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Local Wisdom of Mangrove Utilization in a Remote Coastal Village in Kubu Raya, West Kalimantan: An Ethnoscience Perspective for Contextual Science Education

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Abstract

Science education can be enriched by integrating local culture and wisdom, particularly through the exploration of mangrove ecosystems. Mangroves not only play an essential ecological role but also embody local knowledge that can be linked to scientific concepts. This study aims to identify and describe the local wisdom of the Nipah Panjang, Kubu Raya Regency, West Kalimantan community in utilizing various mangrove species as a source of contextual science learning. A descriptive qualitative design with an ethnopedagogical approach was employed, combining literature review, document analysis, and brief field observations. The findings reveal that six dominant mangrove species, Avicennia alba, Avicennia marina, Bruguiera gymnorrhiza, Excoecaria agallocha, Rhizophora apiculata, and Rhizophora mucronata, are utilized in diverse ways according to their biological traits and bioactive compounds. Their uses include construction materials, firewood, charcoal, traditional medicine (e.g., for eye treatment, anti-inflammatory purposes, and gastric remedies), and support for honeybee cultivation. Such practices highlight the integration of ethnoscientific knowledge with science concepts, including ecosystem adaptation, plant structure, wood properties, and bioactive compounds. By bridging modern science with local wisdom, science education can become more contextual and meaningful, while fostering environmental awareness and a conservation-oriented mindset toward coastal ecosystems.

How to Cite

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INTRODUCTION

Indonesia harbors the largest mangrove forests in the world and possesses extraordinary biodiversity. The uniqueness of Indonesia's mangrove ecosystems lies in their exceptionally high species richness on a global scale, with major distributions found in coastal areas of Kalimantan and Papua (Wijayanti, 2016). One of the most extensive mangrove forests is located in Nipah Panjang, Batu Ampar District, West Kalimantan, which has been widely utilized for ecotourism (Atunnisa et al., 2025; Fariz et al., 2024; Jabbar et al., 2021). Despite being geographically remote, the development of ecotourism has projected Nipah Panjang as an accessible destination, creating a paradoxical image of a "non-remote" area (Jabbar et al., 2021).

In reality, Nipah Panjang is administratively designated as a very remote area concerning the working areas of community health centers in Kubu Raya Regency (Pemerintah Kabupaten Kubu Raya, 2023). The village is difficult to reach by land and is primarily accessed through water transportation. The journey from Rasau Jaya Port to Nipah Panjang takes approximately 3–4 hours, and Rasau Jaya itself is located about 30 km from Pontianak, the provincial capital of West Kalimantan (Permana et al., 2022). This geographical isolation shapes unique socio-cultural practices, including how local communities utilize mangrove resources for daily survival.

Beyond their ecological functions, mangrove ecosystems provide critical socio-economic contributions such as ecotourism and educational services (Maulida et al., 2019). Science education today increasingly emphasizes experiential learning, where students are encouraged to construct knowledge through direct engagement with their surroundings. Contextual approaches allow learners to connect abstract scientific concepts with everyday experiences, including local environments. One promising entry point is through the integration of local culture or local wisdom into science learning, particularly by exploring mangrove ecosystems. Mangroves are not only ecologically vital but also embody diverse cultural practices and indigenous knowledge that can be linked to science education.

Through this integration, students can investigate plants, animals, and microorganisms in mangrove habitats, while simultaneously learning how communities utilize mangrove stems, branches, leaves, flowers, and fruits, for firewood, building materials, traditional medicine, and aquaculture practices. Education is inherently dynamic, reflecting both cultural values and societal transformations. It should, however, remain rooted in local traditions and cultural identities (Darmadi, 2018). Incorporating local wisdom into science education has been shown to enhance environmental awareness and scientific literacy among students (Qodim, 2023). Specifically, embedding the local knowledge of mangrove use provides not only moral and ethical values but also instills ecological responsibility and an understanding of ecosystem balance, which is highly relevant for science learning (Widiarini et al., 2025). While prior studies have explored mangroves as contextual learning resources (Fahmi & Fajeriadi, 2024; Hidayat et al., 2025; Utami et al., 2021), most focus on biodiversity aspects, whereas the dimension of local wisdom remains underexplored.

The relationship between mangrove forests, ethnoscience, and contextual learning in the National Curriculum is complementary (Marfiana et al., 2025). Mangrove ecosystems provide real natural phenomena that are relevant to study in science, such as root structures, adaptation mechanisms, and organism interactions. Local community knowledge about the use of mangroves enriches scientific perspectives through ethnoscience, which shows the relationship between the biological characteristics of plants and their use in everyday life (Rangga et al., 2023). Contextual learning then connects these two aspects through experience-based learning activities, problem solving, and discussion of local phenomena. This approach directly supports the achievement of science competencies in the Merdeka Curriculum, especially on the topics of ecosystems, biodiversity, adaptation, and secondary metabolites. Thus, the integration of mangrove forests in learning not only enables students to understand science more meaningfully, but also fosters environmental conservation values and appreciation for local wisdom as part of 21st century competencies.

Overall, contextual science education grounded in local wisdom represents an innovative and meaningful pedagogical approach that simultaneously fosters cultural preservation and national identity. Integrating Nipah Panjang's mangrove-based local wisdom into science education is expected to enrich student learning by offering authentic engagement with local flora and fauna. The purpose of this study is to identify and describe community knowledge regarding the utilitarian functions of mangrove species in Nipah Panjang. The reconstructed ethnoscience framework is anticipated to serve as an alterna-

tive learning resource, directly supporting the mitigation of biodiversity loss, one of the pillars of the triple planetary crisis (Miao & Ndu-neseokwu, 2025), and aligning with SDGs 14 (Life Below Water) and 15 (Life on Land).

METHOD

The study location in this study is a remote coastal village in Kubu Raya Regency, West Kalimantan. The key area in this study is in Nipah Panjang Village, Batu Ampar District (Figure 1). Nipah Panjang Village is difficult to access by land and is generally reached via water transportation such as motor aek (motorized wooden boats) and spit (motorboats). The journey by motor aek takes approximately 3–4 hours from Rasau Jaya Port, which itself is located about 30 km from Pontianak, the capital city of West Kalimantan Province. The total population of Nipah Panjang Village is around 2,778 inhabitants, concentrated mainly in the northeastern settlement area (BPS Kubu Raya Regency, 2024). The southern part of the village is dominated by peat swamp forest, while mangrove forests are concentrated in the northern part of Nipah Panjang.

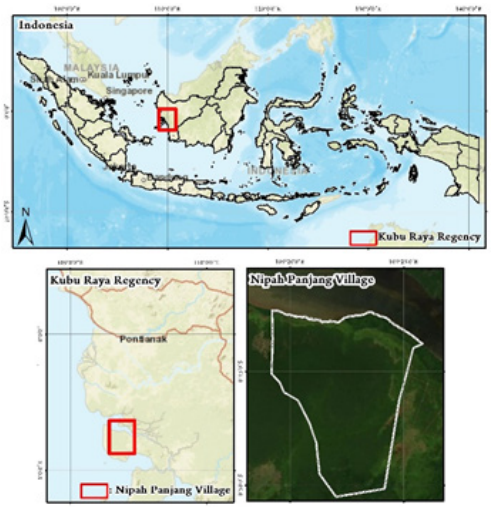

Figure 1. Study location

This study employed a descriptive qualitative design with an ethnopedagogical approach, emphasizing the role of local wisdom in education. The research explored patterns of mangrove utilization within the community of Nipah Panjang, Kubu Raya Regency, West Kalimantan. Data were collected through two complementary techniques: (i) a literature-based analysis to reconstruct ethnoscientific knowledge of mangrove ecosystems and identify science concepts embedded within local practices, and (ii) short open observations (open observation) supported by in-depth interviews with community members regarding the utilization of mangrove forests, in which a single key respondent provided detailed narratives based on lived experience. The combination of literature review, field observation, and interview techniques ensured methodological triangulation in capturing both conceptual and empirical dimensions of local knowledge.

The focus of this investigation was to document how mangroves are perceived and utilized by local communities, and to explore how these practices can be integrated into contextual science learning. Local wisdom broadly includes rituals, tourism practices, traditional games, clothing, folklore, artistic expressions, infrastructure, institutional systems, and land management strategies (Fariz et al., 2025). However, in this study, the scope of local wisdom is specifically limited to community practices related to mangrove utilization. Furthermore, the identified forms of mangrove utilization are discussed in relation to relevant literature and mapped against potential compatibility with the Relevant Science Concepts in the Indonesian secondary school curriculum (Grades VII–XI).

RESULT AND DISCUSSION

The mangrove forests of Nipah Panjang Village, located in Batu Ampar Sub-district, Kubu Raya Regency, West Kalimantan, constitute part of one of the largest mangrove areas in Indonesia, covering approximately 61% of the sub-district's total land area (Ritabulan et al., 2016). These forests are notable not only for their high species richness and dense canopy structures (Zulkarnain, 2016; Fatria, 2017), but also for their ecological uniqueness, as the closed canopy provides critical habitat for the proboscis monkey (Nasalis larvatus) (Yokassye et al., 2019). Between 2013 and 2018, approximately 3.12 hectares of mangrove deforestation were recorded in this region. However, the rate of forest loss has declined compared to previous decades, largely due to devolution policies that strengthened community-based forest management rights (Atunnisa et al., 2025).

Figure 2. Mangrove in Nipah Panjang Village

The local community plays an active role in mangrove conservation through sustainable practices such as kelulut honey farming, forest honey harvesting, and crab cultivation under the silvofishery system (Atunnisa et al., 2025; Fariz et al., 2024). In addition, ecotourism initiatives have been developed to simultaneously enhance community livelihoods and promote mangrove conservation. These integrated efforts reflect a dual commitment to ecological preservation and socioeconomic resilience. Mangrove ecosystems serve not only as natural buffers against coastal erosion but also as repositories of local wisdom deeply embedded in community practices. The socio-economic dynamics of Nipah Panjang are inseparable from local perceptions and traditions associated with mangrove use. Various mangrove species are utilized for daily needs, ranging from construction and fuel to medicine and apiculture. Table 1 provides an overview of mangrove species and their uses by the local community.

Table 1. Local and Scientific Names of Mangrove Species and Their Uses in Nipah Panjang Village

Local Name	Scientific Name	Utilization by Local Community
Api-api	*Avicennia alba*	Timber for construction, firewood
Api-api putih	*Avicennia marina*	Timber for construction, firewood
Tumu	*Bruguiera gymnorrhiza*	Fruit used as traditional eye medicine
Buta-buta	*Exoecaria agallocha*	Bark used for anti-inflammatory treatment
Bakau	*Rhizophora apiculata*	Timber for construction, charcoal, fuel, medicine, apiculture
Belukap	*Rhizophora mucronata*	Timber for construction, fuel, medicine for gastric ailments

Although firewood use has declined, now reserved mainly for special events such as weddings, mangroves remain integral to the livelihoods of Nipah Panjang residents (Flassy et al., 2024). Beyond material use, mangroves embody ecological and cultural significance, making them vital for both biodiversity and human well-being. From a scientific standpoint, the knowledge embedded in these practices offers rich opportunities for contextual science education. By integrating ethnoscientific insights into science curricula, students can explore concepts of ecology, biodiversity, and sustainable resource management through the lens of local practices. For instance, Avicennia alba, locally known as api-api, is widely used for construction and fuel. With a dry density of approximately 0.83 g/cm^3, it is well-suited for light structures such as house pillars or flooring (Kusmana, 2010). Its high lignin and cellulose content generates a calorific value of 4,000–4,500 kcal/kg, producing stable heat for cooking (FAO, 2007). Similarly, Avicennia marina demonstrates comparable physical and chemical properties, further enriched by tannins, phenols, and mineral salts that enhance durability in humid environments (Alongi, 2009).

Another example is Bruguiera gymnorrhiza (tumu), whose fruits are traditionally used as eye medicine. Scientifically, the species contains tannins, flavonoids, and alkaloids with antibacterial, anti-inflammatory, and antioxidant properties (Ragavan, 2017). Beyond medicinal use, its starchy fruits offer potential as alternative food sources (Patimah, 2022), while its bioactive compounds may serve as natural antimicrobials for food preservation (Hastarini, 2014). The Exoecaria agallocha (buta-buta) is valued for its bark, traditionally prepared as poultices or decoctions for inflammation. Pharmacologically, the species contains flavonoids (antioxidants), triterpenoids (anti-inflammatory), and saponins (cell-permeability enhancers) (Abeysinghe et al., 2014; Ravikumar, 2011). Other parts of the plant, including leaves and latex, exhibit additional medicinal potential such as anticancer and antibacterial effects (Pambudi, 2022).

Likewise, Rhizophora apiculata (bakau) is considered a multipurpose species: its timber is used for construction and charcoal, while its flowers provide nectar for honey production. With a high calorific value of 4,800–5,000 kcal/kg, its charcoal burns efficiently (FAO, 2007). Bioactive compounds such as flavonoids, triterpenoids, and saponins contribute to its medicinal applications, particularly as antioxidants with anticancer potential (Khairun, 2018). The distinctively bitter-

salty honey produced from its flowers further enhances its economic value (Hasrizart et al., 2023; Hidayatulloah, 2016). Similarly, Rhizophora mucronata (belukap) is utilized for construction, firewood, and traditional remedies for gastric ailments. Its phytochemical content, including alkaloids, flavonoids, and tannins, underpins its medicinal use as a gastroprotective agent (Nur et al., 2022). This body of local knowledge demonstrates a direct connection between ethnoscience and core science concepts such as plant adaptation, ecosystem roles, and bioactive compounds. To highlight this connection, Table 2 maps ethnoscientific practices of mangrove utilization to relevant science concepts across educational levels.

Table 2. Mapping of Mangrove Ethnoscience to Science Education Concepts

Mangrove Species	Community Use	Relevant Science Concepts	Educational Level
Avicennia alba	Timber, fuel	Plant structure, coastal adaptation, wood density	Grade VII
Avicennia marina	Timber, fuel	Plant structure, coastal adaptation, wood density	Grade VII
Bruguiera gymnorrhiza	Eye medicine	Bioactive compounds, ethnopharmacology	Grade X
Exoecaria agallocha	Anti-inflammatory	Secondary metabolites, pharmacology	Grade XI
Rhizophora apiculata	Timber, charcoal, medicine, honey	Ecosystem adaptation, wood properties, local economy	Grade VII
Rhizophora mucronata	Timber, fuel, gastric medicine	Plant structure, anti-ulcer bioactivity	Grade X–XI

The reconstruction of original science through mangrove ethnoscience, as presented in Table 2, demonstrates how local wisdom can be integrated into science learning. The various uses of mangrove species, ranging from timber, fuel, and charcoal to traditional medicine and honey, can be mapped to scientific concepts such as plant structure, bioactive compounds, pharmacology, and ecosystem adaptation. These contextual science concepts can be embedded in curricula from junior to senior high school levels, making learning more relevant and meaningful. Contextual learning of this kind is particularly suitable for remote areas with limited educational facilities, such as in coastal villages of Kubu Raya, where students are directly surrounded by mangrove ecosystems. Several studies emphasize that contextual learning is highly relevant in remote regions because it connects scientific material with students' daily lives (Zimmerman et al., 2017), strengthens community engagement, and adapts to local socio-cultural conditions. In Indonesia, for instance, contextual character education in remote schools has been proven effective when supported by local wisdom and community participation, thereby enhancing the quality and relevance of education (Hermino & Arifin, 2020). Thus, the integration of mangrove ethnoscience into science education not only facilitates students' understanding of scientific concepts but also fosters appreciation of local culture and encourages its preservation.

Despite its contributions, this study has several limitations. First, data collection relied mainly on literature review and limited field observation, without in-depth interviews or participatory engagement with Nipah Panjang residents. Consequently, the findings remain exploratory rather than empirically comprehensive. Second, the reconstruction of local knowledge emphasized practical uses of mangroves, such as timber, fuel, and medicine, while cultural dimensions like rituals, myths, or silvofishery practices were not fully addressed (Fariz et al., 2024). Third, the study only conceptualized curriculum integration; classroom trials, learning media development, and impact evaluations were not conducted, leaving the educational effectiveness of mangrove ethnoscience untested.

Future research may address these gaps in several ways. Community-Based Participatory Action Research (CBPAR), as demonstrated by Mangkhang (2024) in Thailand, can engage teachers, students, and local communities in reconstructing mangrove knowledge while co-developing culturally grounded learning resources. Likewise, spatial ecological approaches, such as those proposed by Modal (2023) in the Sundarban Delta, can map linkages between local practices (e.g., silvofishery, non-timber product utilization) and ecosystem sustainability.

In addition, experimental implementation of ethnoscience-based modules in classrooms is necessary to evaluate their impact on scientific literacy, critical thinking, and environmental awareness. Studies such as Albarracín-Vivo et al. (2024) and Stern et al. (2022) highlight the importance of considering gender and socio-demographic variables in such assessments. These directions not only strengthen the integration of ethnoscience into curricula but also align with the United Nations' SDG 14 (Life Below Water) and SDG 15 (Life on Land), thereby contributing to global efforts against biodiversity loss within the broader triple planetary crisis. In sum, this study illustrates how mangrove ethnoscience from a remote coastal village in Kubu Raya can serve as a pedagogical bridge between local wisdom and modern science. By advancing both conservation and contextual education, such initiatives have the potential to sustain biodiversity, enhance community resilience, and nurture globally responsible citizens.

CONCLUSION

The mangrove ecosystem in Nipah Panjang reflects a close interrelation between local knowledge and the sustainable utilization of natural resources. Various mangrove species, such as Avicennia alba, Avicennia marina, Bruguiera gymnorrhiza, Excoecaria agallocha, Rhizophora apiculata, and Rhizophora mucronata, are selectively used in accordance with their biological and chemical properties. The community employs mangrove wood for construction, fuel, and charcoal production, owing to its durability and resistance to decay, while parts of the plants, including the fruit of B. gymnorrhiza and the bark of E. agallocha, serve as traditional medicines due to their bioactive compounds. These practices demonstrate how ethnoscientific knowledge can support sustainable resource management and provide meaningful, contextualized insights for science education.

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