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Quantitative ethnobotany of mangrove plant uses by the coastal community of Sicanang Belawan, North Sumatra, Indonesia

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Abstract. *Siregar ES, Jumilawaty E, Tanjung M, Risnasari I, Basyuni M, Syafitri A, Hartanto A. 2025. Quantitative ethnobotany of mangrove plant uses by the coastal community of Sicanang Belawan, North Sumatra, Indonesia. Biodiversitas 26: 5181-5194.* Sicanang Belawan, North Sumatra, Indonesia, harbors a mosaic of coastal and mangrove ecosystems that support local livelihoods. However, unsustainable extraction and the decline of ecotourism threaten both biodiversity and Traditional Ecological Knowledge (TEK). This study aimed to document mangrove plant species utilized by the Sicanang Belawan community and to apply quantitative ethnobotanical indices to identify species of cultural and livelihood significance. Fieldwork was conducted between November 2024 and January 2025 in Belawan Sicanang Sub-district, Medan, North Sumatra, Indonesia. Ethnobotanical data were obtained through structured and open-ended interviews with 71 informants selected by snowball sampling. Plant species were identified through guided forest walks and voucher specimens deposited at Herbarium Medanense (MEDA). Quantitative indices, including Relative Frequency of Citation (RFC), Cultural Importance (CI), Relative Importance (RI), and Cultural Value for ethnospecies (CVe), were calculated. The respondent pool was predominantly female (60.6%), though men reported significantly more plant uses. No significant differences were observed among age or occupation groups. A total of 19 plant species from 10 families were recorded. Fruits (32.43%), leaves (31.75%), and trunks (30.96%) were the most commonly used parts. The main use categories were food (185 reports), construction (176), animal fodder (104), fuel (96), and medicine (89). *Nypa fruticans* ranked highest across all indices (RFC: 0.887, CI: 2.535, RI: 0.929, CVe: 1.350), followed by *Acanthus ilicifolius*, highlighting their central role in livelihood, health, and material culture. These findings demonstrate the continued reliance of coastal communities on mangrove resources and highlight the value of traditional ecological knowledge in sustaining local livelihoods. Incorporating such knowledge into community-based conservation and mangrove management can strengthen ecological resilience and ensure the long-term sustainability of coastal ecosystems.

Keywords: *Acanthus ilicifolius*, edible fruits, *Nypa fruticans,* quantitative ethnobotany, snowball sampling

INTRODUCTION

Indonesia, the world's largest archipelagic nation, comprises approximately 17,504 islands and a coastline extending more than 95,000 km. This coastal expanse supports about 3.2 million hectares of mangrove forests, ranging from narrow fringing belts to extensive complexes several kilometers wide. Mangroves represent one of the most diverse and ecologically significant vegetation systems in the tropics, with an estimated 202 associated plant species, including 89 tree species, 44 shrubs, 19 lianas, 5 palms, 44 epiphytes, and one fern (Kusmana 2018). Despite this richness, about 70% of Indonesia's mangroves have been degraded, primarily through aquaculture expansion, urbanization, and overexploitation (Friess et al. 2016). The ecological importance of mangroves for coastal protection, carbon storage, and biodiversity is well established; equally important, but less documented, is their role in sustaining cultural practices and livelihoods.

Ethnobotanical studies in mangrove ecosystems highlight the close interdependence between communities and their surrounding flora. Globally, coastal peoples have long used mangrove species for food, medicine, fodder, fuel, and construction materials (Hossain and Islam 2015). In South and Southeast Asia, species such as *Nypa fruticans*, *Avicennia marina*, and *Sonneratia alba* recur as multipurpose resources, providing edible fruits, timber, traditional remedies, and materials for housing and handicrafts (Dejene et al. 2020; Suwardi et al. 2020). In Malaysia, *Rhizophora* and *Bruguiera* species are particularly valued for fuelwood and charcoal, while in the Philippines and Thailand, nipa palm sap is widely processed into sugar and alcohol (Albuquerque et al. 2019). These comparisons demonstrate both convergences and local adaptations, illustrating how ethnobotanical practices are shaped by ecology, economy, and culture.

In Indonesia, ethnobotanical surveys across coastal regions reveal consistent reliance on mangroves for subsistence and commerce. Studies in Aceh and South Kalimantan emphasize the central role of *N. fruticans* fruits in food security and micro-enterprises (Suwardi et al. 2020). In Java, communities harvest *Avicennia* and *Rhizophora* wood for fuel and construction (Damastuti et al. 2023), whereas in Sulawesi, *Sonneratia* species are used as animal fodder and traditional medicine. However, most published works are descriptive, with limited application of quantitative indices that assess cultural salience and use diversity. Quantitative ethnobotany, employing indices such as Cultural Importance (CI) and Relative Frequency of Citation (RFC), provides a more rigorous basis for comparing species significance across communities (Tardio and Pardo-de-Santayana 2008). Yet such approaches remain rare in Indonesian coastal ethnobotany, and virtually absent for North Sumatra.

Sicanang Belawan, located in North Sumatra, encompasses approximately 470 ha of mangroves with 29 species documented (Syafitri et al. 2024). The community is multi-ethnic, including Javanese, Malay, Banjarnese, and Batak groups, with livelihoods centered on silvofishery, aquaculture, small-scale trade, and resource-based household industries (Ginting et al. 2021; Manurung et al. 2021; Rais et al. 2021). Ecosystem services from mangroves underpin both local food security and economic resilience. However, the area also faces persistent anthropogenic pressures. Unsanctioned logging for fuel and construction, accumulation of unmanaged waste, and abandonment of ecotourism projects have weakened both ecological integrity and conservation potential (Ginting and Siregar 2020; Harefa et al. 2022; et al. 2024). Traditional Ecological Knowledge (TEK) in Sicanang is at risk. Although older generations retain knowledge of mangrove species and uses, intergenerational transmission is inconsistent, and younger residents increasingly depend on market goods rather than forest resources. This dynamic mirrors wider Southeast Asian trends, where undervaluation of TEK has contributed to resource decline (Tang and Gavin 2016). Despite the ecological and cultural importance of Sicanang's mangroves, systematic documentation of local ethnobotanical knowledge, particularly through quantitative approaches, remains lacking.

Previous ethnobotanical studies in Indonesia have highlighted species lists and uses but rarely assessed cultural importance with standardized indices. In North Sumatra, research has focused on aquaculture, shrimp populations, and tourism potential, leaving a gap in understanding how communities interact with mangrove flora at a cultural and livelihood level. Without such knowledge, conservation strategies risk overlooking species that are central to local identity and resilience. This study aimed to document mangrove species utilized by the Sicanang Belawan community and to apply quantitative ethnobotanical indices to identify species of cultural and livelihood significance. By situating local knowledge within a broader comparative and methodological framework, the study provides insights essential for biocultural conservation and participatory management of mangrove ecosystems.

MATERIALS AND METHODS

Study area

The research was conducted from November 2024 to January 2025 in Belawan Sicanang Sub-district, located at 3°45'31.6"N and 98°39'06.0"E. Administratively, the area falls under Medan Belawan District, Medan City, North Sumatra, Indonesia, and covers a total area of approximately 1,510 ha (Figure 1). The region is geographically bordered by Belawan Bahari Sub-district to the east, Labuhan Deli Sub-district to the south, Hamparan Perak Sub-district to the west, and the Pantai and Belawan Rivers to the north. The population of Belawan Sicanang Sub-district was recorded at 17,775 individuals, comprising 4,061 households, with 3,148 male-headed and 913 female-headed households. The primary occupations of residents include employment in the fishing, farming, homemakers, and small-scale agriculture. The population is predominantly of Batak and Javanese ethnic backgrounds. Educational attainment is generally low, with most residents having completed only elementary or junior secondary school, although a minority have attained senior secondary or tertiary education. Islam is the dominant religion, followed by Christianity and, to a lesser extent, Buddhism.

Sampling and informants

A total of 71 informants were interviewed. Informants were identified through snowball sampling, a purposive, non-probability technique widely used in ethnobotany to recruit individuals with specific knowledge when expertise is unevenly distributed across a community (Alexiades and Sheldon 1996). Initial participants were recommended by village leaders and local Non-governmental organizations (NGOs), after which earlier interviewees referred additional respondents. Selection criteria emphasized individuals recognized locally for their knowledge of mangrove plants, including fishermen, farmers, homemakers, traders, and elders. This approach ensured coverage of both gender and occupational groups, while prioritizing knowledge depth.

Data collection

Two complementary tools were used: (i) Structured interviews and questionnaires, to document demographic characteristics, plant species used, plant parts utilized, and modes of application; and (ii) Open-ended interviews and guided walks, to allow in-depth accounts and contextual explanations of uses. These followed standard ethnobotanical field manuals (Alexiades and Sheldon 1996). Prior to fieldwork, questionnaires and interview guides were piloted with three community members to ensure clarity, cultural appropriateness, and validity. Minor adjustments were made to improve phrasing. Informed verbal consent was obtained from all participants, and interviews were conducted in Bahasa Indonesia with local dialect translation when needed. Ethical standards followed institutional, national, and international guidelines for ethnobiological research, including the International Society of Ethnobiology (ISE) Code of Ethics.

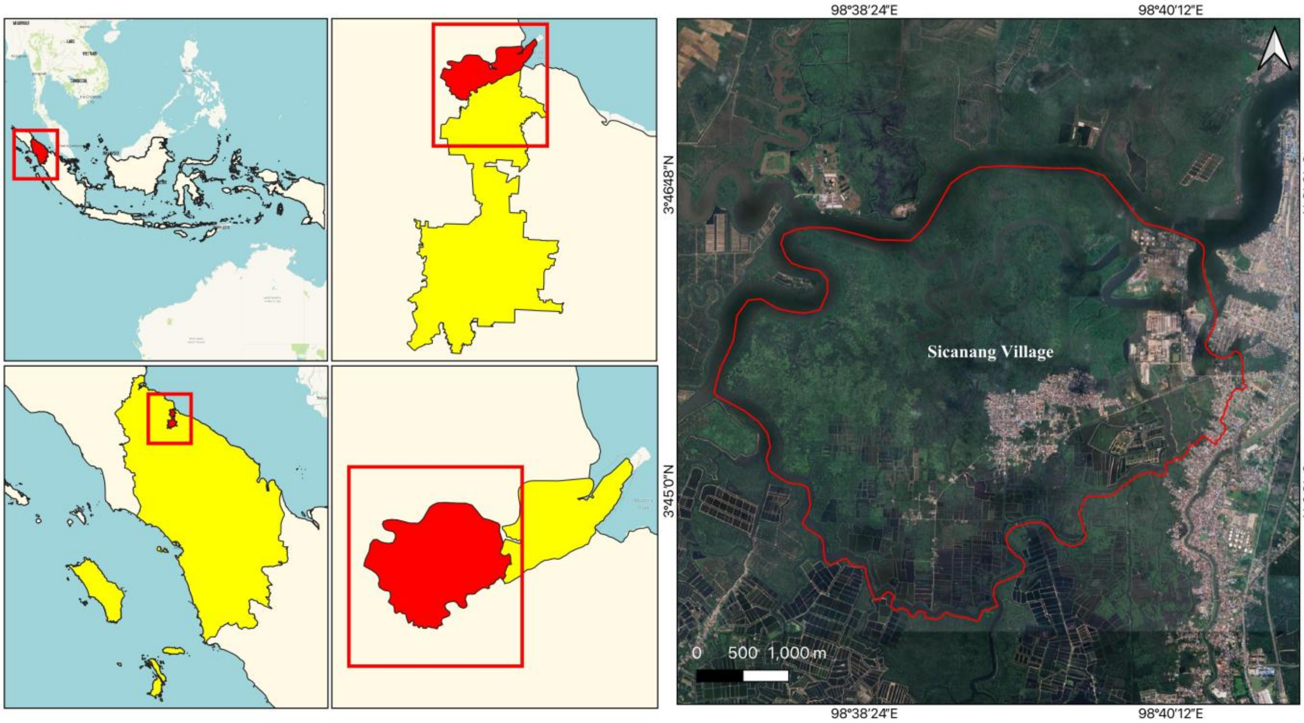

Figure 1. Geographical location of the study area in Sicanang Village, Medan Belawan District, North Sumatra, Indonesia. The map indicates administrative boundaries, major rivers, and the extent of mangrove forest cover. A scale bar (km) and north arrow are included for spatial reference

Plant identification and voucher specimens

Guided walks with key informants were undertaken to verify plant identity and uses in situ. Voucher specimens with flowers and/or fruits were collected, identified using "Flora Malesiana" and regional references, and cross-validated through botanical databases (World Flora Online, IPNI, POWO). Specimens were deposited at the Herbarium Medanense (MEDA), Universitas Sumatera Utara.

Data analysis

All interview data were organized in Microsoft Excel. Quantitative ethnobotanical indices were calculated to assess cultural significance: Use Reports (URs) is the total uses for the species by all informants (from i_1 to ${}^{i}N$) within each use-category for a species (s). This metric (Equation 1) represents the cumulative count of informants who cited at least one use for a given species within a specific use-category (NC), as well as the total number of distinct uses recorded in that category (u_1 to ${}^{u}NC$) (Prance et al. 1987).

$$UR_s = \sum_{u=u_1}^{{}^{u}NC} \sum_{i=i_1}^{{}^{i}N} UR_{ui} \qquad [1]$$

Cultural Importance (CI) index is calculated by dividing the total number of Use Reports (URs) for each species by the total number of informants, thereby accounting for both the frequency and diversity of uses attributed to each species (Equation 2) (Tardio and Pardo-de-Santayana 2008).

$$CI_s = \sum_{u=u_1}^{{}^{u}NC} \sum_{i=i_1}^{{}^{i}N} UR_{ui/N}. \qquad [2]$$

Frequency of Citation (FC) is the total number of informants who reported at least one use for a given plant species (Equation 3) (Prance et al. 1987).

$$FC_s = \sum_{i=i_1}^{{}^{i}N} UR_i \qquad [3]$$

Number of Uses (NUs) is the total count of use reports across all categories for each respective species, while NC is the number of use categories (Equation 4) (Prance et al. 1987).

$$NU_s = \sum_{u=u_1}^{{}^{u}NC} \qquad [4]$$

Relative Frequency of Citation (RFC) index for each species was calculated by dividing either the number of informants who mentioned the species (FC) or the total number of Use Reports (URs) by the total number of informants interviewed (N) (Equation 5) (Tardio and Pardo-de-Santayana 2008).

$$RFC_s = \frac{FC_s}{N} = \frac{\sum_{i=i_1}^{{}^{i}N} UR_i}{N} \qquad [5]$$

Relative Importance (RI) index for each species was calculated as the average of two standardized metrics: $RFC_{s(max)}$, which is the relative frequency of citation for the species (s) over the maximum; and $RNU_{s(max)}$, which is the relative number of uses for *s* over the maximum (Equation 6) (Tardio and Pardo-de-Santayana 2008).

$$RI_s = \frac{RFC_{s(max)} + RNU_{s(max)}}{2} \quad [6]$$

The Use Value (UV) index is similar to CI except that it is calculated by summing the total number of UR for each species across all informants, without categorizing them by use types (Equation 7) (Tardio and Pardo-de-Santayana 2008).

$$UV_s = \sum_{i=i_1}^{i_N} \sum_{u=u_1}^{u_{NC}} UR_{ui/N} \quad [7]$$

Cultural Value (CV_e) of an ethno-species represents one of three composite indices used to evaluate its cultural, practical, and economic significance. The index is derived from the following components: (i) Use Value Coefficient (UC_e), defined as the number of distinct use categories reported for a given ethno-species (e) divided by the total number of potential use categories considered in the study; (ii) Informant Citation coefficient (IC_e), calculated as the number of informants who recognized the ethno-species as useful divided by the total number of informants surveyed; (iii) Informant Use-Citation coefficient (IUc_e), defined as the total number of informants who cited specific uses of the ethno-species (e) divided by the total number of informants (Equation 8) (Reyes-Garcia et al. 2006). Quantitative ethnobotanical analyses and chord diagrams were performed using functions from the ggplot2 package within the ethnobotany R package in R version 4.5.1. An alluvial plot was constructed using OriginPro® 2025b software.

$$CV_e = Uc_e \cdot IC_e \cdot \sum IUc_e \quad [8]$$

RESULTS AND DISCUSSION

Informant demographics

A total of 71 informants from the coastal community of Sicanang participated in the study, with demographic details including age, gender, educational background, ethnic affiliation, occupation, and length of residence summarized in Table 1. The informant pool was predominantly female (60.56%), while male informants comprised 39.44% of the total. A two-tailed independent sample *t*-test revealed a statistically significant difference in plant knowledge between males and females (t: 2.14, p: 0.036), with male informants reporting a higher mean number of utilized plants (6.64) compared to females (5.51). The distribution of age among informants was largely dominated by adults between 25 and 55 years. Specifically, middle-aged adults (35-44 years) accounted for 30.99%, older adults (45-54 years) 23.94%, and young adults (25-34 years) 19.72%. Other age groups, including adolescents, elders, and children, represented the remainder. However, Welch's ANOVA test indicated no significant difference in ethnobotanical knowledge across these age groups (p: 0.625), suggesting consistent and effective knowledge transmission across generations.

Gender differences in ethnobotanical knowledge have yielded mixed results across studies. While some meta-analyses suggest no significant global disparity between men's and women's medicinal plant knowledge (Torres-Avilez et al. 2016), other research highlights that women, particularly from older generations, tend to possess more extensive knowledge of local flora and their medicinal applications (Voeks 2007). Ethnobotanical knowledge is not only gendered but also shaped by the local context and specific categories of plant use. For instance, women are often more knowledgeable about edible and medicinal plants due to their roles in household healthcare and food preparation. In comparison, men typically acquire greater expertise in plants used for construction, fuel, and other utilitarian purposes (Camou-Guerrero et al. 2008).

Table 1. Demographic characteristics of the informants in the study area

Parameter	Category	Number	Frequency (%)
Gender	Male	28	39.44
	Female	43	60.56
Age (in years)	Children (<14)	5	7.04
	Adolescents (15-24)	4	5.63
	Young adults (25-34)	14	19.72
	Middle-aged adults (35-44)	22	30.99
	Older adults (45-54)	17	23.94
	Elders (>55)	9	12.68
Education	Elementary school	30	42.25
	High school	39	54.93
	Diploma and graduates	2	2.82
Ethnic group	Aceh	1	1.41
	Banjar	10	14.08
	Batak	4	5.63
	Jawa	29	40.85
	Karo	2	2.82
	Mandailing	7	9.86
	Melayu	13	18.31
	Minang	5	7.04
Occupation	Fishermen and farmers	23	32.39
	Homemakers	29	40.85
	Laborers	5	7.04
	Students	6	8.45
	Traders and small businesses	8	11.27
Length of residence	≤5 years	1	1.41
	6-10 years	5	7.04
	11-15 years	6	8.45
	16-20 years	2	2.82
	>20 years	57	80.28

In the present study, male respondents exhibited higher knowledge of mangrove plant species and their uses compared to females. This may reflect gendered patterns of daily activities and labor divisions in coastal communities, where men are more directly engaged in fishing, boat making, charcoal (firewood) production, and other resource-based livelihoods that rely on mangrove ecosystems (Robinson 2016). Men are more likely to interact regularly with mangrove habitats, leading to greater familiarity with specific species and their functional applications (Treviño 2022). Additionally, cultural norms in some regions may restrict women's mobility in accessing forested coastal areas, further limiting their exposure to and experiential knowledge of mangrove resources (Lawless et al. 2019).

Age is often considered a contributing factor in shaping TEK, with older individuals generally assumed to possess more extensive ethnobotanical knowledge due to prolonged experiential learning and intergenerational transmission (Pfeiffer and Butz 2005). However, findings on the relationship between age and ethnobotanical knowledge remain inconclusive. Some studies report no significant age-related variation in ethnobotanical knowledge (Ndavaro et al. 2024), while others suggest a positive correlation between age and knowledge accumulation (Hopkins et al. 2015). In the present study, no significant differences in ethnobotanical knowledge were observed across age groups. This relatively uniform distribution of knowledge may be attributed to the long-term residence of most respondents in the study area, where the majority of participants had lived for more than two decades (Table 1). Such extended habitation suggests that at least one full generation has matured in place, allowing for widespread access to and transmission of local plant knowledge within families and communities, regardless of age. This stability may facilitate the horizontal and intergenerational sharing of ethnobotanical knowledge, leading to a more equal distribution of information across age cohorts.

In terms of educational background, the majority of informants had completed senior high school or equivalent (54.93%), followed by those who had completed elementary school (42.25%). Only a small proportion (2.82%) had received higher education at the tertiary level. Eight ethnic groups were represented in the study area, with the Javanese making up the largest proportion (40.85%), followed by Malay (18.31%) and Banjarnese (14.08%). Other ethnic groups, including Batak, Mandailing, Karo, Minangkabau, and Aceh, comprised the remainder. Occupationally, homemakers constituted the largest group (40.85%), followed by fishermen and farmers (32.39%), traders and small business operators (11.27%), students (8.45%), and laborers (7.04%). Consistent with the age group analysis, the ANOVA test revealed no statistically significant difference in the number of plant species cited by informants across occupational categories (p: 0.139). This suggests that the informants' primary livelihood activities did not strongly influence ethnobotanical knowledge. With respect to the length of residence, the majority of informants (80.28%) had lived in the area for more than 20 years, reflecting long-term engagement with the local environment and its plant diversity. A smaller proportion of participants reported shorter residence durations: 11-15 years (8.45%), 6-10 years (7.04%), 16-20 years (2.82%), and ≤5 years (1.41%). These results suggest that prolonged residence may play a role in the accumulation and continuity of local ethnobotanical knowledge in Sicanang, even though other demographic parameters showed no statistically significant differences or could not be tested due to limited sample size and categorical representation.

List of mangrove species in Sicanang Belawan

A total of 19 plant species belonging to 10 families were cited as being utilized by the coastal community in Sicanang (Table 2). The family Rhizophoraceae was the most represented, comprising 6 species, followed by Acanthaceae (4 species), Combretaceae and Lythraceae (2 species each), and one species each from Arecaceae, Asteraceae, Euphorbiaceae, Pteridaceae, and Rubiaceae. Based on their ecological classification, the majority of the recorded species (e.g., *Rhizophora apiculata*, *Bruguiera gymnorhiza*, *Ceriops tagal*, *S. alba*) are true mangroves, which are obligate species adapted to intertidal zones with specialized morphological and physiological traits. Others, such as *Pluchea indica* and *Acrostichum aureum*, are classified as mangrove associates, typically found in the periphery of mangrove forests and exhibiting less salt tolerance. Growth habits across the listed species include trees (e.g., *A. marina*, *Rhizophora stylosa*), shrubs (*Scyphiphora hydrophylacea*), palms (*N. fruticans*), ferns (*A. aureum*), and herbaceous plants (*P. indica*). The number of species recorded in Sicanang (19 species, 10 families) is relatively high compared to other coastal ethnobotanical surveys in Indonesia. For example, Safitri et al. (2024) documented only 11 mangrove species in Siak, Riau, while Arbiastutie et al. (2021) reported 13 medicinally relevant species in West Kalimantan. Conversely, higher richness was noted in East Lampung, where 22 species from 12 families were recorded (Duryat et al. 2024). The dominance of Rhizophoraceae in Sicanang is consistent with patterns observed across Indonesia (Arbiastutie et al. 2021; Duryat et al. 2024), reflecting both the ecological abundance and the high utility of this family, particularly for construction and fuelwood. The dominance of Acanthaceae species, particularly *Acanthus ilicifolius*, reflects the importance of medicinal resources, as also highlighted in Lampung Timur (Duryat et al. 2024). The inclusion of mangrove associates such as *P. indica* and *A. aureum* further illustrates how local communities extend their ethnobotanical repertoire beyond strict mangroves, a pattern also observed in Belitung, where associates such as *Lumnitzera littorea* were noted as key resources for bee-keeping systems (Hayati et al. 2024). This indicates that cultural salience is not limited to major mangrove taxa, but also involves edge species with specialized functions. Differences in recorded species richness among sites likely reflect a combination of ecological and methodological factors. Ecologically, the extent and condition of mangrove forests vary: Sicanang comprises approximately 470 ha with 29 mangrove species documented in vegetation surveys (Syafitri et al. 2024), whereas the Siak mangroves are smaller and more degraded, which may explain their lower recorded diversity (Safitri et al. 2024). Methodologically, some studies focus specifically on medicinal plants (e.g., Arbiastutie et al. 2021), which narrows the spectrum of recorded taxa, while others include comprehensive vegetation analyses (Duryat et al. 2024). Our study was based on ethnobotanical interviews and guided forest walks rather than a full ecological inventory, which may have limited the detection of less commonly used species. Thus, the 19 species reported here should be interpreted as those that are 'culturally salient' and 'used', rather than representing the full floristic diversity of Sicanang's mangroves.

Plant parts utilized

As shown in Figure 2, fruits (32.43%), leaves (31.75%), and trunks (30.96%) were the most frequently cited parts, while bark, roots, flowers, and sap were rarely mentioned (<5%). This triad reflects the multifunctionality of mangrove resources, balancing consumable organs with structural materials. Fruits contribute both dietary and medicinal value, being consumed fresh, processed into syrups, or used in ritual practices (Dejene et al. 2020; Suwardi et al. 2020). Their prominence, also noted in Aceh and Northeast India (Suwardi et al. 2020; Tynsong et al. 2020), is likely tied to the abundance of culturally salient species such as *N. fruticans* and *S. alba*. Leaves are similarly versatile, widely applied in household medicine and food preparation, often under women's care (Voeks 2007), with uses ranging from wound healing to metabolic disorders, echoing findings elsewhere in Indonesia (Rambey et al. 2024). Trunks, meanwhile, remain indispensable for construction, artisanal tools, and firewood (Kharwal and Rawat 2009), with occasional medicinal applications (Chassagne et al. 2016). Comparable reliance on mangrove timber has been observed in Kalimantan and Malaysia (Damastuti et al. 2023), though such practices raise sustainability concerns where overharvesting occurs. The balance between consumable and structural uses illustrates a livelihood strategy adapted to subsistence and material needs. Unlike regions where traditional ecological knowledge is eroding (Tang and Gavin 2016), our data showed no age-related knowledge gaps, suggesting stable intergenerational transmission in Sicanang. Variations from other studies likely reflect ecological conditions and resource availability; for instance, trunk reliance here may stem from limited access to external timber sources. Nevertheless, the study is constrained by its short survey period and snowball sampling, which may underrepresent seasonal or less common practices. Longitudinal and participatory approaches would help capture temporal dynamics and rare uses more comprehensively. The underutilization of other plant parts has also been reported in other mangrove ethnobotanical studies (Bandaranayake 1998; Walters et al. 2008). Bark and roots, although rich in tannins and secondary metabolites, are less accessible and often associated with bitter or toxic compounds, which may limit their dietary and medicinal use compared to fruits and leaves (Bandaranayake 1998). Harvesting roots can also damage plant stability, making them less practical for sustainable use (Walters et al. 2008). Flowers, while ecologically important for pollinators, are typically available only seasonally and provide limited biomass, explaining their marginal role in local uses. Similar perceptions were reported in Xishuangbanna, China, where edible flowers were considered less culturally useful than leafy vegetables because of their small size and limited roles in local traditions (Zhang et al. 2023).

Categorization of plant uses by Sicanang community with the emphasize on medicinal benefits.

Use Reports (URs) are a basic indicator in ethnobotany that reflects the number of citations provided by informants for a particular use associated with a given plant species. It serves as a proxy for measuring the relative importance or cultural salience of species and their applications within a community. In this study, the consolidated UR data revealed a total of 769 individual citations across 19 mangrove species, as reported by 71 respondents (Figure 3). The classification of uses adheres to standard categories used in economic botany, resulting in ten distinct use categories: ANI: Animal food, CON: Construction, ENV: Environmental uses, FOO: Food, FUE: Fuel, MAT: Materials, MED: Medicines, POI: Poisons, SOC: Social uses, and TOO: Tools. Among these categories, the highest number of use reports was documented under food (185 reports), followed by construction (176), animal food (104), fuel (96), medicines (89), and tools (77). The remaining categories each recorded fewer than 30 use reports.

Table 2. Species list, families, and common names of cited plants used by Sicanang community in North Sumatra, Indonesia

Family	Botanical name	Vernacular name
Acanthaceae	*Acanthus ilicifolius*	*Jeruju, Duri-duri*
Acanthaceae	*Avicennia alba*	*Api-api hitam*
Acanthaceae	*Avicennia marina*	*Api-api putih, Api-api jambu*
Acanthaceae	*Avicennia marina* var. *rumphiana*	*Api-api kuning*
Arecaceae	*Nypa fruticans*	*Nipah*
Asteraceae	*Pluchea indica*	*Beluntas*
Combretaceae	*Lumnitzera littorea*	*Teruntun merah*
Combretaceae	*Lumnitzera racemosa*	*Teruntun putih*
Euphorbiaceae	*Excoecaria agallocha*	*Buta-buta*
Lythraceae	*Sonneratia alba*	*Prepat*
Lythraceae	*Sonneratia caseolaris*	*Berembang*
Pteridaceae	*Acrostichum aureum*	*Piyai*
Rhizophoraceae	*Rhizophora apiculata*	*Bakau merah*
Rhizophoraceae	*Rhizophora mucronata*	*Bakau gajah, Bakau daun besar*
Rhizophoraceae	*Rhizophora stylosa*	*Bakau hijau*
Rhizophoraceae	*Bruguiera cylindrica*	*Bakau putih*
Rhizophoraceae	*Bruguiera gymnorhiza*	*Bakau mata buaya*
Rhizophoraceae	*Ceriops tagal*	*Tengar*
Rubiaceae	*Scyphiphora hydrophylacea*	*Cingam*

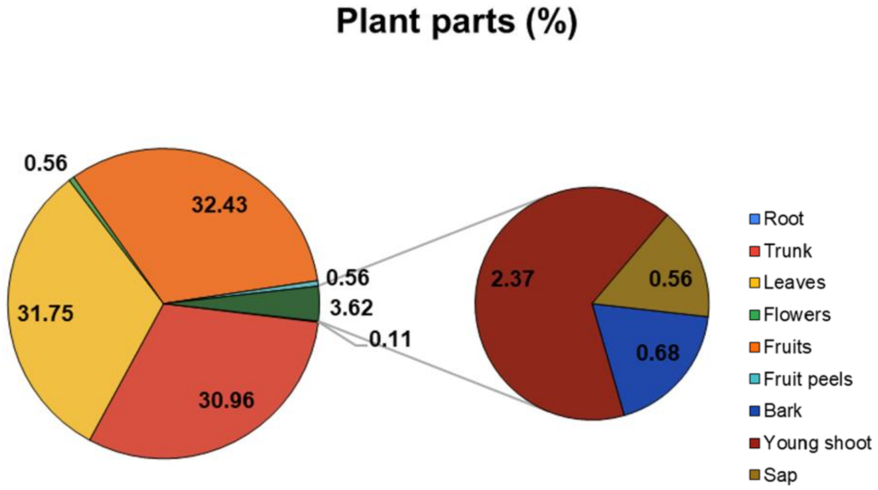

Figure 2. Proportion of plant parts of mangrove species used by the Sicanang community in North Sumatra, Indonesia (N: 71 informants). Data are based on the total number of Use Reports (URs)

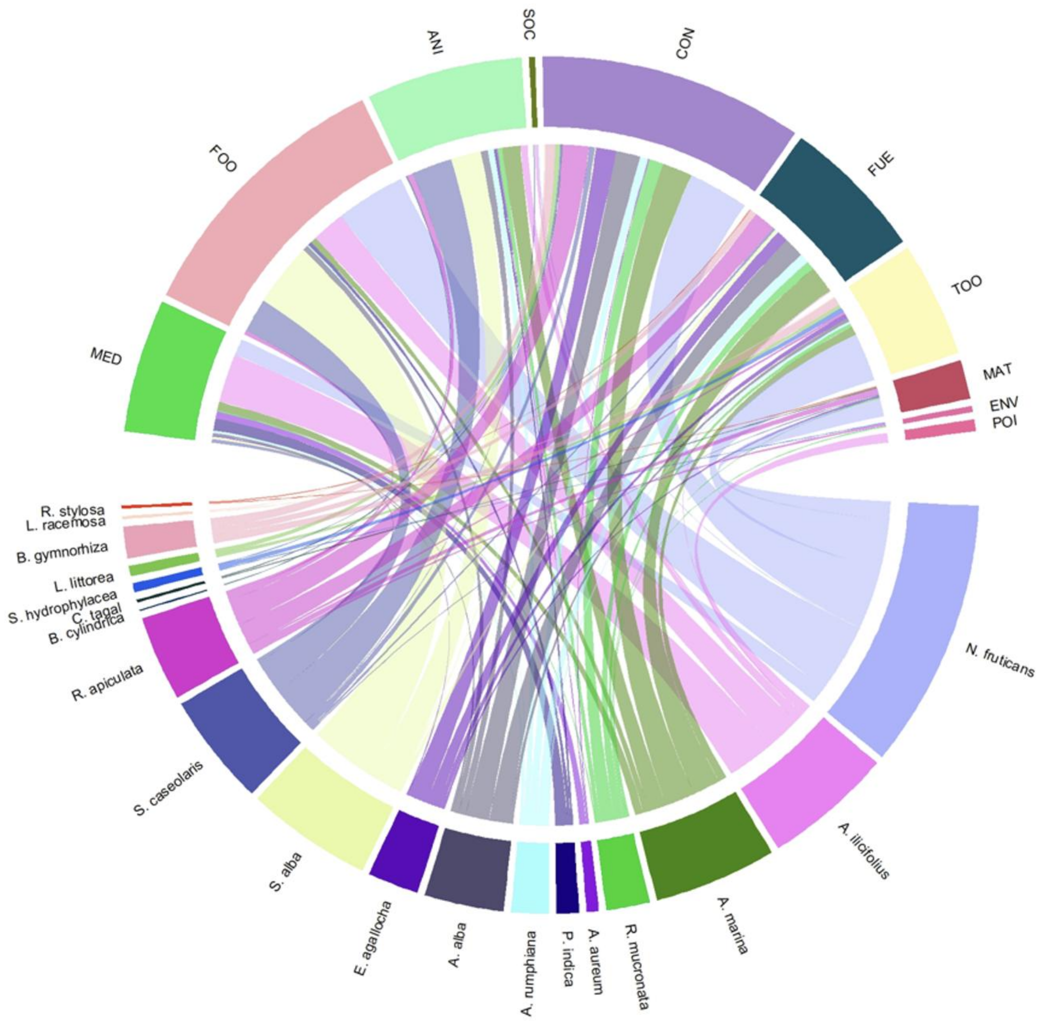

Figure 3. Chord diagram illustrating the relationships between reported plant species and their respective utilization categories by the Sicanang community in North Sumatra, Indonesia. The upper semicircle represents eleven categories (ANI: Animal food, CON: Construction, ENV: Environmental uses, FOO: Food, FUE: Fuel, MAT: Materials, MED: Medicines, POI: Poisons, SOC: Social uses, TOO: Tools). In contrast, the lower semicircle displays the 19 plant species. The width of each colored arc is proportional to the number of Use Reports (URs), indicating the frequency of citation for each plant and use category

In the food (FOO) category, *N. fruticans* (58 reports) and *S. alba* (53 reports) were the most frequently cited species. This dominance is likely attributed to the edibility of their fruits, which are either consumed directly or processed into various food products such as dodol (traditional confectionery), fruit jams, and syrups. The processed forms of mangrove-derived products from fruits, as Non-Timber Forest Products (NTFP), have been found to extend shelf life and diversify the dietary options available to local communities. Moreover, these value-added products contribute to enhancing the economic potential of mangrove resources, thereby serving as a catalyst for the growth of local livelihood sectors (Abubakar et al. 2024; Lukman et al. 2025). For the construction (CON) category, *N. fruticans* again emerged as the most documented species (50 reports), followed by *A. marina* (25 reports). The structural uses were distributed among several species and typically involved materials derived from foliar parts and timber. These plant parts are traditionally used as raw materials for constructing foundation piles, fencing, footbridges, poles, and other infrastructural components vital to coastal living. Nipa palm (*N. fruticans*) has been recognized as a multipurpose mangrove species traditionally utilized for various functions, including roof thatching, food, medicine, and fuel (Hossain and Islam 2015). In addition to its versatility, the species is a good source for charcoal production, although no report was obtained in our study. In addition, the high estimated biomass yield reaching 6 Mt/ha in a year further supports its prominent role in traditional construction and energy applications within coastal communities (Wijana et al. 2023). In the animal food or fodder category, mangrove species were primarily utilized as green fodder for livestock, particularly goats, using fresh or dried foliar biomass.

A smaller subset was processed into fish feed in the form of pellets. The most dominant species in this category were *S. caseolaris* (34 reports) and *S. alba* (25 reports), reflecting their suitability and availability as forage resources in mangrove ecosystems. Several species within the genus *Sonneratia* have been traditionally utilized as fodder, particularly for ruminants. Among these, *S. alba* has shown potential as a supplementary feed source. When combined with *Leucaena leucocephala* leaves, the inclusion of *S. alba* was found to enhance production performance in Peranakan Ettawa goats compared to single-feed formulations (Kardiandi et al. 2021). Although the crude protein content of *S. alba* leaves is relatively lower than that of other conventional forage species, chemical analyses have indicated that they exhibit considerable in-vitro dry matter degradability and volatile fatty acid production (Agustina et al. 2014). Therefore, the presence of *S. caseolaris* and *S. alba* holds potential as an alternative fodder resource for livestock management in coastal and mangrove-adjacent farming systems.

According to the utilization of mangrove plants in the fuel (FUE) category, three species were highly reported, i.e., *A. marina* (23 reports), *R. apiculata* (18 reports), and *A. alba* (17 reports), and others mainly as firewood and charcoal. Several mangrove species have long been recognized as timber-producing plants, with specific uses varying depending on their availability in nature and regional differences. In general, genera such as *Aegiceras*, *Avicennia*, *Bruguiera*, *Camptostemon*, *Ceriops*, *Conocarpus*, *Cynometra*, *Heritiera*, *Kandelia*, *Laguncularia*, *Lumnitzera*, *Rhizophora*, *Scyphiphora*, *Sonneratia*, and *Xylocarpus* have been identified as sources of high-quality firewood and charcoal. Among these, *Rhizophora* species are considered to provide the best-quality fuelwood due to their high wood density, typically exceeding 800 kg/m^3, thus classified as very hard wood (Numbere 2020). In the context of this study, *A. marina* was more commonly utilized, likely due to its greater accessibility in the area and relatively easier harvesting compared to *R. apiculata*. Interestingly, the medicine (MED) category, often a central theme in ethnobotanical studies, ranked fourth in terms of total use reports, with 89 citations. This shows the community's reliance on mangrove species for therapeutic purposes, although perhaps to a lesser extent than food, fuel, or construction-related uses. A summary of the medicinal use data, including specific plant parts, species involved, modes of preparation, and associated therapeutic effects, is illustrated in Figure 4.

The alluvial diagram illustrates that among the various plant parts employed in ethnomedicinal practices, the leaves were the most extensively utilized, encompassing a wide array of mangrove species such as *A. aureum, A. ilicifolius, A. alba, A. marina, A. marina* var. *rumphiana, N. fruticans, P. indica,* and *S. caseolaris*. The findings reflect a fundamental principle in traditional ethnomedicine, wherein leaves are frequently prioritized owing to their richness in bioactive secondary metabolites such as flavonoids, terpenoids, and polyphenols, compounds with well-established anti-inflammatory, antioxidant, and antimicrobial activities (Twaij and Hasan 2022; Neneng et al. 2025). The primary preparation methods involving leaves included direct consumption (chewing), infusions, and poultices. These methods were used to treat wound-related conditions, rheumatoid arthritis, itching, and low back pain, ailments often linked to inflammatory or dermal dysfunctions. Such practices indicate a community-based understanding of plant-based therapeutic efficacy, aligned with symptom-specific relief strategies rooted in empirical knowledge.

Indian camphorweed (*P. indica*) was identified as the species with the broadest spectrum of medicinal uses, with its leaves serving as the principal plant part utilized. Preparations typically involved chewing, poultices, and infusions. The species was traditionally employed to manage a range of metabolic and gastrointestinal disorders, including diabetes, diarrhea, hemorrhoids, hypertension, and hyperlipidemia. Based on the pathophysiological overlaps among these disorders, particularly those involving oxidative stress and systemic inflammation, the therapeutic applications of *P. indica* suggest the presence of phytochemicals with potential hypoglycemic, antihypertensive, or hypolipidemic effects. These bioactivities have been attributed to the presence of various phytochemical constituents, including caffeoylquinic acid derivatives, flavonoids, lignans, phenolics, sterols, terpenes, and thiophenes (Ibrahim et al. 2022). Beyond the more common ailments, several distinctive uses were also documented for *P. indica*, including the treatment of myopia, an uncommon application in ethnobotanical records in Indonesia. In contrast, Ayurvedic approaches and Indian ethnomedicinal practices have been well-documented for their application in the treatment of myopia, a common refractive disorder. These traditional systems have reported improvements in visual acuity through the use of various herbal formulations, suggesting their potential relevance for ocular therapy (Dagar et al. 2024). While current scientific evidence linking *P. indica* to visual health remains limited, this usage may reflect traditional insights into ocular or neurological health, requiring further investigation into its potential neuroprotective or microvascular effects.

Milky mangrove (*Excoecaria agallocha*), though less frequently cited, was exclusively used for snakebite treatment through the direct application of its sap. Snakebite-induced morbidity and mortality remain critical sociomedical concerns in many tropical regions. Due to the limited accessibility of healthcare facilities and the unavailability of antivenom outside hospital settings, rural communities often rely on traditional healers and plant-based remedies (Kadali et al. 2015). In this context, the traditional use of *E. agallocha* as an antivenin plant requires further empirical investigation, particularly given the lack of comprehensive pharmacological evidence supporting its efficacy in snakebite treatment. Phytoconstituents such as alkaloids, cinnamic acid derivatives, coumarins, curcuminoids, flavonoids, steroids, and triterpenoids have been reported to exhibit antivenom properties against snake toxins (Kumar et al. 2025). Previous studies involving related taxa within the Euphorbiaceae family, namely *Acalypha indica* and *Croton urucurana*, have also documented their traditional and pharmacological use in the treatment of snakebite envenomation (Shirwaikar et al. 2004; Gomes et al. 2010). However, a study reported the toxic properties of its latex (sap), especially when derived from the bark, which was known to cause temporary blindness, hence called "blind-your-eye mangrove" (Mondal et al. 2016). These contrasting findings need scientific evaluation to clarify the potential and limitations of this species as an ethnomedicinal resource (Chan et al. 2018).

The fruits of *A. ilicifolius* were also cited in the treatment of toothache and sore throat, primarily through oral consumption (chewing) and infusions. These applications are consistent with the known astringent and antimicrobial properties in mangrove plants, which may alleviate mucosal inflammation and inhibit oral pathogens (Álvarez-Vásquez et al. 2022). The species was also associated with the treatment of boils, potentially attributable to the antiseptic nature of its sap. Several phytoconstituents isolated from *A. ilicifolius* have been associated with relevant biological activities. These include acanthicifoline, p-coumaric acid, lignan glycosides, and phenylethanol glycosides (Zakaria et al. 2024).

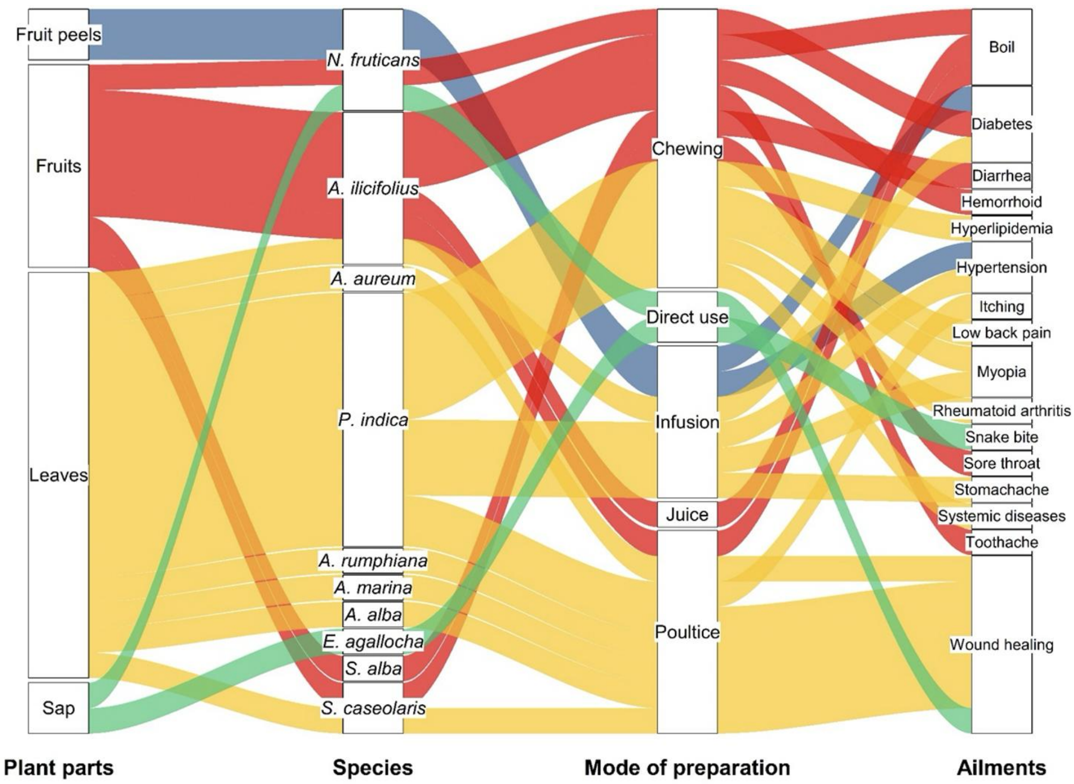

Figure 4. Alluvial plot illustrating the relationship between different plant parts and species used in traditional medicine, their modes of preparation, and associated therapeutic applications

The fruits and fruit peels of *N. fruticans* were reported in the management of diabetes via oral consumption, possibly reflecting their traditional role as a natural alternative to refined sugar, suitable for individuals with restricted glucose intake (Fitri et al. 2023). Wound healing represents one of the most commonly reported medicinal properties associated with mangrove plants, likely due to its relevance to daily physical activities and the importance of accessible first-line treatments in local communities. Mangrove species are known to produce a diverse array of bioactive compounds such as alkaloids, terpenoids, flavonoids, and polyphenols, that contribute to multiple phases of the wound healing process, including inflammation, cell proliferation, and tissue remodeling (Singh et al. 2023; Thomas et al. 2024). These phytochemicals often exhibit antioxidant, antimicrobial, and anti-inflammatory activities, which are essential for optimal wound repair. Moreover, compared to conventional synthetic drugs, plant-derived therapies tend to demonstrate lower toxicity, improved safety profiles, and greater cost-effectiveness, making them particularly valuable in resource-limited settings (Yadav et al. 2024).

Quantitative ethnobotanical analysis of mangrove plants by the Sicanang community

Building upon the categorization of plant uses, quantitative ethnobotanical analysis was conducted to identify the most culturally significant mangrove species in Sicanang systematically. This approach provides a multidimensional perspective by integrating measures of versatility, frequency of citation, and consistency of knowledge across informants. Use Reports (URs) serve as a preliminary indicator of how often a species was mentioned across all uses and respondents. The species with the highest number of UR was *N. fruticans* (180 reports), followed by *A. ilicifolius* (86), *S. alba* (84), *A. marina* (82), and *S. caseolaris* (75). All other species were cited in fewer than 60 reports (Figure 5).

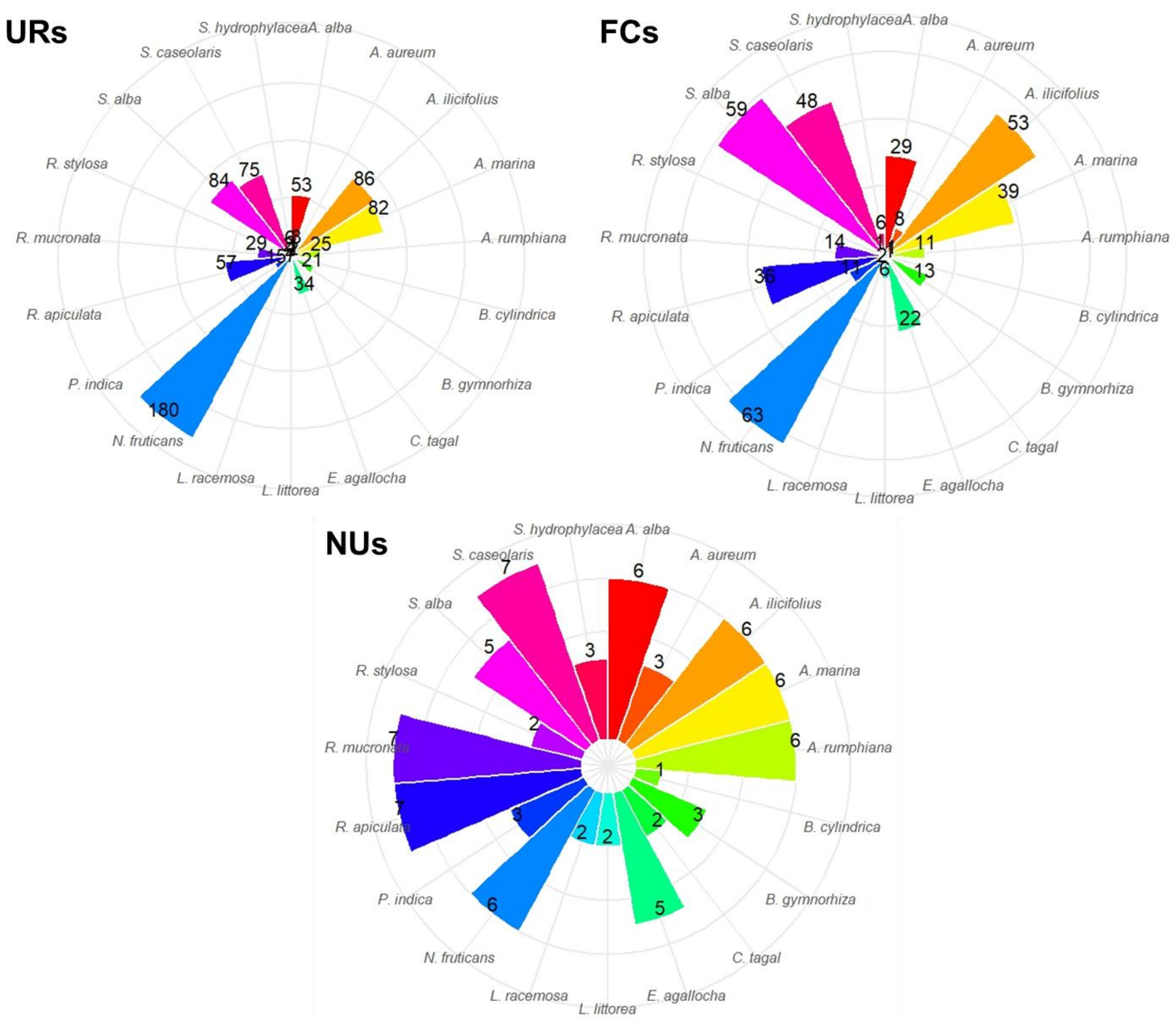

Figure 5. Radial plots illustrating the plant species utilized by the Sicanang community in North Sumatra, Indonesia, based on three ethnobotanical parameters: Frequency of Citations (FCs), Number of Uses (NUs), and Use Reports (URs). Each axis represents one species, with scale values indicating the total number of reports or categories

The dominance of *N. fruticans* in terms of total reports highlights its widespread integration in various traditional health practices. Frequency of Citation (FC) represents the number of informants who mentioned a given species, thereby reflecting its overall familiarity or popularity within the community. The three most frequently cited species were *N. fruticans* (63 citations), *S. alba* (59), and *A. ilicifolius* (53), while the remaining species received fewer than 50 citations. This metric emphasizes the broad recognition and accessibility of these taxa among local users. Number of Uses (NUs) indicates the breadth of ethnomedicinal applications attributed to each species. Notably, *R. mucronata*, *R. apiculata*, and *S. caseolaris* each recorded seven distinct use categories, underscoring their diverse roles across multiple ailment classifications, despite lower frequencies of citation. To further quantify the relative importance of each species, four standardized ethnobotanical indices were utilized: Relative Frequency of Citation (RFC), cultural Importance (CI), Relative Importance (RI), and Cultural Value for ethno-species (CVe) index. These indices allow a multidimensional assessment that incorporates not only how often a species is cited but also how versatile and valued it is across uses and users (Table 3). Again, *N. fruticans* ranked highest across all metrics, with an RFC of 0.887, CI of 2.535, RI of 0.929, and CVe of 1.350, affirming its central role in local uses. Its high citation frequency, broad use categories, and strong cultural value support its prioritization for future pharmacological studies.

Acanthus ilicifolius followed in second place, indicated by a robust CI (1.211) and RI (0.849), reflecting both its popularity and breadth of use. Similarly, *S. caseolaris* ranked third, notable for its relatively high RI (0.881), suggesting its broad application across medicinal categories, even if the citation count was moderate. *Sonneratia alba* placed fourth, driven by strong performance in RFC and CI, whereas *A. marina*, in fifth place, showed moderate scores across all indices, indicating consistent though not exceptional ethnomedicinal utility. Species such as *R. apiculata*, *A. alba*, and *E. agallocha* held intermediate positions, with moderate RFCs and cultural importance but narrower use spectra. On the lower end of the ranking, species such as *P. indica*, despite being associated with unique and pharmacologically relevant uses (e.g., for myopia or metabolic conditions), were cited less frequently, resulting in low CI and RI scores. This discrepancy may reflect limited local knowledge or niche applications rather than reduced therapeutic potential. Species such as *S. hydrophylacea*, *L. littorea*, *L. racemosa*, *C. tagal*, *R. stylosa*, and *B. cylindrica* ranked lowest across all indices, suggesting minimal ethnomedicinal recognition in the studied region. These taxa may either be underutilized or primarily serve ecological rather than medicinal roles within the local context.

The Cultural Value for ethno-species index (CVe), which integrates use diversity, citation frequency, and Cultural Importance (CI) into a composite measure of overall species significance, has not yet been widely applied in quantitative ethnobotanical studies, particularly in the context of mangrove ecosystems. This metric provides additional strength in identifying the highest-ranking species within local utilization systems, especially when studies involve a large number of plant taxa. Recent applications demonstrate its potential in strengthening ethnobotanical assessments. For instance, *Ageratina adenophora* (CVe: 0.031) was highlighted as a unique ethnospecies among 85 medicinal plants documented in Senapati and Kangpokpi Districts, Manipur, India (Gangurde et al. 2025).

Table 3. The most valuable plants in Sicanang based on quantitative ethnobotanical indices

Species	Ethnobotanical indices				Overall ranking
	RFC	CI	RI	CVe	
Nypa fruticans	0.887	2.535	0.929	1.350	1
Acanthus ilicifolius	0.746	1.211	0.849	0.543	2
Sonneratia caseolaris	0.676	1.056	0.881	0.500	3
Sonneratia alba	0.831	1.183	0.825	0.492	4
Avicennia marina	0.549	1.155	0.738	0.381	5
Rhizophora apiculata	0.507	0.803	0.786	0.285	6
Avicennia alba	0.408	0.746	0.659	0.183	7
Excoecaria agallocha	0.310	0.479	0.532	0.074	8
Rhizophora mucronata	0.197	0.408	0.611	0.056	9
Avicennia marina var. *rumphiana*	0.155	0.352	0.516	0.033	10
Bruguiera gymnorhiza	0.183	0.296	0.317	0.016	11
Pluchea indica	0.155	0.211	0.302	0.010	12
Acrostichum aureum	0.113	0.113	0.278	0.004	13
Scyphiphora hydrophylacea	0.085	0.085	0.262	0.002	14
Lumnitzera littorea	0.085	0.099	0.190	0.002	14
Lumnitzera racemosa	0.028	0.028	0.159	0.000	-
Ceriops tagal	0.014	0.028	0.151	0.000	-
Rhizophora stylosa	0.014	0.028	0.151	0.000	-
Bruguiera cylindrica	0.014	0.014	0.079	0.000	-

Notes: RFC: Relative Frequency of Citation, CI: Cultural Importance, RI: Relative Importance, CVe: Cultural Value for ethnospecies

Similarly, *Mangifera indica* (CVe: 0.883) emerged as the most culturally significant species among 71 home-garden plants supporting basic Javanese subsistence needs in Kediri District, East Java, Indonesia (Afrianto 2025). Another study reported that *Vigna unguiculata* subsp. *dekindtiana* (Cve*:* 0.703) among other species' varieties (20 accessions), held exceptional cultural salience in Tanzania, surpassing other wild cowpeas due to its multifunctional uses and high frequency of citation (Godlove et al. 2025). Collectively, these examples emphasize that the CVe index can serve as a robust complementary metric for evaluating species importance, offering deeper insights into cultural preferences, excessive weight to the diverse uses, and priorities that may not be fully captured by traditional indices (Shaheen et al. 2017). However, the use of CVe in this study should be interpreted with caution. First, the relatively small sample size (71 informants) may limit the statistical generalizability of the findings, particularly for species with low citation frequencies. Second, the CVe metric, while integrative, remains sensitive to sample heterogeneity and uneven knowledge distribution within communities. Finally, the absence of comparative CVe data from other mangrove-dependent communities constrains broader generalization, highlighting the need for cross-regional studies to evaluate its robustness in different cultural and ecological contexts. Despite these limitations, the integration of CVe into mangrove ethnobotany represents an important methodological advancement, offering a more nuanced understanding of species importance and community reliance within coastal socio-ecological systems.

In conclusion, this study documented the ethnobotanical knowledge of the Sicanang Belawan coastal community, highlighting the use of 19 mangrove species across food, medicine, construction, fuel, and animal fodder. *Nypa fruticans* and *A. ilicifolius* emerged as the most culturally significant species, underscoring their potential as flagship taxa for conservation and livelihood-based initiatives. Gender differences in plant knowledge were evident, while age and occupation did not significantly influence knowledge distribution, reflecting context-specific patterns of expertise. To strengthen the link between TEK and conservation, several strategies are recommended: (i) promote *N. fruticans* as a conservation flagship through sustainable product development and ecotourism; (ii) establish community-led mangrove nurseries, especially for culturally important species such as *A. ilicifolius*; (iii) integrate ethnobotanical education into local schools to safeguard intergenerational knowledge transfer; (iv) involve residents directly in monitoring, restoration, and policy dialogues to enhance stewardship. These measures would not only preserve mangrove biodiversity but also reinforce the adaptive capacity, identity, and resilience of coastal communities.

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REFERENCES

Abubakar, Abdurrahman M, Sulandjari K, Arsylrakhmatika GA, Sari DA. 2024. Feasibility and development strategies for mangrove fruit-based products in Karawang, West Java. Intl J Design Nat Ecodyn 19 (2): 415-423. DOI: 10.18280/ijdne.190207.

Afrianto WF. 2025. Ethnobotanical documentation of home gardens in relation to Javanese basic life needs in Kediri District, East Java, Indonesia. Asia J Ethnobiol 8 (1): 79-91. DOI: 10.13057/asianjethnobiol/y080107.

Agustina D, Saili T, Asminaya N. 2014. Chemical composition and in vitro ruminal fermentation characteristics of *Sonneratia alba*. Intl J Sustain Trop Agric Sci 1 (1): 45-51.

Albuquerque UP, Nascimento ALB, Soldati GT, Feitosa IS, Campos JLA, Hurrell JA, Hanazaki N, de Medeiros PM, da Silva RH, Ferreira Jr WS, Reyes-Garcia V. 2019. Ten important questions/issues for ethnobotanical research. Acta Bot Brasil 33 (2): 376-385. DOI: 10.1590/0102-33062018abb0331.

Alexiades MN, Sheldon JW. 1996. Selected Guidelines for Ethnobotanical Research: A Field Manual. The New York Botanical Garden Press, New York.

Álvarez-Vásquez JL, Parra-Solano NF, Saavedra-Cornejo GE, Espinosa-Vásquez XE. 2022. Global use of ethnomedicinal plants to treat toothache. Biomed Pharmacol J 15 (2): 847-881. DOI: 10.13005/bpj/2421.

Arbiastutie Y, Diba F, Masriani. 2021. Ethnobotanical and ecological studies of medicinal plants in a mangrove forest in Mempawah District, West Kalimantan, Indonesia. Biodiversitas 22 (6): 3164-3170. DOI: 10.13057/biodiv/d220619.

Bandaranayake WM. 1998. Traditional and medicinal uses of mangroves. Mangroves Salt Marshes 2: 133-148. DOI: 10.1023/A:1009988607044.

Camou-Guerrero A, Reyes-García V, Martínez-Ramos M, Casas A. 2008. Knowledge and use value of plant species in a Rarámuri community: A gender perspective for conservation. Hum Ecol 36: 259-272. DOI: 10.1007/s10745-007-9152-3.

Chan EWC, Oshiro N, Kezuka M, Kimura N, Baba K, Chan HT. 2018. Pharmacological potentials and toxicity effects of *Excoecaria agallocha*. J Appl Pharm Sci 8 (5): 166-173. DOI: 10.7324/JAPS.2018.8523.

Chassagne F, Hul S, Deharo E, Bourdy G. 2016. Natural remedies used by Bunong people in Mondulkiri province (Northeast Cambodia) with special reference to the treatment of 11 most common ailments. J Ethnopharmacol 191: 41-70. DOI: 10.1016/j.jep.2016.06.003.

Dagar S, Fiaz S, Hanifa N. 2024. Scope of Ayurveda treatment in myopia: A systematic review of current trends. J Res Ayurvedic Sci 8 (3): 106-112. DOI: 10.4103/jras.jras_321_23.

Damastuti E, van Wesenbeeck BK, Leemans R, de Groot RS, Silvius MJ. 2023. Effectiveness of community-based mangrove management for coastal protection: A case study from Central Java, Indonesia. Ocean Coast Manag 238: 106498. DOI: 10.1016/j.ocecoaman.2023.106498.

Dejene T, Agamy MS, Agúndez D, Martin-Pinto P. 2020. Ethnobotanical survey of wild edible fruit tree species in lowland areas of Ethiopia. Forests 11 (2): 177. DOI: 10.3390/f11020177.

Duryat D, Yuwono SB, Riniarti M, Hidayat KF, Hidayat W, Rodiani R, Damai AA. 2024. Mangrove species diversity and its use by as medicinal plant by coastal communities of Lampung Timur Indonesia. J Multidiscip Appl Nat Sci 4 (2): 304-318. DOI: 10.47352/jmans.2774-3047.217.

Fitri Y, Yusni Y, Suryadi T, Mudatsir M. 2023. Characteristic and bioactivity values of *Nypa fruticans* from the coastal area in West Aceh District, Indonesia, as a candidate antidiabetic agent. Biodiversitas 24 (10): 5260-5269. DOI: 10.13057/biodiv/d241006.

Friess DA, Thompson BS, Brown B, Amir AA, Cameron C, Koldewey HJ, Sasmito SD, Sidik F. 2016. Policy challenges and approaches for the conservation of mangrove forests in Southeast Asia. Conserv Biol 30 (5): 933-949. DOI: 10.1111/cobi.12784.

Gangurde VV, Kalarikkal VW, Rahangdale DY, Krishna N, Nagayya S, Bandi V, Singh AG, Devi LR, Bora D, Singh K, Srikanth N, Acharya R. 2025. Traditional medicinal plants used by ethnic communities in Senapati and Kangpokpi districts of Manipur, India: A quantitative assessment. Discov Plant 2: 82. DOI: 10.1007/s44372-025-00141-3.

Ginting JB, Supriana T, Wibowo RP. 2021. Risk analysis of polyculture cultivations of tiger shrimp (*Penaeus monodon*) and tilapia (*Oreochromis niloticus*) (Case: Belawan Sicanang Village, Medan Belawan District, Medan City). IOP Conf Ser: Earth Environ Sci 782: 022022. DOI: 10.1088/1755-1315/782/2/022022.

Ginting N, Siregar CR. 2020. Place attachment of the ecotourism in Sicanang Mangrove. IOP Conf Ser: Earth Environ Sci 452: 012076. DOI: 10.1088/1755-1315/452/1/012076.

Godlove J, Lyimo LD, Tryphone GM, Hamisy W, van Zonneveld M, N'Danikou S. 2025. Traditional knowledge and use of wild cowpeas (*Vigna unguiculata*) in selected communities of Tanzania. Front Sustain Food Syst 9: 1562474. DOI: 10.3389/fsufs. 2025.1562474.

Gomes A, Das R, Sarkhel S, Mishra R, Mukherjee S, Bhattacharya S, Gomes A. 2010. Herbs and herbal constituents are active against snake bites. Indian J Exp Biol 48 (9): 865-878.

Harefa MS, Restu, Duha A, Sinabutar AV, Nainggolan E, Manalu FV, Fortunata LA. 2024. Strategic analysis of mangrove ecotourism conservation in Belawan Sicanang, Medan Belawan District, Medan City. Jurnal Wilayah Kota Lingkung Berkelanjutan 3 (1): 109-119. DOI: 10.58169/jwikal.v3i1.388. [Indonesian]

Harefa MS, Wardani A, Ulfami T, Tarigan RP, Rahmadi MT. 2022. Impacts of community activities on the mangrove aquatic ecosystem in Belawan Sicanang Sub-district. J Laguna Geogr 1 (2): 29-34. [Indonesian]

Hayati SD, Qayim I, Raffiudin R, Ariyanti NS, Priawandiputra W, Miftahudin M. 2024. Traditional knowledge of plants for Sunggau rafters on three forest types for conservation of *Apis dorsata* in indonesia. Forests 15 (4): 657. DOI: 10.3390/f15040657.

Hopkins AL, Stepp JR, McCarty C, Gordon JS. 2015. Herbal remedy knowledge acquisition and transmission among the Yucatec Maya in Tabi, Mexico: A cross-sectional study. J Ethnobiol Ethnomed 11: 1-10. DOI: 10.1186/s13002-015-0022-6.

Hossain MF, Islam MA. 2015. Utilization of mangrove forest plant: Nipa palm (*Nypa fruticans* Wurmb.). Am J Agric Forest 3 (4): 156-160. DOI: 10.11648/j.ajaf.20150304.16.

Ibrahim SRM, Bagalagel AA, Diri RM, Noor AO, Bakhsh HT, Mohamed GA. 2022. Phytoconstituents and pharmacological activities of Indian camphorweed (*Pluchea indica*): A multi-potential medicinal plant of nutritional and ethnomedicinal importance. Molecules 27 (8): 2383. DOI: 10.3390/molecules27082383.

Kadali VN, Rao KK, Sandeep BV. 2015. Medicinal plants with anti-snake venom property-A review. Pharm Innov J 4 (7): 11-15

Kardiandi, OdeBa'a L, Aku AS. 2021. The effect of *Leucaena leucocephala* leaf and *Sonneratia alba* leaves on the production performance of the Peranakan Ettawa goat. Jurnal Ilmiah Ternak Halu Oleo 3 (1): 7-11. DOI: 10.56625/jipho.v3i1.16894. [Indonesian]

Kharwal AD, Rawat DS. 2009. Ethnobotanical studies on timber resources of Himachal Pradesh (HP), India. Ethnobot Leaf 13: 1148-1157.

Kumar A, Banjara RA, Aneshwari RK, Khan J, Bernarde PS. 2025. A comprehensive review of recent advances in the use of ethnomedicinal plants and their metabolites in snake bite treatment. Front Pharmacol 16: 1548929. DOI: 10.3389/fphar. 2025.1548929.

Kusmana C. 2018. Mangrove plant utilization by local coastal community in Indonesia. IOP Conf Ser: Earth Environ Sci 196: 012028. DOI: 10.1088/1755-1315/196/1/012028.

Lawless S, Cohen P, McDougall C, Orirana G, Siota F, Doyle K. 2019. Gender norms and relations: Implications for agency in coastal livelihoods. Mar Stud 18 (3): 347-358. DOI: 10.1007/s40152-019-00147-0.

Lukman KM, Quevedo JMD, Rifai H, Alifatri LO, Ulumuddin YI, Sofue Y, Uchiyama Y, Kohsaka R. 2025. Mangrove forest food products as alternative livelihood measures: Mangrove conservation by community in Muara Gembong, Bekasi Regency, Indonesia. Discov Sustain 6: 237. DOI: 10.1007/s43621-025-01049-4.

Manurung FG, Supriana T, Sebayang T. 2021. Analysis of factors affecting the production of tilapia pond cultivation (Case: Belawan Sicanang Village, Medan Belawan District, Medan City). IOP Conf Ser: Earth Environ Sci 782: 022023. DOI: 10.1088/1755-1315/782/2/022023.

Mondal S, Ghosh D, Ramakrishna K. 2016. A complete profile on blind-your-eye mangrove *Excoecaria agallocha* L. (*Euphorbiaceae*): Ethnobotany, phytochemistry, and pharmacological aspects. Pharmacogn Rev 10 (20): 123-138. DOI: 10.4103/0973-7847.194049.

Ndavaro NK, Hegbe AD, Dramani R, Dicko A, Sahani MW, Natta AK. 2024. Effect of age, gender, and formal education on endogenous knowledge of woody plants in communities bordering forest patches of the Lubero Mountain Massif (DR Congo). Ethnobot Res Appl 28: 1-21. DOI: 10.32859/era. 28.10.1-21.

Neneng L, Nawan, Naibaho FG, Rahman S, Septya L, Panjaitan D, Lestari RW, Irsyam ASD, Norwahyunie, Noraini. 2025. Botanical survey of ethnomedicines in Dayak sub-ethnic groups, Ot Danum and Tomum in Central Kalimantan, Indonesia. Biodiversitas 26 (1): 458-469. DOI: 10.13057/biodiv/d260145.

Numbere AO. 2020. Utilization of the mangrove forest for sustainable renewable energy production. Prog Petrochem Sci 3 (3): PPS.000561.2020. DOI: 10.31031/PPS.2020.03.000561.

Pfeiffer JM, Butz RJ 2005. Assessing cultural and ecological variation in ethnobiological research: The importance of gender. J Ethnobiol 25 (2): 240-278. DOI: 10.2993/0278-0771(2005)25[240:ACAEVI]2.0.CO;2.

Prance GT, Balee W, Boom BM, Carneiro RL. 1987. Quantitative ethnobotany and the case for conservation in Amazonia. Conserv Biol 1 (4): 296-310. DOI: 10.1111/j.1523-1739.1987.tb00050.x.

Rais RR, Supriana T, Sebayang T. 2021. Marketing analysis of tiger shrimp (*Penaeus monodon*) (Case: Belawan Sicanang Village, Medan Belawan District, Medan, North Sumatra). IOP Conf Ser: Earth Environ Sci 782: 022038. DOI: 10.1088/1755-1315/782/2/022038.

Rambey R, Nelasufa F, Athoriez APM, Solihin, Rahmawaty, Susilowati A, Afifuddin Y. 2024. Ethnobotanical study of medicinal plants by indigenous community of Aek Guo Village, Mandailing Natal District, Indonesia. Biodiversitas 25 (3): 1046-1056. DOI: 10.13057/biodiv/d250318.

Reyes-Garcia V, Huanca T, Vadez V, Leonard W, Wilkie D. 2006. Cultural, practical, and economic value of wild plants: A quantitative study in the Bolivian Amazon. Econ Bot 60: 62-74. DOI: 10.1663/0013-0001(2006)60[62:CPAEVO]2.0.CO;2.

Robinson EJ. 2016. Resource-dependent livelihoods and the natural resource base. Ann Rev Resour Econ 8 (1): 281-301. DOI: 10.1146/annurev-resource-100815-095521.

Safitri S, Mulyadi A, Nofrizal, Yoswaty D. 2024. Ecological and potential ethnobotanical characterization of mangrove ecotourism area Sungai Bersejarah, Siak Regency, Riau, Indonesia. Intl J Sustain Dev Plan 19 (9): 3453-3463. DOI: 10.18280/ijsdp.190915.

Shaheen H, Qureshi R, Qaseem MF, Amjad MS, Bruschi P. 2017. The cultural importance of indices: A comparative analysis based on the useful wild plants of Noorpur Thal, Punjab, Pakistan. Eur J Integr Med 12: 27-34. DOI: 10.1016/j.eujim.2017.04.003.

Shirwaikar A, Rajendran K, Bodla R, Kumar CD. 2004. Neutralization potential of *Viper russelli russelli* (Russell's viper) venom by ethanol leaf extract of *Acalypha indica*. J Ethnopharmacol 94 (2-3): 267-273. DOI: 10.1016/j.jep.2004.05.010.

Singh K, Sethi VA, Gupta C. 2023. Green miracles: Unravelling the efficacy of phytoconstituents in wound healing: A comprehensive review. Intl J Newgen Res Pharm Healthc 1 (2): 116-132. DOI: 10.61554/ijnrph.v1i2.2023.49.

Suwardi AB, Navia ZI, Harmawan T, Syamsuardi, Mukhtar E. 2020. Ethnobotany and conservation of indigenous edible fruit plants in South Aceh, Indonesia. Biodiversitas 21 (5): 1850-1860. DOI: 10.13057/biodiv/d210511.

Syafitri A, Siregar ES, Elimasni, Jumilawaty E, Tanjung M, Kusmana C, Nasution NAB. 2024. An Introduction to Mangroves in Sicanang Belawan Island. Prokreatif, Medan. [Indonesian]

Tang R, Gavin MC. 2016. A classification of threats to traditional ecological knowledge and conservation responses. Conserv Soc 14 (1): 57-70. DOI: 10.4103/0972-4923.182799.

Tardio J, Pardo-de-Santayana M. 2008. Cultural importance indices: A comparative analysis based on the useful wild plants of Southern Cantabria (Northern Spain). Econ Bot 62: 24-39. DOI: 10.1007/s12231-007-9004-5.

Thomas A, Shinde S, Wavhale R, Jadhav P, Tambe S, Lokhande K, Chitlange S. 2024. In-silico screening of phytomolecules against

multiple targets for wound management. In Silico Pharmacol 12 (1): 19. DOI: 10.1007/s40203-024-00194-4.
Torres-Avilez W, Medeiros PMD, Albuquerque UP. 2016. Effect of gender on the knowledge of medicinal plants: Systematic review and meta-analysis. Evid Based Complement Altern Med 2016: 6592363. DOI: 10.1155/2016/6592363.
Treviño M. 2022. "The mangrove is like a friend": Local perspectives of mangrove cultural ecosystem services among mangrove users in Northern Ecuador. Hum Ecol 50 (5): 863-878. DOI: 10.1007/s10745-022-00358-w.
Twaij BM, Hasan MN. 2022. Bioactive secondary metabolites from plant sources: Types, synthesis, and their therapeutic uses. Plant Biol 13 (1): 4-14. DOI: 10.3390/ijpb13010003.
Voeks RA. 2007. Are women reservoirs of traditional plant knowledge? Gender, ethnobotany, and globalization in northeast Brazil. Singap J Trop Geogr 28 (1): 7-20. DOI: 10.1111/j.1467-9493.2006.00273.x.
Walters BB, Rönnbäck P, Kovacs JM, Crona B, Hussain SA, Badola R, Primavera JH, Barbier E, Dahdouh-Guebas F. 2008. Ethnobiology, socio-economics, and management of mangrove forests: A review. Aqua Bot 89 (2): 220-236. DOI: 10.1016/j.aquabot.2008.02.009.
Wijana S, Setyawan HY, Wan Z, Zhu M, Pranowo D, Dewi IA, Nareswari MP. 2023. The potential of *Nypa fruticans* as an energy source in Indonesia: A review. Adv Food Sci Sustain Agric Agroind Eng 6 (1): 88-96. DOI: 10.21776/ub.afssaae.2023.006.01.8.
Yadav JP, Verma A, Pathak P, Dwivedi AR, Singh AK, Kumar P, Khalilullah H, Jaremko M, Emwas AH, Patel DK. 2024. Phytoconstituents as modulators of NF-κB signalling: Investigating therapeutic potential for diabetic wound healing. Biomed Pharmacother 177: 117058. DOI: 10.1016/j.biopha.2024.117058.
Zakaria NH, Ibrahim MA, Majid FAA, Hashim F, Johari SATT, Hasali NHM. 2024. Ethnobotany, phytochemistry, and pharmacology of *Acanthus ilicifolius*: A comprehensive review. Malay J Med Health Sci 20 (4): 333-344. DOI: 10.47836/mjmhs.20.4.41.
Zhang Q, Cheng Z, Fan Y, Zhang D, Wang M, Zhang J, Sommano S, Wu X, Long C. 2023. Ethnobotanical study on edible flowers in Xishuangbanna, China. J Ethnobiol Ethnomed 19: 43. DOI: 10.1186/s13002-023-00608-1.