

Ethno-Conservation of Sugar Palm (*Arenga pinnata*) in Jambi Tulo: Integrating Local Knowledge, Cultural Values, and Ecological Ethics

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ABSTRACT

Sugar palms (*Arenga pinnata*) hold considerable ecological, economic, and socio-cultural importance for indigenous communities across Indonesia. Yet, rapid modernization and environmental changes have disrupted traditional practices of caring for these trees. This study aims to document and explore the ethno-conservation strategies used by the Jambi Tulo community in Jambi Province to conserve the palms. Adopting a qualitative approach, this research employed ethnographic methods. Fifteen key informants were purposively selected through snowball sampling. Data collection involved in-depth interviews, participant observation, and review of relevant documentation. Analysis was conducted through a descriptive-interpretive lens, guided by Miles and Huberman's interactive model. The results of this study indicate that the management practices of sugar palm in Jambi Tulo embody conservation values that have contributed to maintaining the presence of sugar palm populations in the area over time. These practices are deeply rooted in local knowledge, cultural norms, and ecological awareness, and can be classified into five interconnected domains: spiritual beliefs and ecological ethics, ecological adaptations, management practices informed by local wisdom, sustainable use, and socio-cultural systems. However, the study also highlights pressing challenges, including declining interest among younger community members and economic pressures that threaten ongoing stewardship. These findings underscore the importance of incorporating indigenous knowledge and cultural values into policies and educational programs. By doing so, this research contributes to a deeper understanding of sugar palm ethnoecology in Sumatra, an area that has previously received limited attention.

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INTRODUCTION

Sugar palm (*Arenga pinnata*) is a widely distributed tropical palm, and it is particularly common in places like Jambi Province, Indonesia. From an ecological standpoint, this species plays an important role in maintaining the stability of soil in areas with steep slopes or along river edges. Its dense, fibrous roots help hold the ground together and reduce erosion, which is especially valuable in landscapes prone to degradation. In many secondary forests, sugar palm also forms part of the natural vegetation structure, creating shelter for various animal species and contributing to broader conservation efforts (Rahayu et al., 2025; Withaningsih et al., 2021). Considering these ecological benefits, the sugar palm is a species deserving careful protection.

Beyond its ecological functions, the sugar palm also carries deep economic and cultural meaning for the people of Jambi Tulo. Known locally as *enan*, this palm has long been associated with household prosperity and the everyday wellbeing of the community. In practice, almost every part of palm is being used. The sap is tapped and processed into palm sugar, while the young fruits (*beluluk*) become ingredients in foods and drinks such as *kolang-kaling*. Its coarse fibers (*ijuk*) are adapted for a range of household tools, and the stems and leaves play their own roles in various traditional activities. Taken together, these many uses illustrate how the sugar palm functions as a truly versatile species; one that continues to support local livelihoods in a sustainable way (Latifah et al., 2025; Moge et al., 1991; Rahayu et al., 2025).

The people of Jambi Tulo continue to maintain long-standing traditions in how they use and care for sugar palm, passing this knowledge from one generation to the next. These practices are rooted in an indigenous knowledge system shaped over time through close observation, cultural values, and a deep relationship with the surrounding environment. Through these traditions, the community shows a nuanced understanding of the palm's reproductive patterns, its growth cycle, and the conditions it needs to thrive; insights that are intentionally woven into their sustainable management approaches. Within this worldview, nature is not treated merely as something to be extracted or consumed, but as a partner whose balance must be respected. This perspective forms the basis of an ethno-conservation model in which conservation is not a separate activity; instead, it is naturally embedded within cultural norms and long-held ecological wisdom.

Earlier studies show that indigenous knowledge, along with cultural norms and spiritual practices, plays an important role in how communities manage natural resources in a sustainable

way. Many scholars have noted that these knowledge systems support long-term biological resource management through mechanisms such as customary taboos, traditional cultivation techniques, and carefully regulated harvesting (Gunawan et al., 2025, 2018; Jemian et al., 2025; Waqi'ah & Sarjan, 2025). Taken together, these findings suggest that local communities often hold strong ecological ethics, which are expressed through their rituals, prohibitions, and everyday social rules; elements that, even indirectly, help maintain biodiversity.

Despite this, the Jambi Tulo community now faces significant obstacles in sustaining their traditional sugar palm practices. Shifting socio-ecological conditions, ranging from modernization and changing livelihood strategies to declining interest among younger generations and increased pressure on land, have pushed many long-held traditions to the margins. As these practices fade, the body of indigenous knowledge that once guided sugar palm management also begins to erode. At the same time, the sugar palm itself, along with its ecological and cultural importance, becomes increasingly vulnerable within the Jambi Tulo landscape.

A considerable amount of research has been carried out on sugar palm (*A. pinnata*). Several studies, such as those by Aji & Syaputra (2023), Kadir et al. (2025), and Yudhiantami et al. (2021), have centered on its cultivation. Others, including Anggraini et al. (2025), Meidina et al. (2025), and Withaningsih et al. (2021), paid closer attention to sap production processes. Meanwhile, the economic aspects of sugar palm were examined by Adalina & Sawitri (2021), Fitriwati et al. (2021), Nawawi et al. (2025), and Samad et al. (2024).

Although these studies enrich our understanding, most of them remain rooted in technical or economic perspectives. Much less attention has been given to the sociocultural contexts that shape how communities interact with and manage sugar palm, or to the ecological ethics embedded in those practices. This study seeks to address that gap by deepening the discussion on indigenous knowledge, cultural values, and the ethical principles that guide traditional sugar palm use and management.

This study explores how the Jambi Tulo community engages in ethno-conservation practices related to sugar palm. More specifically, it describes and clarifies the contributions of local knowledge, cultural traditions, and ecological ethics in maintaining the long-term viability of sugar palm populations. The findings are expected to support the development of conservation models grounded in indigenous knowledge, models that can respond flexibly to changing social and environmental conditions, and to offer a solid reference point for strengthening policies on sustainable biological resource management.

RESEARCH METHODS

Research Design

This study adopted a qualitative ethnographic approach (Brown et al., 2020; Zhou & Xiao, 2024). The research was conducted in Jambi Tulo Village, Muaro Jambi Regency, Jambi Province, Indonesia. It explored the local knowledge, cultural traditions, spiritual beliefs, and ecological ethics related to the use and management of sugar palm (*A. pinnata*). The study also examined how these socio-cultural and ecological elements contribute to a community-based conservation system that helped sustain sugar palm populations over time.

Informants

Informants were selected using a snowball sampling technique (Guest, 2015). In practice, initial informants recommended additional participants whom they considered to possess important and relevant knowledge regarding sugar palm. Three main criteria guided participant selection: (1) individuals involved in tapping sap or processing palm sugar; (2) customary leaders with knowledge of beliefs, narratives, and traditions associated with sugar palm; and (3) community members with direct experience in managing the species. Based on these criteria, a total of 15 participants were involved in the study, comprising 11 sap tappers and palm sugar processors with 10–40 years of experience, 2 cultural leaders, and 2 processors of sugar palm fruit (*kolang-kaling*) with 10–25 years of experience.

Data Collection

Data were collected between June and September 2025 through in-depth interviews, participant observation, and various forms of documentation. Interviews were conducted using an in-depth interview, employing interview guide; however, conversations often evolved naturally as participants elaborated on key themes. These themes included community beliefs, values, and myths related to sugar palm (*A. pinnata*); local ecological knowledge, such as where the species grows, how it propagates, and its interactions with other plants and animals; the ethnobotanical uses of sugar palm and associated traditional practices; customary norms, taboos, and indigenous knowledge governing sap collection and processing; and community strategies for maintaining the sustainability of sugar palm populations over time.

Each interview lasted approximately 2–3 hours and was conducted in either the local language or a combination of local language and Indonesian, depending on the participants' preferences. Interviews continued until no substantial new information emerged (data saturation). Repetition and consistency in the information became apparent by the fourteenth interview, while

the final interview yielded no meaningful new themes. All interviews were audio-recorded and documented with the participants' informed consent and were subsequently transcribed verbatim.

Participant observation was undertaken to clarify and enrich the interview data. During the study, we accompanied sap tappers as they harvested sap and processed it into palm sugar, participating in their daily routines as well as observing the rituals and traditions that continue to be practiced in these activities. Accordingly, our role was that of an "observer as participant," whereby we engaged in participants' activities while maintaining sufficient distance for analytical reflection. To enhance the accuracy and depth of the findings, photographs, audio recordings, and detailed field notes were also collected throughout the research process.

Data Validity and Reliability

The validity and reliability of the data were established through several procedures adapted from Budiastuti & Bandur (2018). First, methodological, source, and time triangulation were employed. Methodological triangulation involved comparing information obtained from interviews, observations, visual documentation, and field notes to identify consistent patterns across different forms of evidence. Source triangulation was conducted by comparing information provided by different categories of participants, including sap tappers and palm sugar producers, customary leaders, and *kolang-kaling* processors, to verify the consistency of data related to local knowledge, beliefs, traditions, and cultural practices associated with sugar palm. Time triangulation was achieved by comparing interview findings collected at different visits.

Member checking was also conducted by sharing interpretations and concise summaries of interview data with key informants and providing them with opportunities to confirm, clarify, or elaborate on the intended meaning of their statements. In addition, peer debriefing was undertaken through regular discussions of preliminary insights with colleagues, both during fieldwork and throughout the preparation of this manuscript. Finally, a detailed audit trail was maintained to document the processes of data collection and analysis, thereby ensuring that the research process remained transparent and traceable at every stage.

Data Analysis

The data were analyzed using a descriptive–interpretive approach following the framework of Miles et al. (2014). The analytical process consisted of three interconnected stages. The first stage involved data reduction, during which interview transcripts, field notes, and documentary materials were reviewed repeatedly. Segments of information with similar meanings were assigned preliminary codes and subsequently organized into categories, including local ecological

knowledge, beliefs, traditions, utilization and management practices, and intergenerational knowledge transmission.

The second stage involved data display, which was conducted through matrices, simple tabulations, and descriptive narratives to facilitate the examination of relationships among categories. Research themes were then developed inductively based on patterns emerging from the data, resulting in the identification of five principal dimensions of sugar palm ethnoconservation: cultural beliefs and values, local ecological knowledge, ecologically based natural resource management, adaptive and sustainable utilization, and socio-cultural systems supporting conservation.

The final stage consisted of conclusion drawing and verification to ensure the validity of the findings. This process focused on understanding how meanings, relationships, and recurring patterns were interconnected within the broader community knowledge system.

Researcher Positionality and Reflexivity

We acknowledge that data interpretation in qualitative research is influenced by the relationship between researchers and participants. Therefore, reflexive practices were incorporated throughout the study. To minimize potential bias and enhance the credibility of the findings, interpretations were continuously examined and verified through the triangulation of interview data, participant observations, field notes, and supporting documentation during the analytical process.

Informed Consent and Ethical Considerations

Prior to participation, all informants provided informed consent after receiving a clear explanation of the study objectives, the nature of their involvement, and their right to decline participation or withdraw from the study at any time. Participants were also informed that the findings of this research might be published in academic outlets. Their participation was entirely voluntary, and they remained free to withdraw throughout the data collection process. To ensure confidentiality, all participants were identified using initials only.

The study also obtained permission from local customary leaders, who granted approval not only for the conduct of the research but also for our participation in sap tapping and processing activities. This permission extended to the rituals and knowledge-sharing practices associated with these activities, which were observed and documented during participant observation.

RESEARCH RESULT

Jambi Tulo is known as one of the key sugar-palm-producing regions in Jambi Province. For generations, the tree has been woven into the community's cultural fabric, becoming part of how the village understands itself. People here do not view the sugar palm simply as a source of sap; they regard it as a living being with its own sensitivities and a symbolic role in the community's social life. This way of seeing the tree shapes the customary rules, rituals, and oral traditions that guide how villagers interact with it daily. Their ecological knowledge; about where the trees thrive, how they regenerate, and how they fit into the broader landscape; comes from years of close engagement with their surroundings, continuous observation, and an inherited ecological intuition passed down from one generation to the next.

The sugar palm is commonly imagined as a woman. This personification shapes the belief that the tree has a "soul", which means it should be approached with gentleness and respect. As one informant put it, "People here believe the sugar palm is female, so it must be respected and treated gently; otherwise, it will 'get angry' and refuse to release its sap" (R1, 58 years; R2, 43 years). This understanding underpins the community's ecological ethics and acts as a cultural safeguard, discouraging excessive or careless exploitation of the tree.

One concrete expression of this worldview is the ritual of "proposing to the tree" before any tapping begins. The act symbolizes the bond between the tapper and the sugar palm. As one informant explained, "Before tapping, the tree must first be proposed to because it is believed to be a maiden. After the proposal, the tree is considered the tapper's wife and ready to release sap. The sap is like a mother's milk that sustains life" (R3, 50 years; R2, 43 years). In this sense, the ritual carries both spiritual meaning and practical moral weight, reminding tappers to approach the tree with care. While some of the more experienced tappers still observe the ritual, many younger ones are no longer closely involved in their practice.

Community members also read the landscape closely; paying attention to soil conditions, light, humidity, and even the appearance of particular animals; to make sense of how sugar palms grow, bear fruit, and regenerate naturally. Their use of the tree is shaped by moral commitments and customary rules that stress care, restraint, and respect for the natural world, all of which help ensure that the sugar palm remains available for the generations that follow. This knowledge is not passed down solely through spoken explanations; it is also conveyed through daily practices, the way elderly people carry themselves, and the ethical habits that, in their view, influence the quality of sap the tree produces.

Beyond rituals, the community also passes down ecological and spiritual values through *pantun* (poetic verses) and *mantra* (chants). The *pantuns* often carry moral lessons about caring for the environment, while the *mantras* function as prayers and reminders of the discipline required in tapping. One tapper noted, “There are specific *pantun* and *mantra* used during tapping to persuade the palm to produce abundant and high-quality sap” (R3, 50 years; R4, 61 years). A commonly recited verse goes, “*Anak itik betali rumbe, sudah rumbai bedaun pulo. Aik setitik menjadi sungai, sudah sungai lautan pula,*” expressing a hope that the tree will yield generous amounts of sap. These oral traditions help nurture an emotional and spiritual bond between the community and the sugar palm.

Local cosmology also incorporates a form of social control rooted in beliefs about the misfortune that can follow when a sugar palm is mistreated. One informant explained, “We believe that treating a sugar palm tree disrespectfully, such as cutting it down or building a house too close to it, can bring misfortune. We also believe that if the taboos related to sap tapping are violated; for example, if the tapper is dishonest or lazy and does not tap the tree regularly; the sap may stop flowing or dry up” (R5, 43 years). These beliefs encourage community members to follow customary rules and function as internal safeguards that help maintain the long-term sustainability of sugar palm populations.

Local knowledge about sugar palm habitat and regeneration grows out of long-standing experience and the community’s intimate engagement with the landscape. Their understanding of the tree’s ecology does not come from scientific frameworks, but from reading natural signs, watching how the plant behaves, and continuously interacting with its environment. Each feature of a site; its soil, its moisture, the animals that appear there; is interpreted as a clue to how sugar palms grow, produce fruit, and renew themselves. This ecological insight is woven into everyday life and is regarded as truth shaped by generations of accumulated experience.

Residents of Jambi Tulo note that sugar palms appear in many places such as home gardens, mixed-crop fields, and forested areas; but they grow most densely along riverbanks, which they regard as the tree’s ideal habitat (Figure 1). As one informant put it, “There are many sugar palms here... but the most are on the riverbanks” (R2, 43 years). Their observations go beyond simple distribution patterns. People also recognize the ecological role of the tree, especially its ability to stabilize riverbanks. “The roots are strong, so they hold the soil in place,” another resident explained (R2, 43 years). They further link the presence of sugar palms to soil fertility, believing that fallen leaves and decaying fronds create humus that “makes the land fertile where sugar palms

grow” (R6, 61 years). This set of understandings shows how the community interprets connections among root structure, soil aeration, and water infiltration.



Figure 1. Aren (*Arenga pinnata*) in the typical Jambi Tulo Landscape

Ecological norms also play a role in guiding how sugar palms are conserved. Productive trees should not be cut down, except when the community agrees it is necessary for a community shared purpose. People further distinguish variations in sap quality based on where the palms grow. According to several tappers, wild palms that grow on raised mounds or along river cliffs tend to yield more sap and with a noticeably sweeter taste.

The community also has a clear understanding of how sugar palms regenerate, particularly through animals that feed on the fruits. They recognize that wild boars, civets, and squirrels act as natural seed dispersers. One resident explained, “Wild boars eat many palm fruits... the seeds drop elsewhere” (R2, 43 years). Others added that civets and squirrels pass the seeds through their droppings, allowing new palms to grow at considerable distances from the parent tree (R8, 70 years; R13, 61 years). These observations show how closely people pay attention to the ecological relationships between local wildlife and the regeneration of sugar palms.

The community also pays close attention to how sugar palms interact with nearby plants. They have noticed that palms growing among taller trees; especially large fruit trees like durian; tend to stretch upward and produce more flower clusters. As one resident put it, “If the trees

around it are tall, like durian, the sugar palm grows tall too, and the flower clusters are more abundant” (R9, 70 years). In contrast, palms that stand alone in open spaces usually remain shorter because they face less competition. These observations reveal the community’s nuanced understanding of how sugar palms adapt within mixed and diverse vegetation.

The people of Jambi Tulo possess detailed knowledge of the morphology and functions of different parts of the sugar palm (Figure 2), enabling them to utilize the species comprehensively with little to no waste. Leaves are used for a variety of household needs and as materials for traditional roofing, while trunks from senescent or non-productive palms are processed as a communal food resource. Community members also distinguish accurately between male and female inflorescences, reflecting their practical ecological knowledge of the species. Male inflorescences are tapped for sap production, whereas female inflorescences are left to mature into fruits. The immature fruits, locally referred to as *beluluk*, serve as a food source, while mature seeds contribute to natural regeneration through dispersal by frugivorous animals. This knowledge supports both the sustainable utilization and continued regeneration of sugar palm populations within the local landscape.

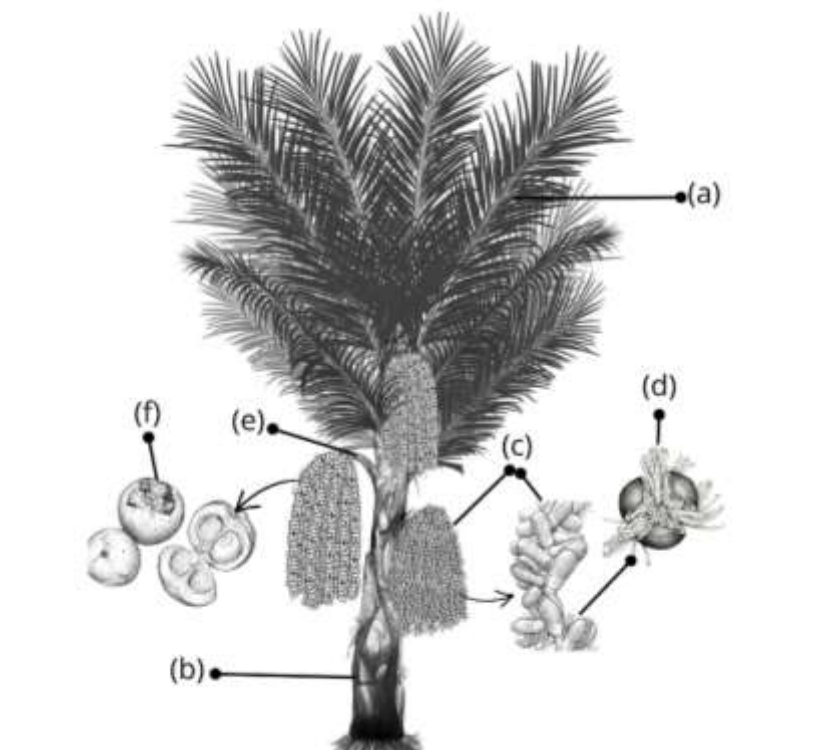


Figure 2. Parts of the sugar palm (*Arenga pinnata*): (a) leaf, (b) trunk, (c) male inflorescence cluster, (d) male flowers, (e) female inflorescence cluster, and (f) sugar palm fruit (*beluluk*).

Community members reported that their understanding of the functions of different sugar palm parts guides how they utilize and manage the species, including practices related to sap tapping. They know these palms produce fruit only once over the course of their life time (monocarpic); though the fruits do not appear all at once but come out slowly over time. In practice, they tap only the male inflorescences, deliberately leaving the female ones untouched so they can form fruit and eventually seeds for natural regeneration. As one community member explained, “We only tap the male inflorescences; the female ones are left alone so they can produce *beluluk* for food and for new seedlings” (R6, 61 years; R7, 48 years). Once the fruits ripen, animals help carry the seeds to new places, allowing sugar palms to spread across the landscape.

The community also relies on ecological cues to decide when tapping should start. They wait patiently for natural pollination to take place before doing anything, since tapping too early could disrupt the process. One tapper described the signs they look for, noting that the flowers shift color and become lively with insects: “When the blossoms turn the shade of young sungkai (*Peronema* sp.) leaves, a few start to open, and insects gather around them, that’s when we know it’s time to tap” (R3, 50 years). By following these signals, they avoid disturbing pollination and allow seeds to form properly.

Customary rules also play a role in controlling both the quality and the volume of sap collected. One long-held taboo, which people still take seriously, forbids giving sap to anyone while on the way to the processing house. As one informant put it, “Sap must not be given on the road, or the sap produced will be little or even dry up” (R10, 38 years). The community is likewise very familiar with how quickly sap ferments. A tapper explained that “if sap is left too long, it quickly turns sour and can no longer be processed into sugar” (R3, 50 years; R4, 55 years). Together, these taboos and their practical know-how operate as local safeguards, helping maintain good tapping practices and ensuring the sap remains of high quality.

From a young age, children in Jambi Tulo learn that every part of the sugar palm holds some kind of use. This lesson stays with them, shaping a lifelong awareness that the tree must be cared for if it is to keep supporting future generations. Their approach to the sugar palm is guided by customary rules, inherited beliefs, and the practical wisdom passed down by experienced tappers. As a result, the way the community manages, harvests, and protects the tree is grounded not only in economic needs but also in a deeper respect for ancestral teachings; ones that remind them that nature continues to give if people refrain from taking more than they should.

The people of Jambi Tulo manage sugar palms with an approach that blends efficiency with long-term ecological care. Almost nothing from the tree goes to waste. As several informants

explained, the sugar palm supports many aspects of daily life: its sap becomes sugar, vinegar, the *beluluk* fruit is processed into *kolang-kaling*; the fibers are used for roofs and ropes; the fronds serve construction needs; and the inner shoot is reserved for important ceremonies. In their words, “everything is used.” In the past, even the pith inside the trunk served as a source of carbohydrates, especially in times when food was scarce. Today, that practice has faded, largely because the processing is laborious and other, easier food sources are available. Altogether, these observations illustrate how deeply the sugar palm is woven into both the economic routines and the cultural life of the community.

Customary norms also shape how the community uses sugar palms. One of the key rules is that productive palms should never be cut unless the purpose clearly serves the collective good. In addition, people do not establish sugar palm in monoculture system; instead, they allow the trees to grow on their own in home gardens, along riverbanks, or within mixed-crop fields. Many informants noted a long-held belief that palms grown through deliberate planting do not yield good sap; “The elders say that planted sugar palms do not produce sap,” as several people remarked. This way of managing the palms helps sustain wild populations while preserving the natural vegetation patterns of the surrounding landscape. At the same time, sugar palm products continue to provide important income, all without disrupting land ecology or placing undue pressure on natural stands of the species.

In Jambi Tulo, the sugar palm has woven itself into everyday life, influencing how people work, relate to one another, and show respect for the natural world. Skills such as tapping, knowing when and how to share sap, safeguarding productive trees, and following the customary rules that guide tapper behavior form a social system that has been handed down across generations. This knowledge is not only spoken about but lived; taught through parental example, reinforced through customary law, and absorbed as personal values. For the community, the sugar palm is far more than a source of income; it carries moral lessons, nurtures collective identity, and helps sustain a balanced relationship between people and their environment.

The social structure in Jambi Tulo plays a central role in keeping both knowledge and resources related to sugar palms alive. People learn not through formal instruction, but through everyday practices, customary expectations, and the informal teaching woven into community life. One example often mentioned is the expectation that young men must be able to tap sap before they marry. As one elder explained, “A man who wants to marry a local girl must first be skilled in tapping sugar palms as a requirement” (R2, 43 years). This custom effectively ensures that tapping skills; ranging from technique to timing and tree care; are consistently passed on. Most of this

learning takes place through direct experience, usually within families and through community-based apprenticeship.

Beyond the technical aspects, tapping is also surrounded by moral expectations that people believe can affect both the quantity and quality of the sap. As one tapper explained, “If we lie or are lazy, the sap becomes ‘lazy’ too. The palm knows our behavior” (R3, 50 years). This way of thinking links a tapper’s character with the results of their work, weaving values like honesty, discipline, care, and prayer into everyday resource management. These teachings are continually reinforced through oral traditions; *pantun*, *mantras*, and other spoken forms; recited during tapping. While they carry aesthetic and spiritual meaning, they also function as reminders of conservation principles, work ethics, and the importance of treating nature with respect.

Customary rules also shape how economic benefits from sugar palm sap are shared within the community. People hold the view that raw sap is a communal resource rather than private property. Because of this, a tapper is expected to offer sap to anyone who asks; yet it is not allowed to sell it in unprocessed form. Only after the sap has been processed; most commonly into sugar; it can carry monetary value.

DISCUSSION

The analysis shows that the Jambi Tulo community’s knowledge and long-standing practices surrounding the sugar palm can be understood through five interconnected elements. First, there are the spiritual and symbolic values that guide how the plant is perceived. Then comes the community’s ecological understanding, especially their awareness of the ecosystem services the sugar palm supports. A third element involves the ways they manage the resource, which are closely aligned with the plant’s reproductive patterns and the rhythms of the local environment. The fourth concerns their adaptive, almost zero-waste approach to using the palm. Finally, the broader social and cultural structures act as the foundation that keeps all these practices sustainable. None of these components functions in isolation. Instead, they weave together into a cohesive social–ecological system that helps ensure the sugar palm continues to thrive in the Jambi Tulo landscape over the long term (Table 1).

Table 1. The conservation values of local traditions and knowledge related to sugar palm

No.	Dimension	Local Knowledge and Traditional Management	Conservation Value
1	Spiritual Values and Ecological Ethic	Personification of the sugar palm as a woman who must be treated with respect and gentleness. Ritual “proposing to the tree” before tapping. Use of “mantra” during the tapping process.	eco-spiritual conservation system

No.	Dimension	Local Knowledge and Traditional Management	Conservation Value
2	Local Ecological Knowledge and Ecosystem Services	Local knowledge of ideal habitat, ecological functions, distribution patterns, and interactions with flora and fauna. Belief that wild palms produce more abundant and sweeter sap. Belief that cultivated sugar palms will not produce palm sugar. Prohibition against building permanent structures near sugar palms.	ecosystem-based conservation
3	Ecology-based Natural Resource Management	Tapping conducted only on male inflorescences. Timing of tapping based on natural indicators and inherited experience. Tapping procedures follow local methods to maintain sap quality and yield.	ethnoecological management
4	Sustainable (Adaptive) Utilization	Prohibition against cutting productive palms without clear benefit. Utilization of the entire plant with no waste (zero-waste utilization). Principles of optimal use without harming the tree's regenerative capacity.	community-based conservation
5	Socio-Cultural System	Men wishing to marry a Jambi Tulo woman must possess tapping skills. Tappers are required to uphold ethical conduct to obtain high-quality and abundant sap. Taboo against giving fresh sap to others while on the road. Principle of sharing sap with those in need as a form of social solidarity.	social-ecological systems

Taken together, these five components provide a way to show that sugar palm conservation in Jambi Tulo is far more than an ecological or economic activity. It grows out of a system in which spiritual values, hands-on ecological observations, customary rules, and long-practiced adaptive strategies all work together; a system refined and reinforced across generations. Framing the discussion in this way not only documents what the community does but also helps explain how these different elements interact to form an ethnoecological model of conservation that aligns surprisingly well with many modern conservation ideas. In the end, the study points to the significant promise of local knowledge as a basis for conservation policies that are more inclusive, more just, and ultimately more sustainable.

Spiritual Value and Ecological Ethic as the Foundation of Sugar Palm Conservation

The study shows that efforts to conserve the sugar palm in Jambi Tulo are grounded in much more than practical or economic concerns. They draw heavily on spiritual beliefs, ethical views about the environment, and long-standing cultural symbols. One striking example is the way

the sugar palm is personified as a woman; a portrayal that reveals a worldview in which nature is treated as a moral being, valued for its own sake rather than for what it can provide economically (Berkes et al., 2000; Taylor et al., 2020; Washington et al., 2017).

The practice of “proposing to the tree” acts as a kind of informal rule that shapes how people use the resource. When the palm is imagined as “the tapper’s wife,” it subtly encourages tappers to care for the tree; protecting its health, tapping it responsibly, and allowing it to regenerate naturally. In this way, symbolic and spiritual meanings become practical tools that help sustain conservation-oriented behavior.

Ecological values are also passed down through *pantun* and *mantras* (local oral traditions) both of which serve as important tools for ecological learning. *Pantun* often carries moral lessons about compassion, hard work, and honesty, while *mantras* remind people to act carefully and respectfully when dealing with the natural world. These teachings gain even more force through beliefs in moral consequences, such as the idea that breaking taboos can bring misfortune or cause the sap flow to decline. Similar patterns have been noted in wider ethnoecological studies across Indonesia, where belief systems consistently emerge as key drivers of ecological sustainability (Amrul, 2024; Marpaung, 2025; Niman et al., 2023; Wahyuni et al., 2025; Yulisinta et al., 2024).

For the people of Jambi Tulo, the natural world is more than just a resource; it is a sacred space shaped by belief and symbolism. Their eco-spiritual approach to conservation reflects not only moral and cosmological understanding but also a heartfelt connection to their surroundings. In this view, protecting the environment is not simply an act of management; it is an expression of identity, responsibility, and emotional engagement with the land they inhabit.

Nevertheless, the continuity of this value system is increasingly challenged by modernization and changing cultural orientations within the community. Several younger sap tappers no longer recite the traditional rhymes and chants that once accompanied sap-tapping activities, indicating that some customary practices are gradually being abandoned because they are perceived as less relevant to contemporary life. In addition, the occupation of sugar palm tapping has become less attractive to younger generations, who often view alternative livelihoods as offering greater economic opportunities and a more modern and prestigious lifestyle. These trends may weaken younger generations’ cultural attachment to sugar palm and reduce the transmission of traditional ecological knowledge associated with its management. Over time, such changes could diminish community appreciation of sugar palm and, consequently, undermine the cultural foundations that have historically supported its conservation in Jambi Tulo. These finding highlights that the long-term sustainability of culturally based conservation systems depends not only on ecological and

economic factors but also on the community's ability to maintain and transmit cultural values, traditional knowledge, and collective identity across generations.

Local Ecological Knowledge and the Enhancement of Ecosystem Services

The community holds a remarkably detailed understanding of how the sugar palm contributes to the stability of their landscape. They pay close attention to where the palms grow, especially along riverbanks, and recognize how the tree's roots help anchor the soil. Such observations reveal a clear awareness of the ecosystem services the palm provides, most notably its role in preventing erosion in riparian areas.

Residents also observe that the soil surrounding sugar palms is noticeably more fertile, a point that aligns with ecological studies on how forest litter enriches soil organic matter and supports nutrient cycling. Their customary prohibition against cutting sugar palms, reinforced by the belief that these naturally growing trees yield sweeter, more plentiful sap, ends up functioning as an indirect conservation measure, helping to protect the habitats where these palms thrive.

The community is also aware of how wildlife, such as wild boar, civets, and squirrels, plays a role in dispersing sugar palm seeds. They have noticed, too, that palms tend to grow taller when surrounded by other vegetation. This observation fits well with ecological theories of light competition, where shading from the canopy encourages stem elongation and can ultimately increase sap production. These insights resonate with a wide body of ethnoecological and tropical ecology research that highlights the central role of traditional ecological knowledge in maintaining forest species (Ariyadi et al., 2022; Berkes et al., 2000; da Silva et al., 2024; Gadgil et al., 1993; Haq et al., 2023).

Despite its strengths, this traditional conservation system also exhibits certain limitations. The belief that naturally occurring sugar palms produce larger quantities of sweeter sap, whereas planted palms yield sap of lower quality, has resulted in sugar palm regeneration in Jambi Tulo occurring almost entirely through natural processes without deliberate human intervention. On the one hand, this belief may help prevent the establishment of monoculture production systems, which are often associated with ecosystem degradation and declines in local biodiversity. On the other hand, exclusive reliance on natural regeneration may reduce the resilience and recovery capacity of sugar palm populations in the face of ongoing deforestation and land-use change.

The decline of seed-dispersing wildlife due to the expansion of oil palm plantations further exacerbates the regeneration challenge. Community members reported that increasing numbers of sugar palm seeds accumulate beneath parent trees because populations of wild boars and civets; the principal consumers and dispersers of sugar palm seeds; have declined. Wild boars are

frequently hunted because they are perceived as agricultural pests that damage cultivated crops, including oil palm nurseries. This trend reflects broader livelihood transitions, as oil palm cultivation is increasingly favored by local communities due to its perceived ability to generate faster economic returns than sugar palm. Consequently, while local ecological knowledge has played an important role in sustaining sugar palm populations, its effectiveness may be constrained under rapidly changing socio-ecological conditions.

Management Practices Rooted in Ecological Cycles

The community's management of sugar palms closely mirrors their understanding of the tree's reproductive patterns and life cycle. Their choice to tap only the male inflorescences reflects a clear awareness that doing so does not interfere with seed formation, while at the same time drawing on practical experience that male flowers consistently produce more sap than female ones.

Tappers rely on a set of ecological cues; shifts in flower color, the presence of certain insects; to decide when to begin or pause tapping. These indicators act as informal conservation guidelines, helping them avoid disrupting the pollination process. Cultural taboos also play a role. For instance, the rule against handing sap over by the roadside is meant to protect its quality, since exposure to heat can trigger early fermentation. Together, these practices blend ecological awareness with cultural norms to support sustainable harvesting.

These kinds of practices resonate with global studies showing that taboos and customary rules often function as surprisingly effective conservation measures (Amrul, 2024; Janaki et al., 2021; Ogwu & Osawaru, 2022; Verma & Kumar, 2025). In Jambi Tulo, such norms and observations come together to form an ethnoecological management system rooted in the community's own empirical understanding of ecological processes.

Nevertheless, this ecologically grounded sugar palm management system faces growing challenges due to changing economic aspirations within the community. Sugar palm tapping is currently dominated by older community members, while younger generations, particularly unmarried individuals, are generally reluctant to engage in sugar palm management. The occupation is often perceived as physically demanding, less prestigious, and economically less attractive than alternative livelihood opportunities. As a result, the continuity of traditional ecological knowledge and management practices associated with sugar palm may become increasingly vulnerable as older practitioners retire from active involvement.

Adaptive and Zero-Waste Utilization in Community-Based Conservation

Sugar palm management in Jambi Tulo reflects a conservation model shaped and carried out by the community itself; one that weaves together economic needs, ecological awareness, and cultural practice. Their nearly complete use of the palm, from its sap and fruit to its leaves and trunk, illustrates a zero-waste approach. This kind of holistic utilization naturally reinforces long-term ecological sustainability.

The rule forbidding the cutting of productive palms operates as an in-situ conservation measure, effectively limiting overharvesting before it can occur. At the same time, the community's choice to maintain mixed-crop systems rather than shift to monocultures reveals an underlying ecological awareness; one that recognizes the benefits of biodiversity, healthier soils, and more stable water dynamics.

Economically, the sugar palm provides the community with multiple sustainable income sources; palm sugar, vinegar, *kolang-kaling*, and even materials for construction; all without placing undue pressure on the surrounding ecosystem. This pattern fits well within the broader principles of ethno-conservation, which highlight how local knowledge, ecological processes, and economic needs can reinforce one another rather than compete (Berkes, 2004; Brooks et al., 2013; Pretty & Smith, 2004; Sele & Mukundi, 2024).

Socio-Cultural Systems as Pillars of Sustainability

The long-term sustainability of sugar palms is closely tied to the community's established social and cultural structures. One example is the expectation that young men must acquire tapping skills before they are considered ready for marriage. This norm functions as a cultural rule, effectively securing the transfer of technical knowledge from one generation to the next through a longstanding apprenticeship system.

Moral principles like honesty and discipline are woven into the practice of tapping itself. The notion that a tapper's conduct can directly influence sap quality acts as a subtle form of moral enforcement, connecting social behavior with ecological consequences. This interplay between ethics and environmental outcomes aligns closely with broader social–ecological systems frameworks (Artmann, 2023; Gain et al., 2021).

Pantun and *mantras* serve not only as vessels for ecological knowledge but also as tools for reinforcing cultural identity and maintaining the continuity of local language (Arofat & Indrastuti, 2022; Yenrizal et al., 2024). Rules governing the distribution of sap reflect a form of moral economy (Carrier, 2018), aiming to ensure fair access while preventing overuse of the resource.

Taken together, the socio-cultural systems of Jambi Tulo play a crucial role in supporting ecological conservation and bolstering the community's overall resilience.

Many of these socio-cultural practices are gradually declining in response to ongoing social and cultural change. Intergenerational knowledge transmission, for example, was traditionally reinforced through cultural expectations that prospective husbands should possess sap tapping skills prior to marriage. However, this practice is no longer implemented consistently within a community that has become increasingly open and socially diverse. Likewise, the spirit of reciprocity and social solidarity reflected in the custom of sharing sap with community members in need may become increasingly vulnerable under growing economic pressures.

These changes highlight the importance of adaptive measures to support the continuity of local knowledge systems. Efforts such as documenting and digitizing traditional knowledge, as well as integrating local ecological and cultural knowledge into formal and non-formal educational programs, may provide effective mechanisms for strengthening the transmission of social and ecological values to younger generations. In addition, government support for the development of sugar palm-based creative industries, including palm sugar powder, liquid palm sugar, and other value-added products, could represent a strategic approach to enhancing the economic attractiveness of sugar palm management. Beyond increasing economic returns, such initiatives may encourage greater youth participation in sugar palm-related livelihoods while reinforcing the long-term sustainability of the socio-cultural systems that underpin community-based conservation in Jambi Tulo.

Sustainability Challenges Amid Social and Environmental Change

Protecting the sugar palm goes beyond simply managing its physical resources; it also means preserving the cultural knowledge and practices that have supported its use for generations. Today, however, this balance faces increasing strain. Changes in people's livelihoods, ongoing environmental degradation, and shifting social and cultural patterns are gradually eroding the traditional systems that have long maintained the sustainability of the sugar palm.

One of the most pressing challenges today is the waning interest among younger generations in learning the skills of tapping and sugar production. As an elder tapper explained, "Young people no longer want to learn tapping; the work is hard and the income is slow" (R4, 55). This shift poses a serious risk to the continuity of both technical know-how and ecological understanding, which were traditionally passed down through oral traditions.

From an economic perspective, many community members are moving away from sugar palms in favor of more lucrative crops, mainly oil palms. This shift has led to changes in land use

and the disappearance of secondary forest areas that are crucial for the growth of sugar palms. The motivation behind this change is clear: as one community member put it, “Oil palm produce faster. With sugar palm, you must wait long and results are uncertain” (R2, 43; R3, 50).

From an ecological standpoint, the natural regeneration of sugar palms faces multiple obstacles. Declining wildlife populations; particularly wild boars; have reduced the dispersal of seeds, while climate variability, unpredictable rainfall, soil erosion, and occasional fires add further strain to these fragile systems.

At the same time, the transmission of knowledge is under threat. Traditional management practices remain largely undocumented, passed down orally among an aging group of practitioners. Policy-level efforts also fall short. Government conservation programs tend to focus on biological interventions like reforestation, often overlooking local knowledge systems and the culturally rooted ways communities understand and interact with their environment.

Contributions to Ethno-conservation Theory and Sugar Palm Studies

The ethno-conservation practices of the Jambi Tulo community offer fresh perspectives to a body of literature that has largely concentrated on the cultivation, production, and economic dimensions of sugar palm (Adalina & Sawitri, 2021; Aji & Syaputra, 2023; Anggraini et al., 2025; Kadir et al., 2025; Meidina et al., 2025; Nawawi et al., 2025). Unlike most previous research, this study brings attention to a holistic approach that weaves together spiritual beliefs, ecological understanding, reproductive management, zero-waste utilization, and the wider socio-cultural context. By highlighting these interconnected dimensions, the work expands both ethnoecological theory and frameworks for community-led conservation. Moreover, the findings underscore that the long-term sustainability of sugar palm is not determined solely by cultivation methods or sap yield, but also by the socio-cultural mechanisms that have evolved and been transmitted across generations within the community.

Conceptually, the proposed ethno-conservation model comprises five interrelated dimensions, as described in the preceding sections: (1) local ecological knowledge, (2) ecologically based natural resource management, (3) ecological ethics and spirituality, (4) social systems and knowledge transmission, and (5) sustainable utilization (Figure 3). Rather than operating independently, these dimensions interact synergistically to support the long-term persistence of sugar palm populations and the ecosystems in which they occur. Local ecological knowledge informs management decisions and practices, while ecological ethics and spiritual values foster a sense of responsibility toward nature. Social institutions and intergenerational knowledge transmission contribute to the continuity of conservation-related practices, whereas sustainable

utilization creates incentives for maintaining the resource base while securing livelihood benefits. Together, these dimensions form a dynamic socio-ecological system that underpins community-based sugar palm conservation.

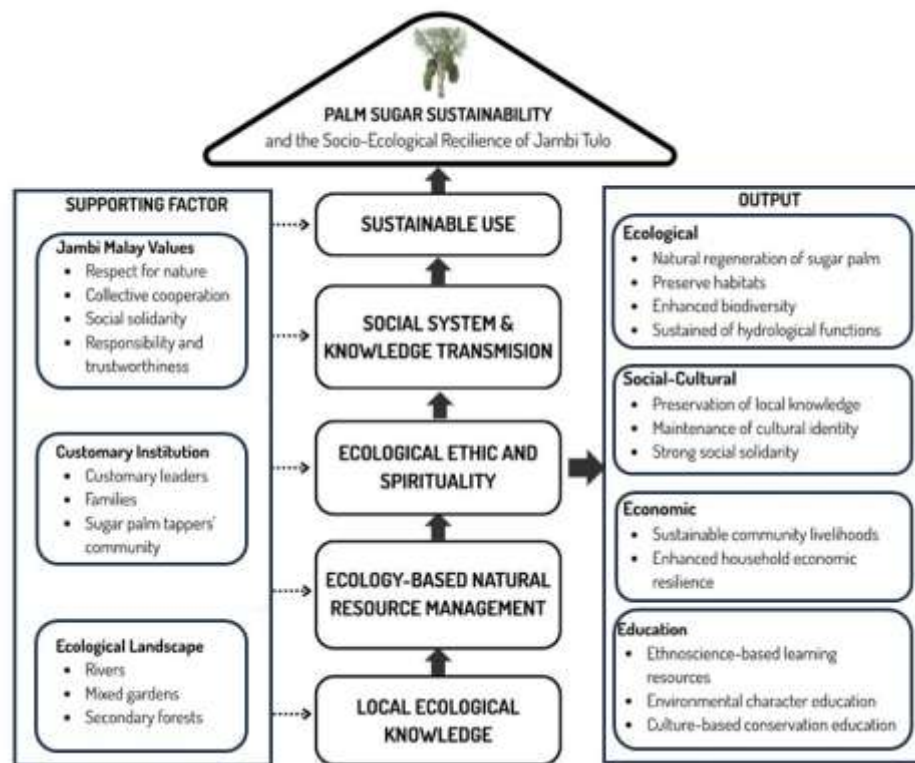


Figure 3. Ethno-conservation Model of Palm Sugar (*Arenga pinnata*)

The first dimension, local ecological knowledge, serves as the cognitive foundation of the ethno-conservation system. As discussed in the earlier sections, this knowledge has been accumulated through long-term interactions between the community and its environment and transmitted across generations. It enables community members to understand key aspects of sugar palm ecology, including regeneration processes, appropriate harvesting practices, ecological functions, and species interactions within the broader landscape. By informing decisions regarding resource use and management, local ecological knowledge provides the basis for adaptive and ecologically informed stewardship of sugar palm resources.

The second dimension, ecologically based natural resource management, functions as the operational component of the ethno-conservation system. While local ecological knowledge provides an understanding of ecological processes, this dimension translates that understanding into management practices and decision-making. By aligning resource use with the biological characteristics of sugar palm and the ecological dynamics of the surrounding landscape, community members can balance utilization with conservation objectives. As a result, management

practices contribute not only to resource productivity but also to the long-term resilience of both sugar palm populations and the ecosystems in which they occur.

The third dimension, ecological ethics and spirituality, provides the normative framework that shapes human–nature relationships. Rather than viewing sugar palm solely as an economic resource, community members embed its management within a system of cultural values, moral obligations, and spiritual beliefs. Ritual practices, oral traditions, and customary prohibitions reinforce respect for the species and encourage responsible resource use. In this way, conservation is supported not only through practical knowledge but also through ethical commitments and culturally embedded forms of environmental responsibility.

The fourth dimension, social systems and knowledge transmission, ensures the continuity of conservation-related values and practices over time. The persistence of sugar palm management traditions depends on mechanisms through which ecological knowledge, practical skills, and cultural norms are shared within families and the wider community. These processes are reinforced by customary institutions, social expectations, and community-based forms of regulation, thereby facilitating the long-term reproduction of both knowledge and conservation practices.

The fifth dimension, sustainable utilization, links conservation objectives with local livelihoods. As described earlier, sugar palm provides a wide range of products and benefits that support household economies while maintaining the regenerative capacity of the resource. Embedded within agroforestry systems and guided by norms that discourage overexploitation, its utilization contributes simultaneously to economic well-being, biodiversity conservation, and landscape resilience. Consequently, sustainable use functions not merely as an outcome of the ethno-conservation system but also as a key incentive for its continued maintenance.

The five dimensions are further supported by three enabling factors that provide the broader context within which the ethno-conservation system operates. The first is the cultural values of the Jambi Malay community, including respect for nature, cooperation, social solidarity, and stewardship, which provide the ethical foundation for natural resource management. The second is the role of customary institutions, involving customary leaders, families, and sap-tapping communities in regulating, monitoring, and transmitting conservation-related practices. The third is the ecological landscape itself, particularly riparian areas, mixed agroforestry gardens, and secondary forests that offer suitable conditions for the persistence of sugar palm populations. Together, these enabling factors create the social and ecological environment necessary for the effective functioning of the ethno-conservation system.

The model generates outcomes across multiple dimensions of sustainability. Ecologically, it contributes to the maintenance of natural regeneration processes, habitat conservation, biodiversity persistence, and the preservation of hydrological functions. Socially and culturally, it supports the continuity of local knowledge, reinforces cultural identity, and strengthens community cohesion. Economically, it provides a basis for sustained livelihoods through forms of resource use that do not undermine ecological integrity. In addition, the model offers educational value by serving as a rich source of ethno-scientific knowledge, supporting environmental character education, and illustrating how conservation principles can be embedded within local cultural traditions.

Despite these strengths, the long-term viability of the Jambi Tulo Sugar Palm Ethno-conservation Model is increasingly challenged by ongoing social and ecological transformations. Land-use change, particularly the conversion of secondary forests and mixed agroforestry systems into oil palm plantations, has contributed to the fragmentation of sugar palm habitats and the isolation of remaining populations. At the same time, younger generations show declining interest in sugar palm tapping and processing, as employment opportunities in industrial, commercial, and service sectors are often perceived as offering greater economic prospects and social prestige. These trends may weaken the intergenerational transmission of local ecological knowledge and erode the socio-cultural foundations upon which the ethno-conservation system depends. Consequently, adaptive approaches are needed to ensure that the values, knowledge, and conservation practices associated with sugar palm remain relevant and meaningful under changing socio-economic and environmental conditions.

CONCLUSION

This study shows that the Jambi Tulo community's management of the sugar palm (*A. pinnata*) embodies a form of ethno-conservation, blending local knowledge, cultural values, and ecological ethics. Their customary systems, including rituals, taboos, and oral traditions, serve not only to maintain sugar palm populations but also to strengthen cultural identity. At the same time, the research highlights an emerging crisis in knowledge transmission. Shifting social values, waning interest among younger generations, and mounting economic and ecological pressures all threaten the continuity of these time-honored conservation practices, which have long underpinned the community's social–ecological resilience.

The ethno-conservation practices of the Jambi Tulo community provide a valuable model for managing natural resources through approaches rooted in local knowledge. Beyond this, the

study's findings carry significant implications for environmental policy, especially regarding the protection of sugar palm habitats and the active participation of local communities in conservation initiatives. Integrating these insights into school curricula, particularly in regions where sugar palms are a major part of local livelihoods, could play an important role in revitalizing cultural knowledge and ensuring that it is passed down to future generations.

Future studies should explore how young people perceive and engage with ethno-conservation knowledge and practices, while also delving into ways to improve and adapt sugar palm tapping techniques. By making sugar palm products more economically attractive, such research could encourage communities to sustain and even enhance the traditions and cultural practices linked to them. In the long run, these efforts are likely to boost not only the economic value of sugar palms but also the resilience and adaptability of local communities in the face of rapid environmental, social, and technological changes.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

F. Astriawati: conceptualization, methodology, validation, investigation, formal analysis, writing original draft, and visualization. **B. Hariyadi:** methodology, validation, investigation, resources, data curation, writing review & editing, and supervision. **A. Turrohmah:** investigation, validation, resources, data curation, and data administration. **W. D. Kartika:** investigation, validation, and project administration. **C. Multahadah:** investigation and validation. **R. Dani:** investigation and validation. **D. Mursyd:** investigation, validation, and project administration. **I. Tentia:** investigation, validation, and documentation.

DECLARATION OF THE USE OF AI

During the preparation of this work, the authors used Gemini for image generation and ChatGPT 5.5 for language editing and correcting typographical errors in the manuscript. After using these tools, the authors carefully reviewed and edited the content as necessary and take full responsibility for the content of this publication.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

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