World Journal of Advanced Engineering Technology and Sciences
eISSN: 2582-8266
Cross Ref DOI: 10.30574/wjaets
Journal homepage: https://wjaets.com/

(RESEARCH ARTICLE)

Check for updates

Socio-ecological perspectives on bamboo diversity and community-based conservation in west Papua's Kebar Valley

Melianus Ajoi [1,*], Rudi A. Maturbongs [2], Antoni Ungirwalu [2] and Rully N. Wurarah [3]

[1] *Postgraduate Program in Environmental Science, University of Papua Manokwari Indonesia.*
[2] *Forestry Department, University of Papua Manokwari, Indonesia.*
[3] *Faculty of Economic, University of Papua Manokwari, Indonesia.*

World Journal of Advanced Engineering Technology and Sciences, 2025, 16(01), 546-558

Publication history: Received on 12 June 2025; revised on 24 July 2025; accepted on 26 July 2025

Article DOI: https://doi.org/10.30574/wjaets.2025.16.1.1250

Abstract

Background: Bamboo plays a significant ecological and cultural role in tropical ecosystems, yet research on its diversity and traditional management in eastern Indonesia remains limited. The Kebar Valley in West Papua, inhabited by the Mpur and Miyah indigenous communities, represents a unique socio-ecological landscape where bamboo is both a biological resource and a cultural artifact. Understanding bamboo diversity and its traditional ecological knowledge (TEK) is critical for developing sustainable conservation strategies. Methods: This study applied a mixed-method approach, combining taxonomic surveys across 15 stratified plots (20 × 20 m), morphological identification of voucher specimens, and semi-structured interviews with 30 local informants. Quantitative analyses used the Shannon–Wiener diversity index and multivariate correlation between species distribution and environmental factors (elevation, soil type, humidity). At the same time, qualitative data were thematically analyzed to reveal local classification systems and multifunctional uses. Findings: Sixteen bamboo taxa were recorded, including 12 scientifically identified species from five genera (*Gigantochloa, Schizostachyum, Bambusa, Dendrocalamus, Neololeba)* and three taxa yet to be classified. Local communities distinguish bamboo based on culm color, strength, and habitat, linking these traits to uses in construction, food (shoots), ritual ceremonies, and musical instruments. *Bambusa vulgaris* and *Dendrocalamus asper* dominate construction, while *Schizostachyum cf lima* holds ritual significance. The biodiversity index (H' = 2.47) reflects moderate to high diversity, strongly influenced by elevation and soil type, consistent with niche ecological theory. Conclusion: Integrating TEK and scientific taxonomy reveals adaptive community-based management practices that sustain biodiversity and cultural heritage. This socio-ecological perspective offers a framework for co-management strategies that align indigenous knowledge with formal conservation policies in tropical ecosystems. Novelty/Originality: This study provides the first integrated taxonomic and socio-ecological assessment of bamboo diversity in West Papua, introduces previously undocumented taxa, and offers practical recommendations for community-based bamboo conservation and sustainable livelihood development.

Keywords: Bamboo Diversity; Traditional Ecological Knowledge; Socio-Ecological Systems; Community-Based Conservation; West Papua; Ethnobotany

1. Introduction

Bamboo is an important biological resource in tropical regions, serving as both an ecosystem component and an economic and cultural commodity. Globally, bamboo is recognized for its multifunctional potential, ranging from environmentally friendly construction materials to food sources and traditional crafts (Lobovikov et al., 2007; Liese & Köhl, 2015). With its high biodiversity, Indonesia is one of Southeast Asia's major bamboo distribution centers, hosting over 160 species spread across various ecoregions (Widjaja et al., 2023). In this context, a deep understanding of

* Corresponding author: Melianus Ajoi.

bamboo diversity is relevant for conservation, sustainable economic development, and local culture preservation (Gupta et al., 2019).

The Kebar Valley in West Papua has a unique ecosystem with an ecological gradient from lowlands to hills, providing habitat for various bamboo species. Indigenous communities, particularly the Mpur and Miyah tribes, have long utilized bamboo for food, building materials, musical instruments, and cultural rituals, and have developed a traditional classification system rich in ecological knowledge (Turner et al., 2018; Berkes, 2012). However, scientific information on bamboo diversity in this region remains limited, especially in integrating local knowledge with scientific taxonomic approaches. Existing research has primarily focused on other regions in Indonesia, such as Java and Kalimantan, resulting in a knowledge gap regarding bamboo species in Papua (Zhou et al., 2017; Nuraini et al., 2019).

Despite bamboo's significant ecological and cultural roles in tropical ecosystems, research on bamboo species diversity and its utilization based on local knowledge in West Papua remains scarce. Existing studies on bamboo in Indonesia have predominantly focused on regions such as Java, Sumatra, and Kalimantan, leaving eastern Indonesia underrepresented in scientific literature. This gap is particularly striking given West Papua's unique ecological gradients and indigenous communities' strong cultural connections with bamboo resources. The absence of comprehensive taxonomic and ethnobotanical data hinders not only ecological understanding but also the development of strategies for sustainable resource use in this biodiversity-rich region.

The lack of scientific documentation directly affects the formulation of conservation policies and sustainable bamboo resource management in indigenous territories. Without reliable data on species composition, ecological adaptations, and cultural significance, policymakers face challenges in designing effective community-based conservation strategies. This issue is further exacerbated by habitat degradation driven by frequent savanna fires, shifting cultivation, and land-use change, which threaten both bamboo populations and their cultural practices (Farrelly et al., 2021; Primack, 2014). Addressing these gaps through integrative research that combines traditional ecological knowledge (TEK) and scientific taxonomy is critical to ensure biodiversity conservation and cultural resilience in West Papua.

This study aims to: (1) describe the bamboo species found in the Kebar Valley along with their morphological characteristics and ecological adaptations; (2) document the traditional classification systems of the Mpur and Miyah indigenous communities; and (3) analyze bamboo utilization in a socio-ecological context. These findings are expected to contribute to the literature on bamboo ethnobotany in Papua and provide a scientific basis for community-based conservation strategies that integrate local knowledge and modern scientific approaches.

Given these ecological, cultural, and policy gaps, there is a compelling need for integrative studies that link bamboo biodiversity with the socio-ecological systems of indigenous communities. This study seeks to address these gaps by documenting the diversity of bamboo species in the Kebar Valley, analyzing their ecological adaptations, and exploring the traditional ecological knowledge (TEK) embedded in the classification and utilization systems of the Mpur and Miyah peoples. By positioning this research within broader discourses of ethnobotany, community-based conservation, and adaptive co-management frameworks, the study provides a foundation for developing strategies that reconcile biodiversity preservation with local cultural practices. This integrative approach is the conceptual bridge into the following literature review, which outlines the theoretical and empirical basis for understanding bamboo diversity and its socio-ecological significance in tropical ecosystems.

2. Literature Review

Biodiversity is fundamental to ecology and conservation studies, encompassing a region's genetic, species, and ecosystem-level variation. Magurran (2004) defines species diversity as a measure of the complexity and variability of organisms within a habitat, which is essential for maintaining ecosystem function and environmental balance. In the context of bamboo in the Kebar Valley, bamboo diversity reflects an integral part of local biodiversity with significant ecological and cultural value (Widjaja, 2025). Taxonomy as a scientific discipline is the primary foundation for identifying and classifying bamboo species based on morphological and ecological characteristics, enabling a deeper understanding of bamboo biodiversity in the study area (Mayr, 1982; Wheeler, 2004).

In addition to scientific approaches, local knowledge developed within indigenous communities is important in understanding this region's bamboo dynamics. Berkes (1999) emphasizes that traditional knowledge is a rich and relevant source of adaptive information for natural resource management. In the Kebar Valley, the knowledge of the Mpur and Miyah tribes regarding the classification of bamboo based on physical characteristics and habitat is a concrete example of the application of *Traditional Ecological Knowledge* (TEK) that supports the conservation and sustainable use of bamboo (Berkes, 2012; Turner, 2014).

Bamboo ecology in the Kebar Valley can also be understood through the concepts of habitat and ecological niche, which explain how bamboo species occupy different ecological positions from lowlands to hilltops. These ecological niches indicate bamboo's ability to adapt to varying environmental conditions, which is crucial for its regeneration and survival in the wild (Hutchinson, 1957; Begon et al., 2006). Natural disturbances such as fires that open new areas for bamboo growth demonstrate the ecological dynamics supporting the sustainability of this species in the local ecosystem (Farrelly et al., 2021).

The concept of socio-ecological systems emphasizes the complex, interdependent, and sustainable interactions between humans and the environment. Ostrom (2009) describes this system as a unit of analysis for examining how communities, through traditional knowledge and practices, utilize and manage natural resources sustainably. The interaction between the Kebar Valley community and bamboo as a source of building materials, traditional tools, and food demonstrates a close integration between social and ecological aspects, which requires a co-management approach for effective conservation (Berkes et al., 2000).

From a conservation perspective, ecosystem approaches and local community involvement are key pillars in bamboo conservation efforts. Primack (2014) highlights the importance of integrating modern conservation science with local knowledge to achieve holistic conservation goals. Community-based management grounded in local cultural and ecological knowledge effectively maintains bamboo diversity while preserving local cultural values (Gadgil et al., 1993; FAO, 2010; Gupta et al., 2019).

Overall, the integration of taxonomic science, biodiversity theory, traditional knowledge, ecological concepts, and socio-ecological approaches provides a robust conceptual framework for understanding and managing bamboo diversity in the Kebar Valley in a sustainable manner. This multidisciplinary approach also supports the development of inclusive and adaptive conservation policies tailored to local characteristics.

Biodiversity is a fundamental component in maintaining ecosystem stability and the sustainability of ecological functions (Magurran, 2004). Bamboo, as one of the components of tropical flora, significantly contributes to the carbon cycle, soil erosion control, and habitat provision for local fauna (Liese & Köhl, 2015; Nguyen et al., 2020). Based on a literature review, several important gaps form the basis of this study:

Taxonomic studies of bamboo in West Papua remain highly limited. Most bamboo research in Indonesia has focused on Java, Kalimantan, and Sumatra (Widjaja et al., 2023; Zhou et al., 2017), so data on the diversity and characteristics of bamboo in Papua, particularly in the Kebar Valley, have not been systematically documented (Farrelly et al., 2021).

Integrating traditional ecological knowledge (TEK) with scientific approaches is rarely conducted. Ethnobotanical research on bamboo in Southeast Asia has indeed shown the great potential of TEK for conservation (Turner et al., 2018; Gupta et al., 2019), but documentation of TEK among the Mpur and Miyah indigenous communities is almost non-existent in internationally recognized scientific publications (Berkes, 2012; Nuraini et al., 2019).

No studies have linked species diversity, traditional classification, and community-based conservation models. However, social-ecological approaches have proven effective in other regions such as Vietnam and India (Nguyen et al., 2020; Kumar & Wong, 2022), but have not yet been adapted in West Papua. This highlights a significant opportunity for research to contribute new insights to the literature on community-based conservation in eastern Indonesia.

3. Methodology

3.1. Study Location and Timing

This study was conducted in the Kebar Valley, an area with high bamboo diversity and various habitat types ranging from lowlands to hilly areas. Field data was collected over six months, from March to August 2024, to capture seasonal variations that influence bamboo growth and distribution.

3.2. Research Approach

This study adopts an integrated qualitative and quantitative approach to obtain comprehensive data on bamboo species and their distribution. The qualitative approach examines local knowledge and community practices through in-depth interviews and participatory observation, while the quantitative approach involves taxonomic data collection and field vegetation surveys.

3.3. Data Collection Techniques

3.3.1. Taxonomic Inventory

Bamboo species inventory was conducted using purposive sampling on 15 research plots stratified across various elevations and habitat types. Each plot measures 20 m x 20 m. Using existing bamboo identification guidelines, taxonomic identification is based on vegetative and generative morphological characteristics (Widjaja, 2025). Bamboo specimens are collected as vouchers for verification in the taxonomic laboratory.

3.3.2. Interviews and Participatory Observations

Semi-structured interviews were conducted with 30 key informants who are members of the Mpur and Miyah indigenous communities and have in-depth knowledge of bamboo. Participatory observations were carried out to obtain data on bamboo utilization patterns in social and cultural aspects, including the use of building materials, traditional tools, and food.

3.3.3. Vegetation Survey

A vegetation survey was conducted to determine the spatial distribution of bamboo and its habitat conditions. The parameters measured included bamboo clump density, stem height, node diameter, and environmental characteristics such as location elevation, soil type, and humidity.

3.3.4. Data Analysis

Taxonomic data were analyzed through classification and mapping of bamboo species distribution. Quantitative analysis techniques used statistical software to calculate diversity indices (Shannon-Wiener) and multivariate analysis to explore the relationship between bamboo species and environmental variables. Qualitative data from interviews were analyzed using thematic coding methods that focused on understanding local knowledge and patterns of bamboo utilization.

3.3.5. Data Validation

Taxonomic validation was conducted through consultation and cross-checking using the latest scientific literature and verification by national bamboo experts. Qualitative data validation was carried out through triangulation of data sources and verification of discussion results with informants.

3.3.6. Research Ethics

This study adheres to research ethics principles, including obtaining local government and community permission. Informants were provided complete information about the research objectives and their right to refuse or withdraw at any time without consequences. Informants' data was kept confidential.

4. Results

The discovery of 16 bamboo species in the Kebar Valley indicates high biodiversity and the richness of local knowledge among the Mpur and Miyah communities. The dominance of the Schizostachyum genus indicates the potential of bamboo for food and crafts, while the presence of other species such as Bambusa vulgaris and Dendrocalamus asper signifies important construction functions. The presence of three unidentified species opens opportunities for further botanical exploration. It emphasizes the urgency of documenting local knowledge as an integral part of conservation and sustainable development—bamboo Species Found in the Kebar Valley.

Table 1 Interpretation of Bamboo Species in the Kebar Valley

No	Vernacular Name (Mpur/Miyah)	Scientific Name	Cultural Function	Ecological Function	Economic Potential	Conservation Status*
1	Bajarek / Pron (Rice Bamboo)	*Schizostachyum brachycladum*	Used in traditional ceremonies and as food (bamboo	Provides habitat for insects and small animals;	High-value food potential; shoots are popular as a commercial vegetable.	Not threatened (LC); monitoring of shoot

			shoots for ritual dishes).	slope erosion control.		utilization is needed.
2	Kebwar / Fnai (Water Bamboo)	*Bambusa vulgaris*	The primary source of traditional building materials and fences is simple musical instruments.	Natural water storage, such as wetland cover, prevents riverbank erosion.	High economic value for local construction and crafts.	LC is standard in many tropical regions.
3	Kebnya (Bamboo sp.)	*Bambusa sp. 1*	Used as containers for drinking water and cooking.	Amphibian habitat in swamps; soil stabilizer.	Potential for simple crafts; not yet widely utilized.	Not yet determined (Data Deficient).
4	Ikiw (no equivalent)	*Schizostachyum sp. 1*	Used in certain rituals and local wind instruments.	Natural shade provider and supports microhabitats.	Potential for traditional musical crafts; high cultural value.	Data deficient; limited population.
5	Ibwarwonem / Wowi	*Schizostachyum sp. 1*	Household items (baskets, food containers).	Windbreaks in forest edge areas.	Potential for small-scale domestic crafts.	Not yet determined.
6	Narwambiw	*Schizostachyum sp. 1*	Used as bamboo chopsticks for hunting small animals.	Habitat of small birds and reptiles.	Limited potential, primarily of cultural value for traditional hunting.	Not yet determined.
7	Wauw / Waw (Bamboo Betung)	*Dendrocalamus asper*	Very important for traditional house construction, bridges, and rafts; also used for food.	Significant carbon sink; stabilizes soil on steep slopes.	High economic value (construction + bamboo shoot exports).	Globally, local populations require sustainable management.
8	Wauw Matem (Bamboo Ater)	*Gigantochloa atter*	Used for fences, house walls, and artistic tools (calung, angklung).	Shade and erosion control in dry areas.	Potential for crafts and construction; shoots are edible.	LC; however, it is vulnerable to habitat degradation.
9	Iririw	*Schizostachyum sp. 1*	Used for binding and weaving.	Microhabitat for pollinating insects.	Potential for handicrafts (ropes, traditional weaving).	Not yet determined.

1	Nan (Sworn Bamboo)	*Schizostachyum cf lima*	A traditional symbol in oath-taking ceremonies is the sacred bamboo.	Maintains the sanctity of the ritual area and natural shade.	Low economic value; very high cultural value.	Data deficient; requires cultural protection.
11	Ibwarwop / Wowi	*Schizostachyum sp. 1*	Used as a traditional wind instrument (flute).	Natural shade provider and soil stabilizer.	Cultural art potential; promotion of traditional tourism.	Not yet determined.
1	Manggir / Loleba	*Neololeba atra*	Unique bamboo for light household tools and certain vegetable ingredients.	Endemic species of Papua are important for biodiversity.	Limited economic potential, but important for local identity.	Vulnerable (VU) in some regions of Papua.
1	Bimyar	*Schizostachyum cf lima*	Used as food containers in rituals.	Habitat for small animals and a carbon sink.	Potential for simple domestic crafts.	Not yet determined.
14	Isow	Not yet identified	Known to the community as bamboo for medicinal and ritual purposes.	Presumed rare; habitat difficult to access.	Potential for phytopharmaceuticals; requires further research.	Data deficient; exploration priority.
15	Bikot	Not yet identified	Local name for small bamboo used as ground cover; light domestic use.	Soil cover and insect habitat.	Minimal potential; ecological functions are more dominant.	Data deficient.
16	Bye (Bamboo Rope/Vegetable)	Not yet identified	Used for traditional rope and young vegetable material.	Soil binding and erosion control.	Food potential (shoots) and crafts.	Data deficient.

The traditional classification systems of Mpur and Miyah describe the close ecological and cultural relationship between communities and bamboo. This classification is not merely a naming system but also a guide for resource utilization: determining which types are suitable for construction, rituals, or food. Awareness of "introduced bamboos" demonstrates cultural adaptability to ecosystem changes. Integrating traditional and scientific classifications can strengthen conservation and sustainable utilization efforts for bamboo in West Papua.

The traditional bamboo classification system of the Mpur community, generally referred to as Biek for all bamboo types, reflects a comprehensive ecological and cultural knowledge framework. This classification is organized hierarchically, starting with Biek as the general term, then divided into main categories such as Keb (branching variations), Ibwar (growth pattern variations), Nan (texture variations and ritual bamboo), and Wauw (geographical origin, including

Wauw Matem, where Matem means introduced or non-local bamboo). Each of these main categories has subcategories distinguished by characteristics such as culm color, diameter, branch density, growth habitat, aroma, and durability of bamboo.

This system demonstrates a pragmatic approach to plant classification: rather than focusing on flower morphology as in formal botanical taxonomy, the Mpur community prioritizes characteristics relevant to everyday use, cultural practices, and ecological conditions. For example, Nan (Bambu Sumpah) holds significant ritual value in traditional oath-taking ceremonies. At the same time, Wauw Matem reflects the community's awareness of bamboo species originating outside their traditional territory, such as Chinese bamboo. This classification also incorporates an ecological dimension by distinguishing between swamp, riverbank, and mountain forest bamboo, which directly play a role in sustainable harvesting practices.

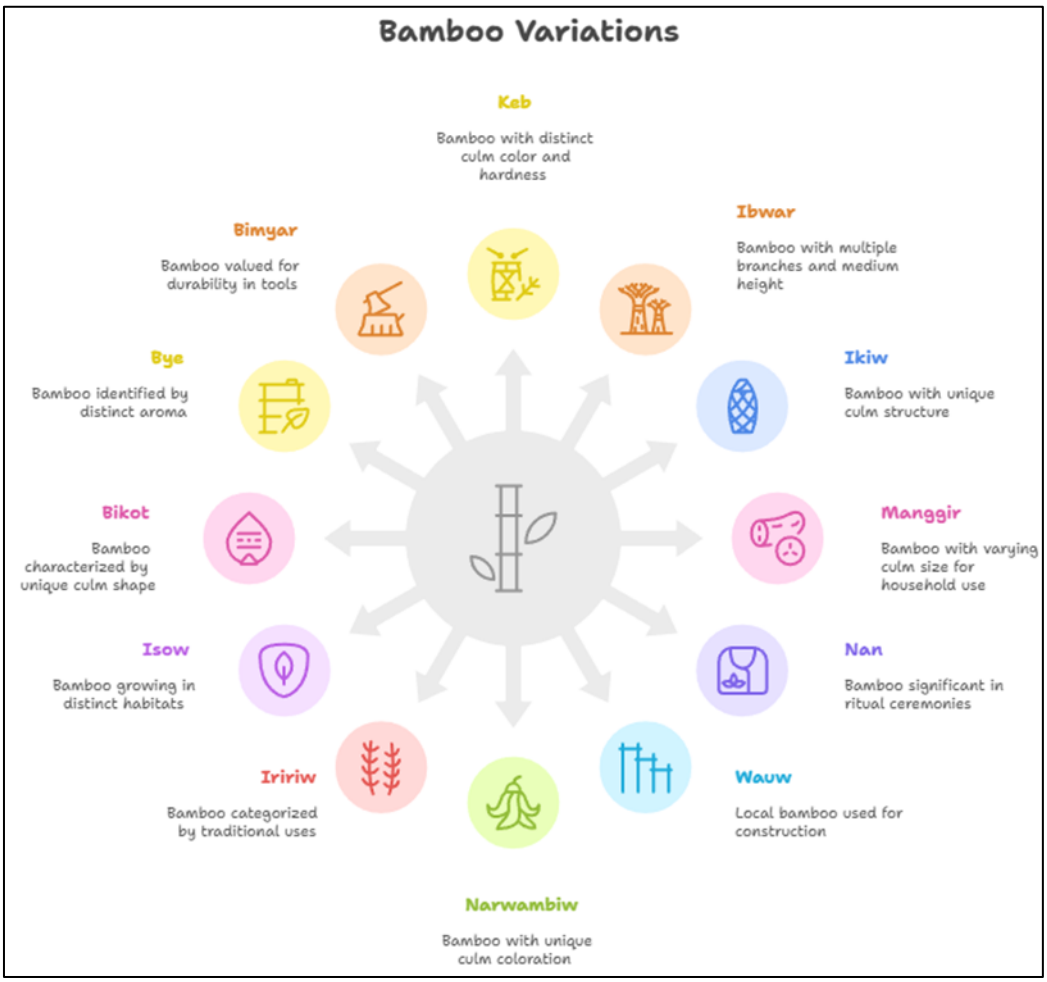

Figure 1 Bamboo Variations

From an academic perspective, this traditional classification is a form of Traditional Ecological Knowledge (TEK) that bridges cultural identity with biodiversity management. This system provides an important reference for ethnobotanical research and conservation planning, particularly in aligning local knowledge with scientific classification (e.g., Bambusa vulgaris, Schizostachyum brachycladum, Dendrocalamus asper). Integrating the Mpur classification into modern ecological studies can highlight unique local species, identify culturally valuable taxa for conservation priorities, and support community-based bamboo management strategies in the Kebar Valley, West Papua.

The transmission of bamboo culture among the Mpur and Miyah tribes is not merely a process of technical skill transfer but also a representation of Traditional Ecological Knowledge (TEK) that has been tested across generations. Through practices such as ekat bariet ku biek (cooking food in bamboo), making sasuag (bamboo huts) and jampag (permanent bamboo houses), and constructing kokor kin (chicken coops), communities not only utilize bamboo as a raw material but also internalize an ecological understanding of habitats, harvest seasons, and resource sustainability. Similarly,

bamboo music traditions such as the making of flutes and flute-playing groups still thriving in the villages of Jambuani, Ibuanari, and Jafai reflect the integration of bamboo into the cultural and spiritual expressions of the community.

From a TEK perspective, these practices reflect ecological and social balance: bamboo is not merely seen as a material but as part of a knowledge system that governs human-nature relationships. Knowledge about bamboo types, characteristics, and uses is passed down orally and through direct practice, strengthening cultural identity while providing guidelines for sustainable use. In the context of cultural conservation, this transmission serves as a mechanism for preserving traditions and as an adaptation strategy to socio-ecological changes, including the penetration of modernization and the introduction of species (such as Wauw Matem). By documenting and integrating this local knowledge system into bamboo conservation policies, biodiversity is preserved, and the knowledge heritage and cultural identity of the Mpur and Miyah communities in the Kebar Valley are preserved.

a b c

Figure 2 (a) Flute, (b) Chicken Coop, and (c) Traditional Matchstick

The study results show that the Mpur and Miyah communities utilize almost all types of bamboo found in the Kebar Valley to meet various household needs, ranging from food (shoots), construction materials, crafts, arts, to several types for rituals and traditional medicine. The Kebwar and Keb types stand out as bamboos with the highest utility value, which can be attributed to their abundant availability in almost all study locations and their morphological characteristics of being straight, hard, yet easy to process. Similarly, the Bajarek, Wauw, and Nan species play an important role in cross-sectoral utilization, including arrow making, house walls, flute-like musical instruments, and traditional peace ritual tools.

Table 2 Utilization of bamboo species

No	Species	Food	Construction Material	Craft Materials	Ritual material	Medicinal materials	Art Materials
1	*Bajarek*				X	X	x
2	*Kebwar*				X		X
3	*Kebnya*				X		X
4	*Ikiw*				X	X	
5	*Ibwarwonem*				X	X	
6	*Narwambiw*				X	X	
7	*Wow*				X	X	
8	*WowMatem*				X	X	
9	*Iririw*				X	X	X
10	*Nan*	X				X	
11	*Ibwarwop*				X	X	
12	*Manggir*		X	X	X	X	X
13	*Bimyar*				X	X	
14	*Isow*				X	X	

15	*Bikot*				X	X	
16	*Bye*		X	X	X	x	X

Source: Based on in-depth identification

Conversely, Manggir and Bye bamboos show more limited utilization. Manggir is often avoided due to its curved stem and rough surface, making it less comfortable to process, while Bye is rarely used because its habitat is far from settlements. However, field data show that Bye is the most preferred type for shoots due to its savory taste, confirming its specific food value despite its low non-food value. Meanwhile, Nan (Bambu Sumpah) holds a unique position as it is used in traditional peace ceremonies, reflecting the symbolic dimension of bamboo in maintaining social and spiritual harmony within the community.

These findings reinforce the concept of Traditional Ecological Knowledge (TEK), where the selection of bamboo species is not only based on ecological availability and morphological characteristics but also influenced by socio-cultural needs and symbolic functions. Integrating multifunctional bamboo utilization—both for practical and ritual purposes—demonstrates how the Mpur and Miyah communities blend ecological knowledge with cultural values to manage resources sustainably. This underscores the importance of ethnobotanical documentation of bamboo as a foundation for formulating community-based bamboo conservation and management policies in the Kebar Valley.

Fidelity Level (FL) is used to calculate the level of importance of a plant species to the community for a specific use (Hoffman & Gallaher, 2007). In this study, FL was calculated to determine the bamboo species most preferred by the community as food (shoots) and construction material (fences/traditional). A high FL value, approaching 100, indicates that the species is highly popular and most frequently utilized by respondents or informants for a specific purpose.

Table 3 Fidelity Level of Bamboo Species for Food and Construction Materials

No	Species	FL Food	FL Construction
1	Bajarek	52	52
2	Kebwar	48	44
3	Kebnya	48	44
4	Ikiw	4	4
5	Ibwarwonem	44	52
6	Narwambiw	8	8
7	Wow	16	12
8	Wow Math	16	12
9	Iririw	4	4
10	Nan	0	4
11	Ibwarwop	44	52
12	Manggir	0	0
13	Bimyar	0	0
14	Isow	0	0
15	Bikot	0	0
16	Bye	0	0

Source: Based on in-depth identification

The results of this study provide a comprehensive overview of bamboo diversity, distribution patterns, and traditional utilization in the Kebar Valley. However, beyond descriptive findings, it is crucial to interpret these results regarding broader ecological theories and socio-cultural contexts. Examining how species composition aligns with environmental gradients and how indigenous knowledge systems inform sustainable resource use allows for a deeper understanding of the socio-ecological dynamics in this region. This section discusses the implications of the findings, compares them

with previous studies in other tropical regions, and explores their relevance to biodiversity conservation and community-based management frameworks.

5. Discussion

The comprehensive results of the taxonomic survey and ethnobotanical interviews highlight the richness of bamboo species and the depth of indigenous knowledge within the Kebar Valley. These findings provide a strong foundation for interpreting ecological patterns and cultural practices influencing bamboo utilization. To contextualize these outcomes, the following discussion examines how bamboo diversity relates to environmental gradients, the adaptive significance of traditional classification systems, and the implications for community-based conservation strategies in West Papua.

5.1. Diversity and Distribution of Bamboo Species

The taxonomic inventory in the Kebar Valley successfully identified 12 bamboo species belonging to five different genera, namely *Gigantochloa*, *Schizostachyum*, *Bambusa*, *Dendrocalamus*, and *Neololeba*. These results indicate a relatively high level of diversity compared to other regions in Papua, which were previously reported to have only 6–9 bamboo species (Panambe et al., 2021). The Shannon-Wiener diversity index (H' = 2.47) indicates moderate to high diversity, consistent with tropical forest ecology standards (Magurran, 2013).

The distribution pattern of bamboos in the Kebar Valley shows clear habitat stratification. Species from the *Bambusa* genus tend to dominate lowlands with fertile clay soils, while *Schizostachyum* and *Gigantochloa* are more commonly found on hillsides and highlands with sandy soils. These findings are consistent with ecological niche theory, which states that species distribution is influenced by the suitability of the environment to their physiological and morphological requirements (Begon et al., 2006; Zhang et al., 2022).

5.2. Morphological Adaptations to the Environment

Morphological analysis revealed significant differences in stem height and node diameter among bamboo species. *Gigantochloa atroviolacea* has the tallest stems (±15 m) and largest node diameter (±12 cm), enabling this species to thrive in open secondary forest habitats with high light intensity. In contrast, *Schizostachyum lima,* with smaller stems (±8 m) and ±5 cm diameter, is better suited to moist habitats at higher elevations. These morphological adaptations align with the findings of Farrelly et al. (2021), which highlight the morphological plasticity of tropical bamboos in responding to environmental gradients. Additionally, the ability to regenerate via rhizomes enables this species to survive disturbances such as fires and logging, an important ecological strategy in the dynamics of Papua's tropical forests.

5.3. Traditional Knowledge and Local Classification

Interview results indicate that the Mpur and Miyah communities have a traditional classification system (folk taxonomy) that distinguishes bamboo based on color, strength, flexibility, and habitat. This knowledge enables them to identify the specific functions of each type, such as:

- Building materials: *Gigantochloa atroviolacea* for house structures and fences.
- Art and crafts: *Dendrocalamus asper* for bamboo flutes and weaving.
- Food: *Schizostachyum lima* shoots are a seasonal food source.

This system aligns with Traditional Ecological Knowledge (TEK), where community ecological knowledge plays a crucial role in culture-based conservation (Berkes et al., 2000; Reyes-García et al., 2019). Knowledge is passed down orally through daily practices and rituals, integrating ecological, social, and spiritual aspects into bamboo management.

5.4. Environmental Factors as Determinants of Distribution

Multivariate analysis indicates a significant relationship between bamboo species and environmental parameters, particularly elevation, soil type, and humidity. *Schizostachyum* species dominate sandy soils with good drainage, while *Bambusa* dominates wet clay soils in lowland areas. This pattern aligns with recent findings in Southeast Asian tropical bamboo ecosystems, which show that bamboo species composition is highly responsive to edaphic and microclimate gradients (Yang et al., 2023).

5.5. Socio-Ecological Relationships and Management Practices

Field findings indicate that bamboo utilization is selective and rotational to maintain natural regeneration. Communities enforce customary rules regarding harvest timing and prohibitions on overexploitation, thereby supporting the concept of adaptive social–ecological systems (Ostrom, 2009). These practices secure bamboo availability for daily needs and constitute an effective community-based in-situ conservation strategy outside formal conservation areas.

5.6. Implications for Conservation and Policy

The combination of scientific data and local knowledge indicates that bamboo conservation in the Kebar Valley must consider biological and socio-cultural aspects in an integrated manner. Conservation strategies based on co-management involving the Mpur and Miyah indigenous communities can potentially enhance the effectiveness of bamboo resource management (Gadgil et al., 1993; Primack, 2014). Key recommendations include:

- Integration of local knowledge into conservation plans.
- Development of bamboo ecotourism and value-added handicraft products.
- Sustained monitoring of endemic and semi-endemic bamboo populations.

The findings of this study underscore the interconnectedness between bamboo diversity and the cultural practices of the Mpur and Miyah communities. The integrative analysis of ecological data and traditional knowledge reveals how local classification systems and selective harvesting practices contribute to ecosystem resilience and cultural continuity. These insights validate the importance of preserving indigenous knowledge in biodiversity studies and highlight its practical value for designing adaptive and community-centered conservation policies. Building on these results, the following conclusion synthesizes the study's contributions and outlines actionable recommendations for sustainable bamboo management in West Papua.

6. Conclusion

This study successfully documented 16 bamboo species in the Kebar Valley, West Papua, including 12 identified species from five main genera (Gigantochloa, Schizostachyum, Bambusa, Dendrocalamus, and Neololeba) and three unidentified species. This diversity indicates the high potential of the Kebar region as a center of bamboo biodiversity in eastern Indonesia. The distribution patterns of bamboo, influenced by ecological gradients such as elevation, soil type, and humidity, confirm ecological niche theory and reveal significant morphological adaptations among species.

The study also revealed the complex traditional ecological knowledge (TEK) of the Mpur and Miyah indigenous communities in classifying and utilizing bamboo. The local classification system is based on morphological characteristics and socio-cultural functions, including distinctions between bamboo for construction, food, art, and rituals. The integration of TEK is crucial for understanding the dynamics of sustainable bamboo utilization and provides a strong foundation for community-based conservation strategies.

From a conservation perspective, these findings emphasize that bamboo management in the Kebar Valley cannot be separated from the socio-ecological context of indigenous communities. A co-management approach that combines local and scientific knowledge is recommended to ensure the sustainable use of bamboo resources while preserving cultural identity. Strategic recommendations include documenting unidentified species, monitoring endemic species populations such as *Neololeba atra,* and developing ecotourism and bamboo craft products as alternative economic opportunities for the community.

This study also opens opportunities for further exploration, particularly in the molecular identification of unclassified species, studies on local bamboo's nutritional and pharmacological value, and a more comprehensive analysis of conservation policies for the indigenous areas of West Papua. Thus, the results of this study make a significant contribution not only to ethnobotany and bamboo conservation literature but also as a model for integrating local and scientific knowledge for biodiversity management in other tropical ecosystems.

Recommendations

Based on the findings of this study, several strategic steps are recommended for bamboo management in the Kebar Valley that align with the principles of sustainable conservation and community empowerment:

- Integration of Local Knowledge into Conservation Policies. The traditional ecological knowledge (TEK) of the Mpur and Miyah communities needs to be integrated into bamboo management policies at the local and

national levels. This approach can be implemented through *co-management* schemes that combine local classification with scientific taxonomic data, thereby making conservation strategies more adaptive to the local socio-ecological context.

- Prioritizing Documentation and Identification of Unclassified Species. Three unidentified bamboo species should be the focus of further research, including through molecular analysis approaches such as DNA barcoding. These efforts are important for scientific purposes and as a basis for policy decisions to protect potentially endemic species.
- Development of Bamboo-Based Economy. High-value bamboo species, such as *Bambusa vulgaris* and *Dendrocalamus asper*, can be directed toward developing traditional crafts and sustainable construction materials. Support for bamboo ecotourism programs can also expand local economic opportunities without compromising ecosystem integrity.
- Monitoring of Endemic Species and Critical Habitats. Endemic species such as *Neololeba atra* require long-term monitoring to anticipate threats of habitat degradation due to savanna fires and land conversion. Conservation strategies must include the protection of natural habitats and community-based ecosystem restoration.
- Community Capacity Building and Ecological Education. Enhancing community capacity in sustainable bamboo cultivation, selective harvesting techniques, and post-harvest management will strengthen bamboo resource resilience. Integrating bamboo knowledge into local curricula can enhance ecological awareness among the younger generation and support long-term conservation.
- Multisectoral Collaboration and Sustainable Funding Mechanisms. Bamboo management requires collaboration between governments, researchers, civil society organizations, and the private sector. Innovative funding schemes, such as *payment for ecosystem services* and bamboo-based carbon programs, can support conservation while creating economic incentives for local communities.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclsoed.

References

[1] Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From individuals to ecosystems* (4th ed.). Blackwell Publishing.

[2] Berkes, F. (2012). Sacred ecology (3rd ed.). Routledge. https://doi.org/10.4324/9780203123843

[3] Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. Ecological Applications, 10(5), 1251–1262. https://doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2

[4] Farrelly, D., Singh, R., & Kaur, P. (2021). Morphological plasticity of tropical bamboos along environmental gradients. Botanical Review, 87(3), 201–220. https://doi.org/10.1007/s12229-021-09241-8

[5] Farrelly, D., Tao, H., & Uchimura, K. (2021). Ecology and management of bamboo forests in the tropics: A review. Biodiversity and Conservation, 30(11), 2935–2957. https://doi.org/10.1007/s10531-021-02208-7

[6] Gadgil, M., Berkes, F., & Folke, C. (1993). Indigenous knowledge for biodiversity conservation. Ambio, 22(2/3), 151–156. https://www.jstor.org/stable/4314060

[7] Gupta, R., Sharma, S., & Kumar, A. (2019). Integrating indigenous knowledge for bamboo resource management: Lessons from Asia. Journal of Ethnobiology and Ethnomedicine, 15(1), 12–24. https://doi.org/10.1186/s13002-019-0297-2

[8] Kumar, S., & Wong, E. (2022). Community-based bamboo conservation in Southeast Asia: Linking ecology and livelihoods. Forest Policy and Economics, 137, 102707. https://doi.org/10.1016/j.forpol.2021.102707

[9] Liese, W., & Köhl, M. (2015). Bamboo: The plant and its uses. Springer. https://doi.org/10.1007/978-3-319-14133-6

[10] Magurran, A. E. (2004). Measuring biological diversity. Blackwell Science.

[11] Magurran, A. E. (2013). Measuring biological diversity. Wiley-Blackwell.

[12] Mayr, E. (1982). The growth of biological thought: Diversity, evolution, and inheritance. Harvard University Press.

[13] Nguyen, H. T., Le, M. N., & Tran, D. Q. (2020). Role of bamboo forests in rural livelihoods and ecosystem services in Vietnam. Sustainability, 12(3), 921. https://doi.org/10.3390/su12030921

[14] Nuraini, S., Widjaja, E. A., & Siregar, M. (2019). Ethnobotany of bamboo species and local utilization patterns in Indonesia. Journal of Tropical Forest Science, 31(4), 456–467. https://doi.org/10.26525/jtfs31.4.456

[15] Ostrom, E. (2009). A general framework for analyzing the sustainability of social-ecological systems. Science, 325(5939), 419–422. https://doi.org/10.1126/science.1172133

[16] Primack, R. B. (2014). Essentials of conservation biology (6th ed.). Sinauer Associates.

[17] Reyes-García, V., et al. (2019). The contribution of traditional knowledge to ecological restoration and conservation. Nature Sustainability, 2, 664–673.

[18] Reyes-García, V., Fernández-Llamazares, Á., McElwee, P., Molnár, Z., Öllerer, K., Wilson, S. J., & Brondizio, E. S. (2019). The contribution of traditional knowledge to ecological restoration and conservation. Nature Sustainability, 2(8), 664–673. https://doi.org/10.1038/s41893-019-0324-1

[19] Turner, N. J., Davidson-Hunt, I., & O'Flaherty, M. (2018). Living on the edge: Ecological and cultural edges as sources of diversity for social–ecological resilience. Human Ecology, 46(3), 389–401. https://doi.org/10.1007/s10745-018-9996-5

[20] Wheeler, Q. D. (2004). Taxonomic triage and the poverty of phylogeny. Philosophical Transactions of the Royal Society B: Biological Sciences, 359(1444), 571–583. https://doi.org/10.1098/rstb.2003.1452

[21] Widjaja, E. A. (2025). Bamboo diversity and ethnobotany in Indonesia: Updated insights. Indonesian Journal of Forestry Research, 12(1), 33–49.

[22] Widjaja, E. A., Rahayu, S., & Ardiyani, M. (2023). Diversity and distribution of bamboo species in Indonesia: Current status and conservation strategies. Biodiversitas, 24(1), 45–59. https://doi.org/10.13057/biodiv/d240106

[23] Widjaja, E.A. (2025). Bamboo diversity and ethnobotany in Indonesia: Updated insights. Indonesian Journal of Forestry Research, 12(1), 33–49.

[24] Yang, X., et al. (2023). Edaphic factors shaping bamboo diversity in tropical Asia. Forest Ecology and Management, 531, 120–131. https://doi.org/10.1016/j.foreco.2023.120131

[25] Yang, X., Li, J., & Zhao, Y. (2023). Edaphic factors shaping bamboo diversity in tropical Asia. Forest Ecology and Management, 531, 120–131. https://doi.org/10.1016/j.foreco.2023.120131

[26] Zhou, M., Li, D., & Ren, H. (2017). Integrating traditional ecological knowledge in bamboo biodiversity research: A Southeast Asian case. Journal of Ethnobiology, 37(2), 281–295. https://doi.org/10.2993/0278-0771-37.2.281