

Ethnobotany and Traditional Ecological Knowledge of Sugar Palm (*Arenga Pinnata* (Wurmb.) Merr.) in Pusuk Lestari Village, West Lombok, Indonesia

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ABSTRACT

Keywords:

arenga pinnata;
ethnobotany; traditional
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plant part value; sugar
palm; west lombok

Sugar palm (*Arenga pinnata* (Wurmb.) Merr.) is a multipurpose non-timber forest product that plays important ecological, socio-cultural, and economic roles in rural communities of Indonesia. This research aimed to document *ethnobotanical knowledge*, traditional ecological knowledge (TEK), and plant part utilization patterns of sugar palm in Pusuk Lestari Village, West Lombok, Indonesia. Data were collected using mixed methods, including semi-structured interviews, participant observation, and field documentation with 23 key informants selected via snowball sampling. Plant part utilization was analyzed quantitatively using the Plant Part Value (PPV) index based on reported uses. The results indicate that the community utilizes six main plant organs of *A. pinnata*, namely roots, stems, leaves, inflorescences, fruits, and seeds. Leaves exhibited the highest PPV value (32.14%), followed by stems (28.57%) and inflorescences (21.43%), reflecting a preference for renewable and multifunctional plant organs. In contrast, roots and seeds showed the lowest PPV values, indicating limited use of vital plant organs. Traditional tapping practices are guided by TEK, including phenological indicators, ritual practices, taboos, and the use of natural anti-fermentation agents, which collectively support sap quality, safety, and continuity of production. Sugar palm sap provides stable daily income, while products such as *ijuk*, young leaves, and *kolang-kaling* serve as supplementary seasonal resources. *Ethnobotanical knowledge* and PPV analysis together highlight *A. pinnata* as an economic and cultural keystone species in Pusuk Lestari, with local knowledge guiding adaptive management of the resource.

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INTRODUCTION

Sugar palm (*Arenga pinnata* (Wurmb.) Merr.) is a multipurpose tropical palm widely distributed across the Indo-Malayan region and represents an important non-timber forest product supporting rural livelihoods. The species provides a wide range of ecosystem services—including food resources, construction materials, household energy, fiber, and raw materials for small-scale industries—contributing significantly to local economies in Southeast Asia (Henderson, 2009; Dransfield et al., 2008). Its broad ecological adaptability to humid forests, mixed agroforestry systems, and hilly landscapes enables *A. pinnata* to persist under diverse environmental conditions while supporting community-based livelihood systems (Pongsattayapipat & Barfod, 2009; Lempang, 2012).

From an ethnobotanical perspective, almost all plant organs of sugar palm are utilized by local communities for subsistence and economic purposes. Sap (*nira*) is the primary product used for palm sugar production, while palm fiber (*ijuk*) is widely applied in construction and soil conservation. Stems and pith are used as building materials and starch sources, whereas leaves, petioles, fruits, and young shoots serve culinary, ritual, and technological functions (Sujarwo et al., 2015; Fatriasari et al., 2020). This diversity of uses reflects the high cultural

and economic value of sugar palm and highlights its central role in local socio-ecological systems (Caneva et al., 2017).

The interaction between communities and sugar palm is shaped by traditional ecological knowledge (TEK), which governs plant selection, tapping techniques, phenological assessment, and harvesting rules that emphasize sustainability. Such knowledge is accumulated through long-term interactions between people and their environment and is transmitted across generations as an adaptive management system (Ellen, 2007; Toledo, 1992). In many traditional societies, TEK functions not only as technical knowledge but also as a normative framework that regulates resource use, minimizes ecological risks, and maintains long-term productivity.

Pusuk Lestari Village in West Lombok, Indonesia, represents a landscape where sugar palm is widely utilized and plays an important role in local livelihood strategies. Activities such as palm sap tapping, palm sugar processing, and the use of various plant organs involve a substantial proportion of households, indicating the relevance of sugar palm to the local economy. However, studies that comprehensively integrate ethnobotanical documentation with quantitative assessments of plant part utilization—such as the Plant Part Value (PPV) index—remain limited in hilly agroforestry landscapes like Pusuk Lestari. Most previous studies have focused on descriptive inventories or specific commodities without explicitly examining how patterns of organ utilization are associated with local knowledge and management practices (Astutik et al., 2019).

The Plant Part Value (PPV) approach provides a quantitative framework for evaluating the relative importance of plant organs based on reported uses, allowing comparisons among different organs and revealing patterns of selective utilization within a community (Turner, 1988). When combined with analyses of traditional ecological knowledge (TEK), PPV can elucidate how cultural values, ecological understanding, and economic needs collectively influence local resource-use decisions (Albuquerque et al., 2014; Berkes, 2008). Therefore, this study aims to (i) document ethnobotanical and traditional ecological knowledge related to *A. pinnata* in Pusuk Lestari Village and (ii) analyze the relative importance of sugar palm organs using the Plant Part Value (PPV) index. This research is expected to provide benefits in documenting and validating local knowledge as the basis for sustainable management, enriching Indonesia's ethnobotanical database, and supporting the development of community-based conservation and livelihood strategies.

METHOD

This study was conducted in Pusuk Lestari Village, Batu Layar District, West Lombok Regency, West Nusa Tenggara Province, Indonesia. The village is located in a hilly landscape with elevations ranging from approximately 150 to 460 m above sea level, representing a humid tropical lowland to lower montane zone. Land use is dominated by mixed agroforestry systems, community-managed forests, and riparian areas, which provide favorable ecological conditions for the growth and utilization of sugar palm (*Arenga pinnata*). The climate is humid tropical with seasonal rainfall, influencing the timing and intensity of sap tapping activities. The study area and observation sites were mapped using ArcGIS and are presented in **Fig. 1**.

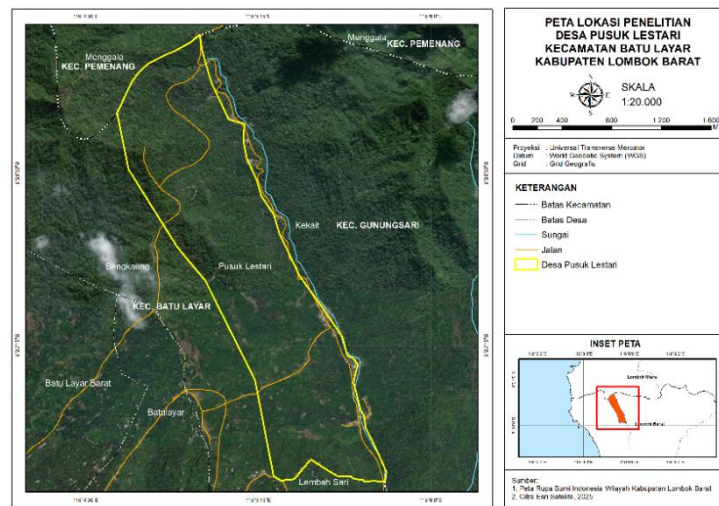


Fig. 1. Study area and observation locations in Pusuk Lestari Village, Batu Layar District, West Lombok Regency, West Nusa Tenggara, Indonesia

Source: Spatial analysis using ArcGIS, based on satellite imagery and field surveys, 2023

Ethnobotanical data were collected through semi-structured interviews, participant observation, and field documentation, following standard ethnobotanical research protocols (Martin, 1995; Bernard, 2011). Informants were selected using purposive and snowball sampling based on predefined criteria, including active involvement in sugar palm utilization, a minimum of five years of experience, and recognized knowledge of tapping practices, processing techniques, or cultural norms related to sugar palm management (Alexiades, 1996). A total of 23 key informants participated in this study, comprising sap tappers, palm sugar processors, traders, and community elders.

Semi-structured interviews were conducted to document the utilization of sugar palm plant organs, tapping techniques, local ecological indicators, seasonal variation in sap production, regeneration practices, and associated cultural norms (Martin, 1995; Cotton, 1996). Participant observation was carried out by accompanying tappers during routine daily tapping activities.

The relative importance of each sugar palm plant organ was quantified using the Plant Part Value (PPV) index. Each distinct utilization of a plant organ reported by an informant was recorded as a reported use (RU) (Turner, 1988). Plant organs were classified into six categories—roots, stems, leaves, inflorescences (mayang), fruits, and seeds—following standard botanical classifications of vegetative and reproductive organs (Raven et al., 2013; Taiz et al., 2015).

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The PPV was calculated using the following formula:

$$PPV(\%) = \frac{RU_i}{\sum RU} \times 100$$

Qualitative data obtained from interviews and participant observation were analyzed using a descriptive thematic approach, with information grouped into key themes including plant organ utilization, traditional ecological knowledge (TEK), tapping practices, and cultural norms related to sugar palm management (Martin, 1995; Bernard, 2011). Quantitative data on plant organ utilization were analyzed using the Plant Part Value (PPV) index based on reported

uses (Turner, 1988). PPV values were calculated for each plant organ and presented in tabular and graphical forms. Qualitative and quantitative results were integrated at the interpretation stage using a concurrent mixed-method approach, enabling the examination of utilization patterns alongside ethnobotanical knowledge and management practices (Creswell & Plano Clark, 2018).

RESULTS AND DISCUSSION

Sugar palm distribution and socio-ecological context in Pusuk Lestari Village

Field interviews and observations indicate that sugar palm (*Arenga pinnata*) is widely distributed across the landscape of Pusuk Lestari Village, occurring on hill slopes, riverbanks, humid valleys, and mixed agroforestry plots. This broad distribution suggests that the village provides favorable microhabitat conditions—particularly stable soil moisture and heterogeneous light availability—that support the persistence of sugar palm within a hilly landscape (Henderson, 2009; Dransfield et al., 2008). Such spatial patterns also reflect the close integration between sugar palm ecology and community-managed land-use systems, forming an important socio-ecological context for understanding local utilization patterns (Martini & Roshetko, 2012).

Two locally recognized palm types were identified: a productive form known as *aren dalam* and a more slender, non-productive form locally referred to as *aren pinang* or *enau bodo*. Although both are locally classified as *A. pinnata*, informants consistently distinguished them based on observable morphological traits and sap productivity, a practice commonly reported in ethnobotanical classification systems that recognize intraspecific variation based on functional attributes (Berlin, 1992; Albuquerque et al., 2014). The *aren dalam* is characterized by a more robust trunk and well-developed inflorescences that yield abundant sap, whereas *aren pinang/enau bodo* exhibits a slender trunk and poorly developed inflorescences, resulting in little to no sap production. These distinctions represent local morphological recognition rather than formal taxonomic differentiation, highlighting the role of traditional ecological knowledge (TEK) in shaping locally perceived functional types of sugar palm based on productivity and management suitability (Berkes, 2008).

From an ethnobotanical perspective, the local distinction between *aren dalam* and *aren pinang* reflects a functional classification system based on productivity and management suitability rather than formal taxonomy. Such recognition of intraspecific variation demonstrates how TEK enables communities to assess resource potential and allocate management effort efficiently, a pattern widely reported in ethnobotanical studies but rarely documented quantitatively for sugar palm in Lombok.

Based on cumulative information from village stakeholders and experienced tappers, the sugar palm population in Pusuk Lestari was estimated at approximately 30,000 individuals across various growth stages, with around 6,000–7,000 mature trees considered potentially productive for sap. The village recorded 478 active tappers managing an average of 14 trees each, with reported daily sap yields ranging from 25 to 40 L per tapper (approximately 5 L per tree per day), indicating a strong dependence of local livelihoods on sustained sap production.

Ethnobotanical utilization of sugar palm (*Arenga pinnata*)

A total of 23 key informants participated in this study, representing core actors within the sugar palm-based livelihood system of Pusuk Lestari Village. Informants were predominantly male (78.3%), reflecting the physically demanding nature of sap tapping, while women were more frequently involved in post-harvest processing activities. Most respondents were aged ≥ 50 years, indicating that knowledge related to sugar palm utilization and management is largely held and transmitted by experienced practitioners.

Interview and field observation data indicate that the Pusuk Lestari community utilizes *Arenga pinnata* through six main plant parts—roots, stems, leaves, male inflorescences, fruits,

and seeds—for a wide range of purposes, including household needs, food, energy, income generation, traditional technologies, and locally perceived health-related practices. These utilization patterns constitute the basis for recording reported uses (RU) in the Plant Part Value (PPV) analysis. A summary of sugar palm plant-part utilization by the local community is presented in **Table 1**.

Table 1. Utilization of sugar palm (*Arenga pinnata*) organs in Pusuk Lestari Village, West Lombok, Indonesia.

Main organ	Sub-part/modification	Utilization (summary)
Roots	Roots	Traditional remedy for stamina recovery (reported use)
Stems	<i>Ruyung</i> (old trunk)	Simple household materials (rack/bench/boards)
	<i>Umbut</i> (apical pith)	Traditional food in ceremonial events (selective harvest)
	<i>Ijuk</i> (palm fiber)	Roofing, broom, rope, simple filtration, gabion/erosion control; sold as commodity
Leaves	Janur (very young leaves)	Decoration; sold for Hindu ceremonial materials
	Young leaf blade	Traditional food wrapper; ornaments
	Midrib (<i>lidi</i>)	Brooms; food fasteners
	Leaf residues	Goat fodder
	Old leaf pieces	Leaf gutter (<i>elak-elak</i>) used to guide sap flow
	Old petiole	Household fuel
Inflorescences	Sap/ <i>nira</i> (male inflorescence)	Palm sugar raw material; fresh drink; sold daily
	Dried male flowers	Goat fodder
	Blooming flowers	Nectar source for stingless bees
Fruits	Immature fruits	<i>Kolang-kaling</i> ; seasonal sales (Ramadan); perceived joint-health benefit
Seeds	Seeds/seedlings	Propagation and replanting on farms/slopes

Source: Field interviews and observations, 2023

Root use was infrequent and selective, with informants reporting occasional decoctions for stamina recovery; such practices are consistent with ethnobotanical reports of bioactive metabolites in palms and tonic-related uses in other Indonesian communities (Silalahi, 2020; Yudiyanto et al., 2022; Gunawan et al., 2018). Limited root harvesting also reflects caution toward vital plant parts contributing to plant stability and slope integrity (Tomlinson, 2006; Martini & Roshetko, 2012).

Stem-derived uses were functionally differentiated: *ruyung* (outer old trunk layer) was used for simple household items and typically obtained from non-productive or naturally fallen palms, while *umbut* (apical pith) was consumed mainly in ceremonial contexts and harvested selectively due to the hapaxanthic growth form of palms (Tomlinson, 2006; Dransfield et al., 2008). Palm fiber (*ijuk*), derived from the fibrous sheath, was widely used for roofing, ropes, brooms, filtration media, and erosion control, consistent with its lignocellulosic durability and tensile properties (Ishak et al., 2012; Huzaifah et al., 2017; Fatriasari et al., 2020).

Leaves showed the highest diversity of uses, including *janur* (very young leaves) for ritual and decorative purposes and trade, young leaf blades as food wrappers, and midribs (*lidi*) for brooms and fasteners; residues served as fodder, and old petioles as household fuel (Sujarwo et al., 2015; Evert & Eichhorn, 2013; Devendra & Leng, 2011; Lempang, 2012). Old leaf segments were also fashioned into *elak-elak* (leaf gutters used to guide sap flow), a locally developed modification reported in other Indonesian sugar palm systems (Tomlinson, 2006; Gunawan et al., 2018).

Male inflorescences, locally referred to as *manggar*, were central to livelihoods through sap (*nira*) production for palm sugar and daily sales; they also supported fodder use and provided nectar resources for stingless bees (*Trigona* spp.), while sap composition underpins its role as a sugar-rich processing substrate (Rindengan et al., 2020; Herniati et al., 2020).

Immature fruits were processed into *kolang-kaling*, linked to the gelatinous endosperm and galactomannan-related textural properties; informants additionally reported perceived associations with joint comfort, although clinical evidence remains limited (Tarigan & Purba, 2015; Thoyibi et al., 2019; Amaliah et al., 2021; Silalahi, 2020). Seeds were used for regeneration and replanting, consistent with dormancy characteristics of palm seeds and field evidence of improved germination under partial shade and moist soils (Dransfield et al., 2008; Karouw & Rindengan, 2012).

The diversity of plant-part utilization observed in this study indicates that sugar palm management in Pusuk Lestari is governed not solely by availability, but by culturally embedded considerations of renewability, risk, and long-term productivity. This pattern supports the concept that ethnobotanical use is structured through socially learned optimization strategies rather than opportunistic extraction.

Traditional Sap Tapping Practices of Sugar Palm (*Arenga pinnata*)

Traditional sugar palm sap tapping in Pusuk Lestari represents a locally evolved production system shaped by long-term interaction between tapper skills, plant physiological responses, and local ecological conditions. This system integrates empirical knowledge of palm reproductive phenology, wound response, and sap-flow regulation into a consistent and efficient tapping sequence adapted to the mountainous agroforestry landscape of Lombok (Tomlinson, 2006; Dransfield et al., 2008; Berkes, 2012).

Inflorescence Preparation and Physiological Conditioning

The initiation of tapping begins with the selection of a male inflorescence (*mayang*) that has reached physiological readiness for sap exudation. From a plant physiological perspective, this stage coincides with increased allocation of photoassimilates to reproductive tissues and the accumulation of soluble sugars within vascular-rich inflorescence tissues, which enhances exudation potential (Karouw & Rindengan, 2012; Tomlinson, 2006). In Pusuk Lestari, tappers rely on phenological indicators such as subtle changes in inflorescence coloration, the emergence of a sweet odor, and increased insect visitation, reflecting long-term experiential learning and repeated observation of plant responses under local conditions (Albuquerque & Medeiros, 2012; Sujarwo et al., 2015).

Prior to wounding, tappers perform a locally termed pre-tapping cleaning practice known as *ngelahan*, which involves removing old leaf bases, palm fiber residues, moss, and other surface materials surrounding the trunk and inflorescence. Sugar palm sap is highly susceptible to early contamination due to its high sugar concentration, and residues on plant surfaces may accelerate undesirable changes even before processing (Santiago-Urbina & Ruiz-Terán, 2014; Quddus & Hariadi, 2018). Beyond quality considerations, informants emphasized that *ngelahan* also improves climbing safety by reducing slippery surfaces and minimizing disturbances from small animals. Within an ethnobotanical framework, this practice represents an adaptive integration of pre-processing quality control and occupational risk management embedded in routine plant-use activities (Albuquerque & Medeiros, 2012; Berkes, 2012).

Following surface preparation, tappers apply rhythmic mechanical stimulation to the inflorescence, locally referred to as *mantokan*, during the pre-tapping period. Palm inflorescences are composed of elastic parenchymatous tissues and flexible vascular bundles that can tolerate repeated mechanical stimuli without immediate structural damage (Tomlinson, 2006; Dransfield et al., 2008). Experimental plant physiology studies indicate that repeated mechanical stimulation can influence tissue elasticity, turgor dynamics, and fluid movement at potential wound sites (Taiz & Zeiger, 2018). In palm sap systems, tissue hydration status and

internal pressure are recognized as key determinants of sap flow continuity (Hebbbar et al., 2015). In Pusuk Lestari, *mantokan* is applied gradually with controlled rhythm and intensity, typically by the same tapper, and informants noted that excessive or irregular stimulation may disrupt flow stability. Comparable mechanical conditioning practices have been documented in other Indonesian palm tapping traditions, supporting its role in enhancing sap exudation while minimizing tissue damage (Hapid et al., 2018; Pangemanan et al., 2019).

Overall, the sequential tapping practices documented in Pusuk Lestari illustrate a highly structured traditional production system in which physiological knowledge of palm response, material selection, and microclimate control are embedded within routine activities. Rather than representing isolated techniques, these practices function as an integrated management strategy that balances sap yield, quality maintenance, and plant longevity. This finding reinforces the view that traditional palm tapping systems operate as adaptive socio-ecological technologies shaped by long-term empirical experimentation.

Controlled Wounding and Flow Initiation

Once the inflorescence is considered physiologically conditioned, sap exudation is initiated through controlled cutting of the inflorescence tip, a practice locally known as *memukaq manggar*. Anatomically, peripheral tissues of palm inflorescences are vascular-rich and physiologically active, making them responsive to superficial incision (Tomlinson, 2006; Dransfield et al., 2008). Plant wound physiology indicates that incision depth strongly influences sap-flow continuity, as excessively deep cuts may trigger protective responses, tissue occlusion, and reduced exudation (Evert, 2015; Taiz & Zeiger, 2018). Accordingly, tappers in Pusuk Lestari apply incremental and carefully monitored cuts, using visual and tactile cues such as tissue color changes, surface moisture, and the appearance of initial sap droplets to maintain a stable and superficial wound surface. Ethnobotanical studies of sugar palm tapping similarly emphasize that precision and consistency of cutting are critical for sustaining sap yield and flow stability (Gunawan et al., 2018; Hidayat et al., 2020).

To protect the exposed wound, tappers apply a covering practice locally termed *mbongarin* or *ungkep*, which serves to maintain a humid microenvironment and shield the cut surface from rainwater, airborne particles, and excessive oxygen exposure. Sap systems are particularly sensitive to fluctuating microclimatic conditions during collection, which can influence both sap quality and flow behavior (Santiago-Urbina & Ruíz-Terán, 2014; Hebbbar et al., 2015). In Pusuk Lestari, the wound is commonly covered using *birak* or taro leaves (*Colocasia esculenta* (L.) Schott), whose broad surface area and hydrophobic cuticle help repel water while providing a physical barrier. Informants reported that leaf selection is based on empirical performance, including mechanical strength and low water absorption, reflecting locally grounded material optimization in pre-processing quality control (Martin & Rose, 2014; Albuquerque & Medeiros, 2012).

Sap Flow Management and Collection Control

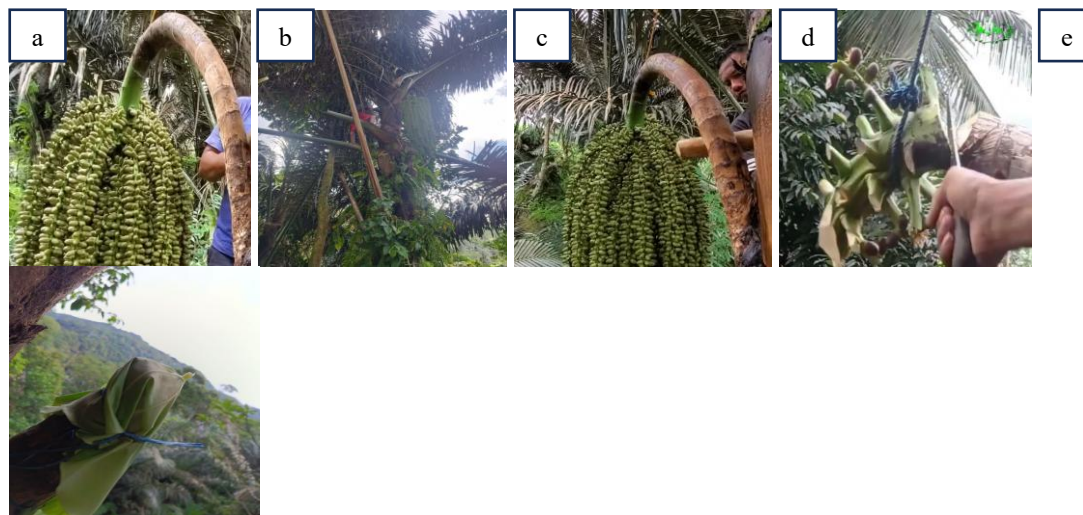
To maintain continuous sap exudation, routine thin shaving of the wound surface is conducted at regular intervals, typically twice daily in the morning and afternoon. Plant anatomical studies indicate that superficial renewal of the cut surface supports sustained flow by preventing tissue occlusion, whereas deeper incisions may reduce exudation through wound-induced sealing responses (Evert, 2015; Taiz & Zeiger, 2018). In Pusuk Lestari, tappers adjust shaving thickness based on visual assessment of tissue freshness and early sap flow behavior, a practice consistent with ethnographic accounts of palm tapping in Bali and Lombok that highlight the importance of incision consistency for yield stability (Sujarwo et al., 2015). The timing of shaving also coincides with diurnal patterns of plant water relations and carbohydrate transport that influence sap flow dynamics in palms (Hebbbar et al., 2015; Pandiselvam et al., 2023).

Sap flow from the wound surface is directed into collection containers using leaf-based channels known locally as *elak-elak*. Leaf surfaces with intact cuticles facilitate gravity-driven flow while minimizing absorption and contamination, thereby supporting efficient sap transfer (Martin & Rose, 2014; Tomlinson, 2006). Tappers in Pusuk Lestari construct *elak-elak* from locally available leaves, including coffee (*Coffea* spp.), cacao (*Theobroma cacao* L.), and sugar palm leaves (*A. pinnata*), with selection based on physical properties such as flexibility, resistance to tearing, and ease of shaping. This practice illustrates empirical understanding of how leaf material characteristics influence sap-flow stability and cleanliness.

During collection, a traditional botanical additive known as *paket*—wood chips of *Dysoxylum parasiticum* (Osbeck) Kosterm.—is placed inside sap containers. Phytochemical studies of *D. parasiticum* and related Meliaceae report the presence of bioactive secondary metabolites, including limonoid- and triterpenoid-type compounds, that exhibit inhibitory effects on microbial growth (Paritala et al., 2015; Isman, 2020). In palm sap systems, the use of botanical additives to delay undesirable quality changes during short-term storage prior to heating is widely reported in traditional contexts (Hebbar et al., 2015; Asghar et al., 2019). Informants in Pusuk Lestari consistently reported that sap collected with *paket* remains clearer and less sour during the collection period, reflecting cumulative household-level observations.

Finally, sap collection containers are covered to reduce exposure to rainwater, insects, airborne particles, and oxygen exchange, thereby supporting short-term quality retention before processing (Santiago-Urbina & Ruiz-Terán, 2014; Hebbar et al., 2015). Bamboo tubes and plastic jerrycans are commonly sealed using *birak* or taro leaves, sometimes combined with an additional plastic layer, to protect the sap during transport from the tree to the processing site.

The sequential stages of traditional sugar palm sap tapping practiced by the local community are summarized in **Fig. 2**, which illustrates the integrated workflow from inflorescence preparation to sap collection and protection.



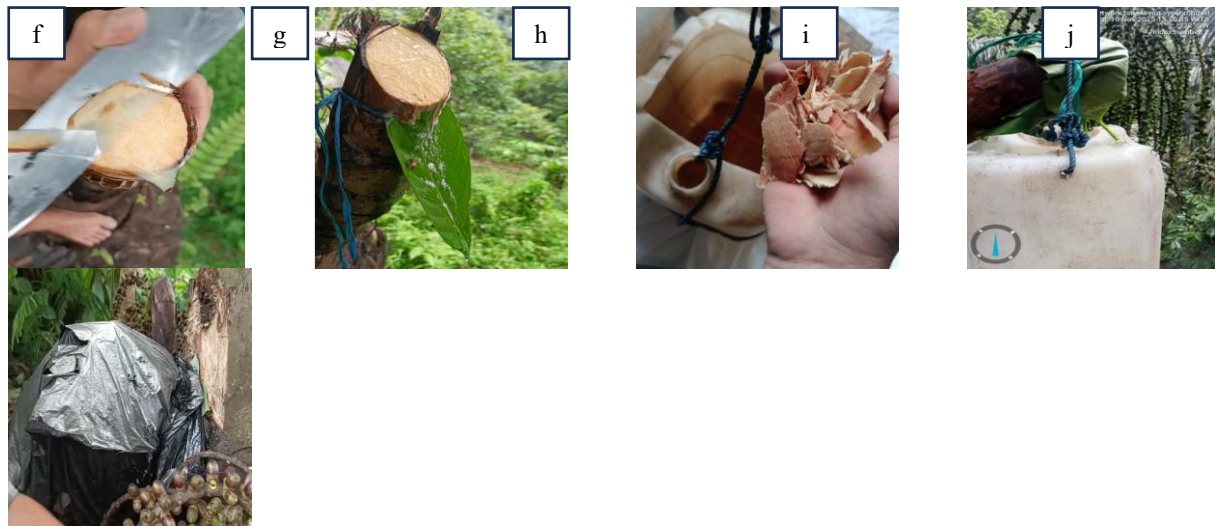


Fig. 2. Traditional sap tapping stages of sugar palm (*Arenga pinnata*) in Pusuk Lestari Village: (a) Selection of a mature male inflorescence based on phenological indicators; (b) pre-tapping cleaning of the trunk and inflorescence (*ngelahan*); (c) rhythmic mechanical stimulation of the inflorescence (*mantokan*); (d) controlled trimming and exposure of the inflorescence tip (*memukaq manggar*); (e) wound covering using *birak* leaves (*Colocasia esculenta* (L.) Schott); (f) thin slicing of the exposed tip to initiate sap exudation; (g) installation of a leaf-based sap flow guide (*elak-elak*); (h) addition of natural anti-fermentation material (*kayu purut*, *Dysoxylum parasiticum* (Osbeck) Kosterm.); (i) placement and covering of the sap collection container; and (j) final sealing of the container using *birak* leaves and plastic to protect the sap during collection.sealing

Source: Field documentation, 2023

Socio-Cultural Dimensions of Sugar Palm Tapping

Traditional sugar palm tapping in Pusuk Lestari is embedded within a complex socio-cultural system in which technical practices are regulated through taboos, rituals, and cultural narratives. These cultural elements function not merely as symbolic expressions but as operational mechanisms that guide tapper behavior, regulate resource use, manage occupational risk, and support the continuity of palm sap production over time (Berkes, 2012; Albuquerque & Medeiros, 2012).

Taboos Regulating Tapping Practices

Taboos observed by sugar palm tappers in Pusuk Lestari constitute a culturally transmitted regulatory system passed down orally by senior tappers and maintained across generations as part of customary tapping etiquette. These norms guide technical behavior so that tapping activities proceed safely, effectively, and consistently within locally accepted standards.

One commonly observed taboo is the avoidance of perfumes or strongly scented oils during tapping. Informants reported that strong external odors were perceived to negatively affect sap quality. From a biological perspective, volatile compounds may indirectly interfere with the surface conditions of the male inflorescence and potentially accelerate early quality changes in sap, thereby influencing taste and stability. Comparable observations have been reported among lontar tappers in Flores and palmyra palm tappers in Thailand, where odor contamination has been associated with faster sap fermentation and reduced product quality (Barfod et al., 2015; Sujarwo et al., 2020).

Another important taboo concerns the avoidance of tapping while experiencing negative emotional states such as anger, anxiety, or sadness. Sugar palm tapping is a high-risk activity that requires fine motor coordination, balance, and precision during climbing and incision.

Ergonomic and ethnographic studies on palm tappers indicate that emotional stress may increase the likelihood of accidents, irregular incisions, and unstable sap flow due to reduced concentration and motor control (Gunawan et al., 2018; Silalahi, 2020). This taboo therefore reflects local awareness of the biomechanical and safety risks inherent in tapping activities.

A further taboo prohibits replacing a long-standing tapper on a productive palm without mutual agreement. This rule can be interpreted as a form of customary tenure and informal stewardship rights that emphasize continuity of management. Individual tappers develop characteristic rhythms of mechanical stimulation and incision depth; abrupt changes in tapper identity may disrupt established patterns of peripheral tissue response in the inflorescence and negatively affect sap flow. Similar continuity-based management practices have been documented among palm-harvesting communities in Sunda, Bali, and Banten, where stable stewardship is considered essential for maintaining productivity (Gunawan et al., 2018; Suharno et al., 2018).

Additional taboos relate to post-harvest handling of sap, such as prohibitions against sharing sap with others during transport prior to processing. Sugar palm sap is a sugar-rich liquid highly sensitive to agitation, contamination, and delays in processing; inappropriate handling can accelerate quality degradation. From a scientific standpoint, such taboos reflect local recognition of sap vulnerability to post-extraction disturbances (Hebbar et al., 2015; Santiago-Urbina & Ruíz-Terán, 2014).

Within an ethnobotanical framework, these taboos should not be interpreted as symbolic prohibitions alone, but rather as culturally embedded mechanisms of technical, ethical, and social regulation derived from long-term experience in managing sugar palm resources (Berkes, 2012; Albuquerque & Medeiros, 2012; Garibaldi & Turner, 2004).

Rituals Associated with Sap Tapping

Ritual practices performed by some tappers in Pusuk Lestari serve as mechanisms of mental regulation and work ethics prior to and during sap tapping. The ritual locally known as *lelakak* involves touching the trunk or inflorescence while uttering a greeting, *basmalah*, or a short prayer before climbing the palm. In the context of high-risk work at height, such pre-activity rituals function to organize focus, stabilize emotions, and psychologically prepare the tapper for tasks requiring balance, precision, and careful incision.

In occupational anthropology, pre-work rituals are understood as cognitive strategies that reduce anxiety, enhance concentration, and improve motor coordination. Studies of traditional labor practices in Indonesia have shown that such rituals contribute to emotional regulation and workplace safety, particularly in activities demanding balance and accuracy, such as palm climbing and precision cutting (Mahdayani, 2016; Sangaji, 2014).

During specific stages such as *mantokan*, some senior tappers recite traditional Sasak chants or mantras transmitted orally by village elders. These chants, which reference water, flowers, and the figure of *Putri Sundari Bungkah*, are delivered softly and repetitively, often synchronized with gentle swinging movements of the inflorescence. This coupling of vocal rhythm and physical motion appears to support consistency of mechanical stimulation and careful handling of the inflorescence.

Comparable prayer- or *mantra*-based rituals have been documented among palm-harvesting communities in East Nusa Tenggara and West Java, where ritual practices serve to foster a sense of safety, request protection, and instill respect toward productive palms (Fathurrahman & Syarifuddin, 2018; Hidayat et al., 2020). While ritual forms vary across regions, their practical functions within palm management systems show notable convergence.

From an ethnobotanical perspective, tapping rituals reflect a form of moral ecology—a value system linking technical behavior to ethical responsibility toward living organisms (Berkes, 2012; Silalahi, 2020). Through ritual practice, the sugar palm is treated not merely as a production object but as a living entity deserving careful and respectful treatment, reinforcing

cautious technical behavior and work discipline that support long-term resource continuity (Garibaldi & Turner, 2004).

Legends and Conservation Ethics

The legend of *Putri Sundari Bungkah*, widely known in Pusuk Lestari, functions as a cultural device that reinforces caution and respect toward sugar palm trees. In environmental anthropology, myths that personify productive plants are understood as moral regulatory mechanisms that limit exploitative behavior and guide resource use within ecologically acceptable boundaries (Berkes, 2012; Silalahi, 2020).

By narrating the transformation of a princess into a palm tree that provides benefits to many people, the legend establishes an emotional bond between humans and the plant. Within an ethnobotanical context, this narrative strengthens moral ecology by linking technical tapping practices with ethical responsibility toward the living resource (Garibaldi & Turner, 2004).

This worldview is reflected in concrete tapping behaviors, including avoidance of excessively deep incisions, maintenance of cleanliness at tapping sites, and the application of controlled movements during early tapping stages. Sugar palm is thus conceptualized not merely as an economic asset but as a culturally significant entity requiring careful stewardship.

The perception of sugar palm as a “giving tree” positions it as a cultural keystone species, whose ecological, economic, and symbolic importance motivates conservation through norms, myths, and customary practices (Garibaldi & Turner, 2004). Similar patterns have been reported in Bali, Lombok, and other regions of Indonesia, where cultural narratives help stabilize tapping techniques and protect productive palms from destructive practices (Gunawan et al., 2018; Hidayat et al., 2020).

More broadly, the legend of *Putri Sundari Bungkah* can be understood as a form of informal ecological governance. Rather than relying on written rules or formal sanctions, the narrative establishes behavioral boundaries that effectively guide technical practices and resource use. Comparable non-formal governance systems have been documented among palm-harvesting communities in Sulawesi and East Nusa Tenggara, where customary norms and symbolic values often prove more effective than external regulations in conserving economically valuable palms (Hapid et al., 2018).

Taken together, taboos, rituals, and legends associated with sugar palm tapping in Pusuk Lestari represent an integrated socio-cultural system that connects technical skill, emotional regulation, and ecological awareness. These cultural mechanisms contribute to workplace safety, sap quality maintenance, and continuity of palm utilization, underscoring the role of cultural knowledge as a critical component of sustainable sugar palm management.

These taboos and ritual practices should therefore be interpreted not merely as symbolic expressions, but as culturally embedded regulatory mechanisms that influence technical behavior, risk management, and resource continuity. Within this framework, belief systems operate as informal governance structures that reinforce careful harvesting practices and reduce the likelihood of overexploitation.

Socio-Economic Aspects of Sugar Palm Utilization

The utilization of *Arenga pinnata* in Pusuk Lestari Village constitutes an important foundation of tapper household economies. Across various regions of Indonesia, sugar palm has been reported to provide significant economic value through the production of molded palm sugar and granulated palm sugar (*gula semut*). This role is reflected, for example, in the community forest (HKm) system of Aik Bual, Central Lombok, where sugar palm processing contributes to relatively stable household income for farmers (Webliana, 2020).

The continuity of daily income derived from sap tapping positions sugar palm as a strategic commodity within rural livelihood systems. This income stability is closely linked to the physiological rhythm of the male inflorescence, which allows tapping activities to be conducted almost year-round and ensures a relatively consistent supply of sap. Similar patterns have been

documented in South Sulawesi, where sugar palm enterprises contribute up to 44.20% of total household income and are operated continuously throughout the year (Sugara et al., 2022).

In addition to sap, tapper households in Pusuk Lestari also utilize secondary sugar palm products such as palm fiber (*ijuk*), *janur* (young leaves), and *kolang-kaling* (immature fruits) as sources of seasonal income. Such product diversification can be interpreted as a livelihood strategy aimed at reducing household economic vulnerability, a pattern commonly observed among rural communities dependent on non-timber forest products (NTFPs) (Sugara, 2022). Comparable strategies have been reported in Central Sulawesi, where diversification of sugar palm products contributes to enhanced household income resilience (Hapid et al., 2018).

In particular, *janur* is utilized as a cross-regional and cross-cultural economic commodity, primarily through sales to Hindu communities in neighboring villages for religious ceremonies. Although its utilization is limited in frequency and seasonal—typically increasing during religious festivals or ceremonial periods—the sale of *janur* provides supplementary income for tapper households. This limited and episodic use indicates that *janur* functions as a complementary rather than primary income source within sugar palm-based household economies.

Gender-based division of labor further strengthens the local economic system. Men are predominantly engaged in high-risk technical activities such as climbing and sap tapping, while women play a crucial role in post-tapping processing stages, including cooking and molding palm sugar. Findings from Pinrang, South Sulawesi, demonstrate that women's participation in palm sugar processing chains makes a significant contribution to overall household income (Yusriani et al., 2023).

The income stability associated with sugar palm utilization in Pusuk Lestari is consistent with patterns reported in the Philippines, Thailand, and India, where palm sap functions as a relatively reliable source of daily income that is less vulnerable to seasonal fluctuations than annual agricultural crops (Lantican et al., 2014). Such income characteristics have long been recognized as a defining feature of NTFPs that serve as economic buffers for rural households (Murthy et al., 2005).

Taken together, sugar palm in Pusuk Lestari can be positioned as an economic keystone resource, supporting household livelihood sustainability through a combination of daily income from sap and seasonal income from secondary products such as *ijuk*, *janur*, and *kolang-kaling* (Webliana, 2020; Sugara, 2022). This dual role underscores the importance of sugar palm not only in economic terms but also in maintaining the socio-economic resilience of rural communities.

The combination of daily income from sap tapping and seasonal income from secondary products positions sugar palm as a livelihood buffer that enhances household economic resilience. Such characteristics are consistent with the role of non-timber forest products as stabilizing elements within rural economies, particularly in landscapes with limited alternative income sources.

Local Ecological Knowledge in Sugar Palm Conservation and Management

Conservation of sugar palm (*Arenga pinnata*) in Pusuk Lestari Village is governed by customary norms and family-based management practices that regulate access, protect productive trees, and support long-term resource continuity. A key rule prohibits the felling of palms that are actively producing sap, reflecting an economically grounded conservation mechanism in which productive trees are regarded as family assets essential for sustaining household livelihoods (Sujarwo et al., 2020; Silalahi, 2020). Comparable patterns have been reported among palm-dependent communities across Southeast Asia, where economically valuable palm species are maintained through customary rules because of their role as livelihood buffers (Barfod et al., 2015).

The local perception of sugar palm as a “giving tree” positions it as a cultural keystone species, defined as a species with high ecological, economic, and symbolic value whose persistence is ensured through norms, myths, and cultural practices (Garibaldi & Turner, 2004). In this context, customary norms function not only to limit extraction but also to shape an ethic of use that links economic benefits with ecological responsibility, consistent with frameworks of traditional ecological knowledge (TEK) (Berkes, 2012).

Restrictions on harvesting *umbut* (apical pith) from palms that are actively tapped reflect local understanding of the hapaxanthic growth form of palms. Because the apical meristem represents the sole growth point, damage to this tissue terminates growth and ends the life cycle of the tree (Tomlinson, 2006). Protection of this vital plant part is widely documented in the management of food palms in Indonesia, where meristematic tissues are strictly safeguarded to maintain productive longevity (Hidayat et al., 2020).

Regeneration of sugar palm is supported through tolerance of natural seedlings around parent trees and selective transplantation of densely growing juveniles to sites considered suitable. This practice demonstrates local capacity to assess microhabitat suitability—such as soil moisture, slope stability, and water availability—as a basis for managing regeneration. Similar approaches have been documented in palm-based agroforestry systems in Sulawesi and Nusa Tenggara, where wild seedlings are preferred because they are perceived as better adapted to local conditions (Gunawan et al., 2018).

Microhabitat management further includes restrictions on soil disturbance around the root zone, retention of leaf litter, and avoidance of removing decaying trunks. These practices can be interpreted as forms of low-disturbance management that maintain soil stability, water retention, and organic matter availability, thereby supporting the relatively shallow root systems of palms (Martini & Roshetko, 2012). From an ecological perspective, reduced soil disturbance and litter retention are known to contribute to microclimate regulation and nutrient balance in tropical agroforestry systems (Berkes, 2012).

Seasonal variation in sap quality, as reported by tappers, also reflects the integration of local ecological knowledge into management decisions. During the rainy season, sap is perceived as more difficult to obtain and more prone to rapid quality decline, prompting immediate processing into palm sugar. Physiologically, high rainfall and humidity may dilute soluble sugar concentrations and disrupt vascular pressure gradients, reducing sap stability after extraction (Steppe et al., 2015). In addition, rainwater may enter the collection system through splash, surface runoff along leaves and sap channels (*elak-elak*), or seepage through non-sealed covers, causing dilution, increased *water activity*, and higher initial microbial inoculum (Aidoo & Nout, 2002; Santiago-Urbina & Ruíz-Terán, 2014). These factors accelerate pH decline and sensory changes if sap is not promptly heated (Hebbbar et al., 2015; Djeni et al., 2022), providing a scientific basis for rapid processing practices during the rainy season.

At the social level, intergenerational inheritance of management rights over sugar palm trees strengthens incentives for long-term stewardship, as family ownership directly links ecological condition with economic benefit. Similar tenure arrangements have been shown to be more effective than formal regulations in conserving economically valuable palms in Sulawesi and East Nusa Tenggara, where customary norms guide extraction and protection practices (Hapid et al., 2018; Sujarwo et al., 2020).

Taken together, sugar palm conservation in Pusuk Lestari can be characterized as an integrated system encompassing ecological, social, and economic dimensions. The combination of customary norms, protection of vital plant parts, natural regeneration, microhabitat management, and seasonal interpretation demonstrates that local ecological knowledge is capable of generating effective conservation strategies without reliance on formal state instruments. This community-based conservation model aligns with findings from palm

management systems elsewhere in Southeast Asia and is relevant as a sustainable approach for managing economically important palm species in tropical landscapes (Lantican et al., 2014).

Plant-Part Utilization of Sugar Palm Based on PPV Values

A total of 28 reported uses (RU) were recorded for *Arenga pinnata* plant parts based on information provided by 23 informants. Leaves exhibited the highest PPV value (32.14%; 9 RU), followed by stem-derived parts (28.57%; 8 RU) and male inflorescences (21.43%; 6 RU). Fruits showed an intermediate PPV value (10.71%; 3 RU), whereas roots and seeds had the lowest PPV values (each 3.45%; 1 RU).

The relative importance of sugar palm plant parts based on the Plant Part Value (PPV) analysis is summarized in **Table 2** and illustrated in **Fig 3**.

Table 2. Plant Part Value (PPV) of sugar palm (*Arenga pinnata*) organs in Pusuk Lestari Village, West Lombok, Indonesia

Plant part	Reported uses (RU)	PPV (%)
Leaves	9	32.14
Stems	8	28.57
Inflorescences (<i>mayang</i>)	6	21.43
Fruits	3	10.71
Roots	1	3.45
Seeds	1	3.45
Total	28	100

Notes: $PPV = (RU_i / \Sigma RU) \times 100$. RU represents distinct reported uses mentioned by informants.

Source: Quantitative data analysis based on interviews, 2023

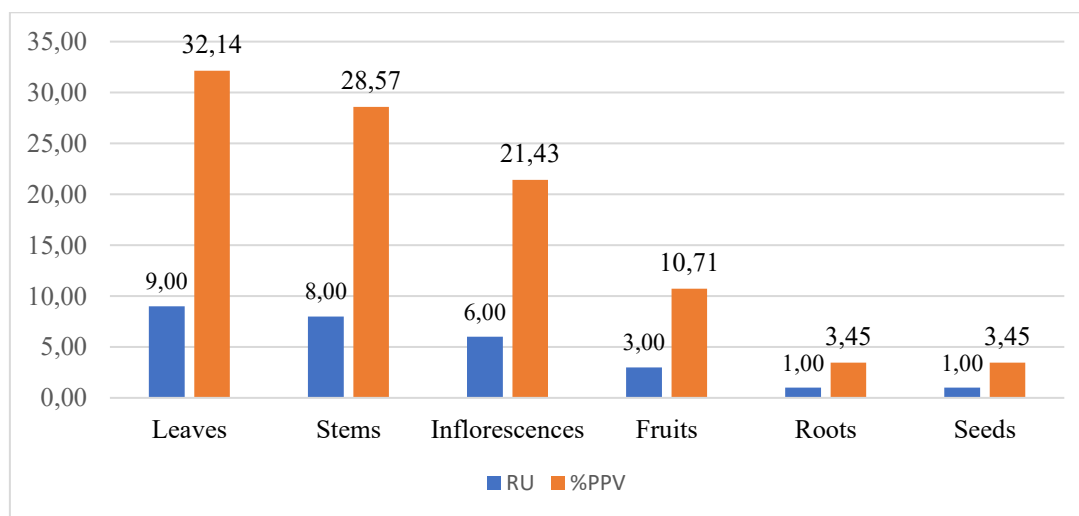


Fig. 3. Plant Part Value (PPV, %) of sugar palm (*Arenga pinnata*) organs utilized by the community in Pusuk Lestari Village

Source: Quantitative data analysis based on interviews, 2023

Results of the Plant Part Value (PPV) analysis indicate that the utilization of *Arenga pinnata* by the community of Pusuk Lestari Village is not random, but follows a selective hierarchy of plant-part use consistent with the principle of ethnobiological optimization. This principle posits that local communities tend to prioritize plant parts that best satisfy functional needs, are readily accessible, and entail relatively low ecological risk, thereby allowing continued use over time (Turner, 1988; Albuquerque & Medeiros, 2012). Accordingly, renewable and multifunctional plant parts exhibit higher PPV values, whereas plant parts whose

exploitation may compromise individual survival or long-term productivity show lower PPV values due to culturally regulated access.

Leaves exhibited the highest PPV value (32.14%). This result reflects the broad functional diversity of leaf-derived uses in everyday life, encompassing domestic, ritual, and technical applications, including *janur* for ceremonial purposes, *lidi* for household implements, leaf blades for food wrapping, petioles as household fuel, and older leaves fashioned into *elak-elak* for sap collection. As a renewable plant part, leaf harvesting does not interfere with palm growth and therefore entails relatively low ecological risk. This hierarchy of use is consistent with the concept of ecological apparency, whereby plant parts that are conspicuous, abundant, and easy to harvest tend to be more intensively utilized and assigned higher use values within local systems (Phillips & Gentry, 1993). Comparable patterns have been reported in ethnobotanical studies of palms in Bali, Lombok, and East Java, where leaves consistently rank as the most intensively used plant part (Sujarwo et al., 2015; Silalahi & Nisyawati, 2018).

Stem-derived plant parts, including *ruyung*, *ijuk*, and *umbut*, also exhibited relatively high PPV values (28.57%) due to their combined structural, technical, and ceremonial functions. Palm fiber (*ijuk*) contributes substantial economic value as a result of its durability and relatively stable market demand (Hidayat et al., 2015; Lempang, 2012). In contrast, the use of *umbut* (apical pith) is tightly regulated by traditional ecological knowledge, as local people recognize that the apical meristem represents the single growth point of hapaxanthic palms. Consequently, *umbut* is harvested only from palms that are no longer productive, reflecting selective protection of biologically critical plant parts to maintain long-term productivity (Dransfield et al., 2008).

Male inflorescences (*manggar*) showed high PPV values (21.43%) because they produce sap (*nira*), the primary commodity supporting daily household income and palm sugar production. Within use-value theory, plant parts that provide direct and routine economic benefits tend to hold high social significance within livelihood systems (Phillips & Gentry, 1993). Studies conducted in West Java, Lombok, the Philippines, and other palm-producing regions consistently identify palm inflorescences as key determinants of tapper income stability (Martini & Roshetko, 2012; Haryoso et al., 2020; Lantican et al., 2014). The central role of sap further reinforces sugar palm as a cultural keystone species that sustains both social and economic systems (Garibaldi & Turner, 2004).

Fruits exhibited intermediate PPV values (10.71%), reflecting their seasonal utilization, primarily for *kolang-kaling* production, and indicating a more specialized role compared with leaves, stems, or inflorescences. Ethnobotanical studies in North Sumatra and West Java similarly report lower PPV values for sugar palm fruits because their use is not continuous throughout the year (Nurdjanah et al., 2017; Gunawan et al., 2018).

Roots and seeds displayed the lowest PPV values (each 3.45%), not because they lack utility, but because their use is deliberately restricted to maintain population sustainability. Roots are harvested only in limited quantities for specific purposes, while seeds are prioritized for regeneration, as sugar palm cannot be propagated vegetatively. This selective limitation exemplifies ecological restraint, a form of traditional conservation grounded in local ecological knowledge that safeguards reproductive capacity and long-term population viability (Berkes, 2008; Martini & Roshetko, 2012).

Taken together, the PPV structure observed in Pusuk Lestari reflects a socially regulated hierarchy of plant-part selection that integrates economic needs, cultural values, and conservation considerations within local knowledge systems. This interpretation is consistent with ethnobotanical studies of palms in Indonesia (Sujarwo et al., 2015; Silalahi, 2020) and across Southeast Asia (Barfod et al., 2015; Sahoo et al., 2020).

In this study, the Plant Part Value (PPV) index serves not only as a quantitative measure of use intensity but also as an interpretative tool for understanding culturally regulated patterns of

resource use. The low PPV values for roots and seeds do not indicate marginal importance, but rather deliberate restriction informed by ecological awareness and conservation ethics. This finding highlights the potential of PPV to capture dimensions of restraint and sustainability that are often overlooked in purely economic assessments of plant use.

CONCLUSION

This study establishes *Arenga pinnata* as a multipurpose non-timber forest product and cultural-economic keystone species in Pusuk Lestari Village, West Lombok, where ethnobotanical documentation combined with the Plant Part Value (PPV) index uncovers a socially regulated hierarchy favoring renewable organs like leaves, stems, and male inflorescences while restricting critical ones such as roots and seeds to ensure population sustainability. Traditional ecological knowledge (TEK) governs management via phenological assessments, structured tapping, and socio-cultural mechanisms—including taboos, rituals, and norms—that regulate harvesting, enhance sap quality and safety, and sustain production without formal regulations. Overall, integrating qualitative TEK with quantitative tools like PPV illuminates how cultural norms, ecological awareness, and economic needs foster sustainable resource use, offering a community-grounded model for agroforestry and conservation in tropical landscapes. For future research, longitudinal studies could track how climate change and market pressures impact TEK transmission and PPV patterns across generations in comparable sites.

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