Ortiz-Solorio; ..	Ethnopedology, Its Evolution and Perspectives in Soil Security: A Review	Shows the development of ethnopedology and its contribution to soil security and knowledge co-production.	Demonstrates subfield maturity, but does not address digital ethnobiology learning resources.
23	Basirat O. Rafiu; Abiodun O. Omotayo; Ibraheem O. Lawal; Adeyemi O. Aremu	Ethnobotanical Uses of Plants in Nigeria: An Analysis of Current Research Trends and Patterns	Shows active ethnobotanical research and rich plant-use knowledge, but also fragmented evidence patterns.	Highlights fragmented ethnobiological data, yet does not solve digital pedagogical organization for science education.

No	Full Author Names	Article Title	General Findings	Research Gap
24	Charles C. Davis; Patrick Choisy	Medicinal Plants Meet Modern Biodiversity Science	Explains the importance of linking medicinal plant knowledge with modern biodiversity science.	Supports cross-disciplinary integration, but not digital ethnobiology resources for science education.
25	Kelsey Leonard	Decolonizing Botanical Gardens	Emphasizes the need to decolonize biological knowledge institutions and respect Indigenous rights and perspectives.	Relevant to knowledge justice but does not discuss digital ethnobiology portals for teaching and learning.
26	Marcellus Mbah; Sandra Ajaps; Petra Molthan-Hill	A Systematic Review of the Deployment of Indigenous Knowledge Systems towards Climate Change Adaptation in Developing World Contexts: Implications for Climate Change Education	Shows that Indigenous knowledge systems are valuable for climate adaptation and educational practice.	Strengthens the educational value of Indigenous knowledge, but not specifically ethnobiology digitalization.
27	Emma Pirie; Tom Whillans; Jennie Knopp; Chris M. Furgal	Approaches and Methods Used to Bring Together Indigenous and Environmental Science Knowledge in Environmental Research: A Systematic Map Protocol	Shows that integrating Indigenous and environmental science knowledge remains methodologically complex.	Relevant to knowledge integration, but not to digitally structured ethnobiology resources for science education.
28	Cuthbert Casey Makondo; David S. G. Thomas	Climate Change Adaptation: Linking Indigenous Knowledge with Western Science for Effective Adaptation	Shows that linking Indigenous knowledge with Western science is important for effective climate change adaptation.	Supports integrative knowledge frameworks, but not digital infrastructure or science education resources.
29	Miriam Kalanda-Joshua; Cosmo Ngongondo; Lucy Chipeta; F. Mpembeka	Integrating Indigenous Knowledge with Conventional Science: Enhancing Localised Climate and Weather Forecasts in Nessa, Mulanje, Malawi	Shows that integrating Indigenous and conventional science can improve localized climate and weather forecasts.	Relevant to knowledge integration, but not to digital ethnobiology or pedagogical reconstruction.
30	Christopher M. Raymond; Ioan Fazey; Mark S. Reed; ...	Integrating Local and Scientific Knowledge for Environmental Management	Provides a foundational framework for integrating local and scientific knowledge in environmental management.	Offers a strong theoretical basis, but not specific guidance for ethnobiology digitalization in science education.

Table 3 shows that the reviewed Scopus-indexed literature can be grouped into three major strands that are closely related to the focus of this study. The first strand consists of studies that position Indigenous and local knowledge as an important foundation for making science education more contextual, meaningful, and culturally responsive. These studies demonstrate that Indigenous knowledge can enrich science education for sustainability, provide relevant local contexts for learning, support Indigenous students in science and STEM, and strengthen intercultural teaching practices in diverse classrooms [50]–[54]. Other studies in this strand further confirm that ethnoscience and Indigenous knowledge integration can contribute to curriculum relevance, critical thinking development, teacher pedagogical perspectives, and the formulation of sustainability-oriented learning principles [55]–[61]. Overall, these studies strongly support the educational value of ethnobiology-related knowledge, but they largely remain focused on pedagogical integration, classroom practice, and curriculum design rather than on the development of digitally structured ethnobiology resources for science education.

The second strand includes studies concerned with digitalization, knowledge management, repositories, artificial intelligence, and the preservation of Indigenous knowledge. These studies emphasize the importance of connecting open science with open Indigenous knowledge, using digital technology and AI for preservation, strengthening library and documentation systems, and developing digital databases for Indigenous knowledge and cultural heritage [62]–[66]. Other works in this strand also show that digital technologies such as AI, cultural heritage applications, and integrative biodiversity reviews provide important pathways for preserving and organizing local knowledge in more accessible forms [67]–[69]. However, the general orientation of these studies is still directed toward preservation, access, governance, and documentation. As a result, although the digitalization agenda is already visible, it has not yet been sufficiently translated into educationally reconstructed ethnobiology resources that can function directly as contextual learning materials in science education.

The third strand reflects the broader development of ethnobiology as a scientific field. The reviewed studies show that ethnobiology and its related subfields have expanded through analyses of scientific production, ethnopodology, ethnobotanical uses of plants, medicinal biodiversity, decolonizing biological knowledge institutions, climate-related Indigenous knowledge systems, and the integration of local and scientific knowledge in environmental management [70]–[79]. These studies confirm that ethnobiology is a rapidly developing interdisciplinary field with strong links to biodiversity, traditional medicine, environmental sustainability, and local knowledge systems. Nevertheless, the dominant orientation of this literature remains concentrated on documentation, conservation, environmental adaptation, and scientific integration, rather than on the creation of digital ethnobiology systems specifically designed for science education.

Taken together, the synthesis of the 30 articles indicates that ethnobiology, digitalization, and science education have developed as three important but still relatively separate domains. Studies in science education emphasize pedagogical and intercultural

integration, studies in digitalization focus on preservation and knowledge organization, and core ethnobiology studies remain centered on biodiversity, local knowledge, health, and environmental management. Therefore, the main research gap identified from this table lies in the limited intersection of these three domains, particularly in the form of digitally structured, pedagogically reconstructed, and education-oriented ethnobiology resources. This gap provides a strong conceptual basis for arguing that future initiatives should move beyond documentation toward the development of digital ethnobiology resources that are explicitly designed to support science education, including the possible development of the Ethnobiology-SASAMBO Digital Portal.

4. Conclusion

This study demonstrates that global ethnobiology research has developed strongly in relation to biodiversity, traditional knowledge, local communities, health, and socio-cultural dimensions, as shown by the bibliometric mapping of 1,094 publications and the thematic structure of the reviewed literature. However, both the bibliometric findings and the systematic literature review indicate that the intersection of ethnobiology, digitalization, and science education remains underexplored. Existing studies in science education mainly emphasize pedagogical and intercultural integration, while studies on digitalization focus more on preservation, access, and knowledge management. At the same time, core ethnobiology research remains largely concentrated on documentation, biodiversity, and traditional knowledge systems. These findings confirm a clear research gap in the digitalization of ethnobiology for science education, particularly in relation to the development of digitally structured and pedagogically reconstructed ethnobiology resources. Therefore, this study provides a conceptual and empirical basis for future initiatives aimed at bridging this gap, including the possible development of the Ethnobiology-SASAMBO Digital Portal as a follow-up response to the identified research gap.

Acknowledgment

The authors express their sincere gratitude to all parties who have supported this study. Special appreciation is extended to the Sasak, Samawa, and Mbojo communities, whose rich biocultural knowledge has provided important context and inspiration for this ethnobiology study. The authors also acknowledge the Dimensions AI platform as the source of bibliometric data and the developers of VOSviewer for providing the software used in the bibliometric analysis.

References

- [1]. Berlin, B. (2014). *Ethnobiological classification: Principles of categorization of plants and animals in traditional societies*. Princeton University Press.
- [2]. Maffi, L. (2005). Linguistic, cultural, and biological diversity. *Annu. Rev. Anthropol.*, 34(1), 599-617. <https://doi.org/10.1146/annurev.anthro.34.081804.120437>
- [3]. Albuquerque, U. P., da Cunha, L. V. F. C., De Lucena, R. F. P., & Alves, R. R. N. (Eds.). (2014). *Methods and techniques in ethnobiology and ethnoecology*.
- [4]. Wolverson, S. (2013). Ethnobiology 5: interdisciplinarity in an era of rapid environmental change. *Ethnobiology letters*, 4, 21-25. <https://www.jstor.org/stable/26423553>
- [5]. Kimmerer, R. W. (2002). Weaving traditional ecological knowledge into biological education: A call to action. *BioScience*, 52(5), 432-438. [https://doi.org/10.1641/0006-3568\(2002\)052\[0432:WTEKIB\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2002)052[0432:WTEKIB]2.0.CO;2)
- [6]. Brondizio, E. S., Aumeeruddy-Thomas, Y., Bates, P., Carino, J., Fernández-Llamazares, Á., Ferrari, M. F.,... & Shrestha, U. B. (2021). Locally based, regionally manifested, and globally relevant: Indigenous and local knowledge, values, and practices for nature. *Annual Review of Environment and Resources*, 46(1), 481-509. <https://doi.org/10.1146/annurev-environ-012220-012127>
- [7]. Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching*, 36(3), 269–287. [https://doi.org/10.1002/\(SICI\)1098-2736\(199903\)36](https://doi.org/10.1002/(SICI)1098-2736(199903)36)
- [8]. Aceves, T. C., & Orosco, M. J. (2014). *Culturally responsive teaching: innovative configuration-2*. University of Florida, Collaboration for Effective Educator, Development, Accountability, and Reform Center. <https://cedar.education.ufl.edu/wp-content/uploads/2014/08>
- [9]. Fasasi, R. A. (2017). Effects of ethnosience instruction, school location and parental educational background on learners' attitude towards science. *International Journal of Science Education*, 39(5), 548–564. <https://doi.org/10.1080/09500693.2017.1281635>
- [10]. Hacıeminoglu, E. (2016). Elementary school students' attitudes towards science and related variables. *International Journal of Environmental and Science Education*, 11(2), 35–52. <https://eric.ed.gov/?id=EJ1092165>
- [11]. van Aalderen-Smeets, S., & Walma van der Molen, J. (2013). Measuring primary teachers' attitudes toward teaching science: Development of the dimensions of attitude toward science (DAS) instrument. *International journal of science education*, 35(4), 577-600. <https://doi.org/10.1080/09500693.2012.755576>
- [12]. Winschiers-Theophilus, H. (2022). Bridging worlds: Indigenous knowledge in the digital world. In *Proceedings of the 22nd ACM/IEEE Joint Conference on Digital Libraries*, 1–2.
- [13]. Tella, A., Jatto, E. O., & Ajani, Y. A. (2025). Preserving indigenous knowledge: Leveraging digital technology and artificial intelligence. *IFLA Journal*, 51(3), 703–721.
- [14]. Łuczaj, Ł. (2023). Descriptive ethnobotanical studies are needed for the rescue operation of documenting traditional knowledge. *Journal of Ethnobiology and Ethnomedicine*, 19(1), 37. <https://doi.org/10.1186/s13002-023-00604-5>

- [15]. De Meyer, E., & Ceuterick, M. (2022). Digital Ethnobiology: exploring the digisphere in search of traditional and indigenous knowledge and practices. *Ethnobotany Research and Applications*, 24, 1–8. Retrieved from <https://ethnobotanyjournal.org/index.php/era/article/view/4067>
- [16]. Elmabaredy, A., & Gencel, N. (2024). Exploring the integration of self-regulated learning into digital platforms to improve students' achievement and performance. *Discover Education*, 3, 262. <https://doi.org/10.1007/s44217-024-00233-4>
- [17]. Momani, M. A. K. A., Alharahasheh, K. A., & Alqudah, M. (2023). Digital learning in sciences education: A literature review. *Cogent Education*, 10(2), 2277007.
- [18]. Balalle, H. (2024). Exploring student engagement in technology-based education in relation to gamification, online/distance learning, and other factors: A systematic literature review. *Social Sciences & Humanities Open*, 9, 100870.
- [19]. Kementerian Kebudayaan Republik Indonesia, "Data Pokok Kebudayaan (DAPOBUD)," DAPOBUD. [Online]. Available: <https://dapobud.kemendbud.go.id/>
- [20]. Perpustakaan Digital Budaya Indonesia, "Perpustakaan Digital Budaya Indonesia (PDBI)," Budaya Indonesia. [Online]. Available: <https://budaya-indonesia.org/>
- [21]. Kirby, K. R., Gray, R. D., Greenhill, S. J., Jordan, F. M., Gomes-Ng, S., Bibiko, H. J.,... & Gavin, M. C. (2016). D-PLACE: A global database of cultural, linguistic and environmental diversity. *PloS one*, 11(7), e0158391. <https://doi.org/10.1371/journal.pone.0158391>
- [22]. Albuquerque, U. P., Silva, J. S., Campos, J. L. A., Sousa, R. S., Silva, T. C., & Alves, R. R. N. (2013). The current status of ethnobiological research in Latin America: gaps and perspectives. *Journal of ethnobiology and ethnomedicine*, 9(1), 72.
- [23]. Andrade J, J., Silva, P. R. R., & de Barros, R. F. M. (2025). Ethnoentomology (1952–2024): scientific production, emerging trends and research gaps. *Journal of Ethnobiology and Ethnomedicine*, 21(1), 82.
- [24]. Marsandi, F., Sutadji, E., Kuntadi, I., Rizal, F., Rahma, A. B. N., & Fajri, H. (2025). Integrating Ethnobotany and Indigenous Knowledge into Higher Education Curricula: Insights from a Global Bibliometric Analysis. *Ethnobotany Research and Applications*, 30, 1-12. <https://ethnobotanyjournal.org/index.php/era/article/view/6622>
- [25]. Borgman, C. L. (2010). *Scholarship in the digital age: Information, infrastructure, and the Internet*. MIT press.
- [26]. Ware, M., & Mabe, M. (2015). *The STM report: An overview of scientific and scholarly journal publishing*.
- [27]. Reyes-García, V., Guèze, M., Luz, A. C., Paneque-Gálvez, J., Macía, M. J., Orta-Martínez, M.,... & Rubio-Campillo, X. (2013). Evidence of traditional knowledge loss among a contemporary indigenous society. *Evolution and Human Behavior*, 34(4), 249-257. <https://doi.org/10.1016/j.evolhumbehav.2013.03.002>
- [28]. Reyes-García, V., Guèze, M., Díaz-Reviriego, I., Duda, R., Fernández-Llamazares, Á., Gallois, S.,... & Pyhälä, A. (2016). The adaptive nature of culture: A cross-cultural analysis of the returns of local environmental knowledge in three indigenous societies. *Current anthropology*, 57(6), 761-784. <https://doi.org/10.1086/689307>
- [29]. Reyes-García, V. (2025). Indigenous and local knowledge systems as pillars of cultural sustainability. *Nature Sustainability*, 8(3), 215–226. <https://doi.org/10.1038/s41893-025-01156-9>
- [30]. Nygren, A. (1999). Local knowledge in the environment–development discourse: From dichotomies to situated knowledges. *Critique of anthropology*, 19(3), 267-288. <https://doi.org/10.1177/0308275X9901900304>
- [31]. McElwee, P., Fernández-Llamazares, Á., Aumeeruddy-Thomas, Y., Babai, D., Bates, P., Galvin, K.,... & Brondízio, E. S. (2020). Working with Indigenous and local knowledge (ILK) in large-scale ecological assessments: Reviewing the experience of the IPBES Global Assessment. *Journal of Applied Ecology*, 57(9), 1666-1676. <https://doi.org/10.1111/1365-2664.13705>
- [32]. Mkhwebane, L. N. (2024). Life sciences teachers' integration of indigenous knowledge: A vision for making science classrooms culturally responsive. *EURASIA Journal of Mathematics, Science and Technology Education*, 20(8), em2483. <https://doi.org/10.29333/ejmste/14859>
- [33]. Mlotshwa, N., & Tsakeni, M. (2024). Challenges Experienced by Teachers when Integrating Indigenous Knowledge Systems in Natural Sciences Practical Work. *African Journal of Research in Mathematics, Science and Technology Education*, 28(2), 300-313. <https://doi.org/10.1080/18117295.2024.2414160>
- [34]. McKenzie, T., & Toia, R. (2025). An inclusive indigenous approach to curriculum development. *International Journal of Inclusive Education*, 29(3), 244-258. <https://doi.org/10.1080/13603116.2022.2127493>
- [35]. Pratomo, H., Wibowo, A. E., Isnawati, A., Alegantina, S., Supardi, S., Susilo, A., & Yunarto, N. (2025). Utilization of Medicinal Plants for Homemade Herbal Medicine in Selong Sub-district, East Lombok Regency, Indonesia. *Tropical Journal of Natural Product Research*, 9(6). <https://doi.org/10.26538/tjnpr/v9i6.52>
- [36]. Husain, F., & Wahidah, B. F. (2018, October). Medicine from nature: Identification of medicinal plants used by belian (sasakese indigenous healer) in traditional medicine in Lombok, West Nusa Tenggara, Indonesia. In *AIP Conference Proceedings* (Vol. 2019, No. 1, p. 050003). AIP Publishing LLC.
- [37]. Sujarwo, W., Keim, A. P., Savo, V., Guarrera, P. M., & Caneva, G. (2015). Ethnobotanical study of Lohoh: Traditional herbal drinks from Bali (Indonesia). *Journal of Ethnopharmacology*, 169, 34-48. <https://doi.org/10.1016/j.jep.2015.03.079>
- [38]. Purwanto, Y. (2021). Applying ethnobiology in sustainable management and utilization of biological resources in Indonesia. *Proceedings of KOB I 2nd International Confer*, 1, 8-23.
- [39]. Scheidel, A., Fernández-Llamazares, Á., Bara, A. H., Del Bene, D., David-Chavez, D. M., Fanari, E.,... & Whyte, K. P. (2023). Global impacts of extractive and industrial development projects on Indigenous Peoples' lifeways, lands, and rights. *Science Advances*, 9(23), eade9557. <https://doi.org/10.1126/sciadv.ade9557>
- [40]. Schroeder, K., Byrne, D., & Klenk, N. (2022). Culture and sustainability: The role of local knowledge in environmental education. *Environmental Education Research*, 28(4), 543–560. <https://doi.org/10.1080/13504622.2021.1952567>

- [41]. Fathurrahman, L.A. (2017). *Kosmologi masyarakat Sasak: risalah inen paer*. Mataram: Penerbit Genius.
- [42]. Arifin, A. A., Ramdani, A., & Andayani, Y. (2024). Development of Learning Tools Based on the Culturally Responsive Transformative Teaching Model with a Socio-Scientific Issues Approach: Evaluation of Validity and Practicality. *Jurnal Penelitian Pendidikan IPA*, 10(11), 9141-9155. <https://doi.org/10.29303/jppipa.v10i11.9188>
- [43]. Ahmad, A. A., Ramdani, A., Andayani, Y., & Hariadi, I. (2024). Pengembangan E-Modul Ekosistem Berbasis Model Culturally Responsive Transformative Teaching dengan Pendekatan Socio-Scientific Issues Berbantuan Software 3D Pageflip Professional. *Journal of Classroom Action Research*, 6(3), 673-685. <https://doi.org/10.29303/jcar.v6i3.9035>
- [44]. Arifin, A. A., Ramdani, A., & Andayani, Y. (2025). Evaluation of Content and Construct Validity of Learning Tools Based on Culturally Responsive Transformative Teaching Model with Socioscientific Issues Approach. *Pustaka Didaktis: Jurnal Media Dan Model Pembelajaran*, 1(1), 20-37.
- [45]. Arifin, A. A., Andayani, Y., & Sedijani, P. (2024). Rekonstruksi etnosains tradisi Pedak Api masyarakat Narmada dalam pembelajaran biologi. *Journal of Classroom Action Research*, 6(1), 241-250. <https://doi.org/10.29303/jcar.v6i2.6366>
- [46]. John, R. Speakman. (2018). Obesity and Thermoregulation. *Handbook of Clinical Neurology*, 156, 431-443.
- [47]. Nurkayatun, D. (2022). Analisa Praktik Klinik Keperawatan pada Bayi dengan Intervensi Inovasi Pemberian Kangaroo Mother Care (KMC) Terhadap Status Termogulasi pada Bayi dengan Berat Badan Lahir Rendah di Ruang NICU RSUD Taman Husada Bontang. Universitas Muhammadiyah Kaltim.
- [48]. Sherwood, L. (2011). *Fisiologi Manusia dari Sel ke Sistem Edisi 2*. Jakarta: EGC.
- [49]. Bisri, D. Y., Oetoro, B., Harahap, S., & Saleh, S. C. (2012). Hipotermia Untuk Proteksi Otak (Hypothermia For Brain Protection). *Jurnal Neuroanestesia Indonesia*, 1(4), 1-13.
- [50]. Robby Zidny, Jesper Sjöström, and Ingo Eilks, "A Multi-Perspective Reflection on How Indigenous Knowledge and Related Ideas Can Improve Science Education for Sustainability," *Science & Education*, vol. 29, no. 1, pp. 145–185, 2020.
- [51]. Robby Zidny, S. Solfarina, Ratna Sari Siti Aisyah, and Ingo Eilks, "Exploring Indigenous Science to Identify Contents and Contexts for Science Learning in Order to Promote Education for Sustainable Development," *Education Sciences*, vol. 11, no. 3, art. 114, 2021.
- [52]. Qingna Jin, "Supporting Indigenous Students in Science and STEM Education: A Systematic Review," *Education Sciences*, vol. 11, no. 9, art. 555, 2021.
- [53]. Julio César Tovar-Gálvez, "Intercultural Teaching Practices for Science Education to Support Teachers in Culturally Diverse Classrooms," *Teaching Education*, 2023.
- [54]. Julio César Tovar-Gálvez, "Bringing Cultural Inclusion to the Classroom through Intercultural Teaching Practices for Science Education (ITPSE) and Guiding Tools," *Science Education*, vol. 107, 2023.
- [55]. Kamal Prasad Koirala, "Ethno Science Practice as Indigenous Wisdom: Challenges to Braiding with Western-Based School Science Curriculum," *Diaspora, Indigenous, and Minority Education*, 2023.
- [56]. Stephany RunningHawk Johnson, "The Importance of Learning with/on/from Land and Place While Honoring Reciprocity in Indigenous Science Education," *Cultural Studies of Science Education*, 2024.
- [57]. Sinthemba Mdeleleni and Kenneth Mlungisi Ngozoa, "Using Topic Specific Pedagogical Content Knowledge to Study Indigenous Knowledge Integration in Grade 11 Physical Science Lessons: Teachers' Perspectives," *African Journal of Research in Mathematics, Science and Technology Education*, 2025.
- [58]. Birgitte Mari Midtervoll Lange, Julie Marie Pedersen, Gunnar Kristiansen, Vivienne Mackisack, and Siw Turid Killengreen, "Integrating Coastal Sámi Traditional Knowledge in Science Education: Challenges, Approaches, and the Path Forward," *Education Sciences*, vol. 15, no. 2, art. 230, 2025.
- [59]. Umar A. Adam, Franklin U. Onowugbeda, Nur Islami, and Kehinde G. Ogolo, "Testing the Potency of Ethnoscience Instruction on Biology Students' Critical Thinking Ability," *The Journal of Educational Research*, vol. 117, no. 4, pp. 218–227, 2024.
- [60]. [60] Thumah Mapulanga and Loyiso Currell Jita, "A Systematic Review of Studies Using the Topic-Specific Pedagogical Content Knowledge Framework in Science Education," *Education Sciences*, 2025.
- [61]. Yared Nigussie Demssie, Harm J. A. Biemans, Renate Wesselink, and Martin Mulder, "Combining Indigenous Knowledge and Modern Education to Foster Sustainability Competencies: Towards a Set of Learning Design Principles," *Sustainability*, vol. 12, no. 17, art. 6823, 2020.
- [62]. Dennis N. Ocholla, "The Complex Marriage: Interfacing Open Science and Open Indigenous Knowledge," *Library Management*, 2025.
- [63]. Adeyinka Tella, Esther Oluwayemi Jatto, and Yusuf Ayodeji Ajani, "Preserving Indigenous Knowledge: Leveraging Digital Technology and Artificial Intelligence," *IFLA Journal*, vol. 51, no. 3, pp. 703–721, 2025.
- [64]. De Graft Johnson Dei and Monica Mensah Danquah, "Mirrors of Knowledge and Indigenous Knowledge Management," *Journal of Librarianship and Information Science*, 2024.
- [65]. Patricia Badenhorst, Muvhulawa Matumba, and Mousin Omarsaib, "Libraries as Agents of Decolonisation: Exploring the Integration of Indigenous Languages into Library Services in South African Public Higher Education Libraries," *Journal of Librarianship and Information Science*, 2025.
- [66]. Sonja E. Bosch and Marissa Griesel, "Exploring the Documentation and Preservation of African Indigenous Knowledge in a Digital Lexical Database," *Lexikos*, 2020.
- [67]. Maneesha Perera, Rajith Vidanaarachchi, Sangeetha Chandrashekeran, Melissa Kennedy, Brenda Kennedy, and Saman K. Halgamuge, "Indigenous Peoples and Artificial Intelligence: A Systematic Review and Future Directions," *Big Data & Society*, 2025.
- [68]. Răzvan Gabriel Boboc, Elena Băutu, Florin Gîrbacia, Norina Popovici, and Dorin-Mircea Popovici, "Augmented Reality in Cultural Heritage: An Overview of the Last Decade of Applications," *Applied Sciences*, 2022.

- [69]. Luan Victor Brandão dos Santos, Daniel Pereira Monteiro, André Luiz Borba do Nascimento, and Roseli Farias Melo de Barros, "The Traditional Knowledge About the Biodiversity of Edible Brazilian Fruits and Their Pollinators: An Integrative Review," *Journal of Ethnobiology and Ethnomedicine*, 2025.
- [70]. Johnson Andrade Junior, Paulo Roberto Ramalho Silva, and Roseli Farias Melo de Barros, "Ethnoentomology (1952–2024): Scientific Production, Emerging Trends and Research Gaps," *Journal of Ethnobiology and Ethnomedicine*, 2025.
- [71]. Georgina Pérez-Rodríguez, Carlos Alberto Ortiz-Solorio, and Ma. del Carmen Gutiérrez-Castorena, "Ethnopedology, Its Evolution and Perspectives in Soil Security: A Review," *Soil Security*, 2023.
- [72]. Basirat O. Rafiu, Abiodun O. Omotayo, Ibraheem O. Lawal, and Adeyemi O. Aremu, "Ethnobotanical Uses of Plants in Nigeria: An Analysis of Current Research Trends and Patterns," *Journal of Ethnobiology and Ethnomedicine*, 2025.
- [73]. Charles C. Davis and Patrick Choisy, "Medicinal Plants Meet Modern Biodiversity Science," *Current Biology*, 2024.
- [74]. Kelsey Leonard, "Decolonizing Botanical Gardens," *Qualitative Research Journal*, 2024.
- [75]. Marcellus Mbah, Sandra Ajaps, and Petra Molthan-Hill, "A Systematic Review of the Deployment of Indigenous Knowledge Systems towards Climate Change Adaptation in Developing World Contexts: Implications for Climate Change Education," *Sustainability*, 2021.
- [76]. Emma Pirie, Tom Whillans, Jennie Knopp, and Chris M. Furgal, "Approaches and Methods Used to Bring Together Indigenous and Environmental Science Knowledge in Environmental Research: A Systematic Map Protocol," *Ecological Solutions and Evidence*, 2024.
- [77]. Cuthbert Casey Makondo and David S. G. Thomas, "Climate Change Adaptation: Linking Indigenous Knowledge with Western Science for Effective Adaptation," *Environmental Science & Policy*, vol. 88, pp. 83–91, 2018.
- [78]. Miriam Kalanda-Joshua, Cosmo Ngongondo, Lucy Chipeta, and F. Mpembeka, "Integrating Indigenous Knowledge with Conventional Science: Enhancing Localised Climate and Weather Forecasts in Nessa, Mulanje, Malawi," *Physics and Chemistry of the Earth*, vol. 36, nos. 14–15, pp. 996–1003, 2011.
- [79]. Christopher M. Raymond, Ioan Fazey, Mark S. Reed, Lindsay C. Stringer, Guy M. Robinson, and Anna C. Evely, "Integrating Local and Scientific Knowledge for Environmental Management," *Journal of Environmental Management*, vol. 91, no. 8, pp. 1766–1777, 2010.