The importance of elephant forage plants for indigenous people around the elephant corridor in Bukit Tigapuluh Landscape and the future development to support the conservation of Sumatran Elephant (*Elephas maximus* Sumatranus)

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Research

Abstract

Background: Datuk Gedang Wildlife Corridor (DGWC) has been designated as a vital area to support a conservation program for Sumatran Elephant (*Elephas maximus* Sumatranus). Indigenous Talang Mamak, Anak Dalam, and Malay people living in the area depend on natural resources to support their necessities. This study aimed to identify and to assess the importance of elephant forage plants utilized by indigenous people to evaluate potential human and elephant conflict in DGWC.

Methods: The data were collected from 41 informants through semi-structured and in-depth interviews. Research plots were installed to identify and collect elephant food plants, and the samples were sent to herbarium for identification. The importance of forage plants for indigenous people was quantitatively evaluated using the index of cultural significance (ICS) analysis.

Results: This study identified 139 plant species consumed by elephants and also utilized by the indigenous Talang Mamak, Anak Dalam, and Malay living around DGWC. Talang Mamak people mostly utilize the forage plants among the others. The ICS of the plants are categorized as follows: 2 species with very high ICS, 11 species with high ICS, and 34 species s with medium ICS, and 91 species with low ICS.

Conclusion: Indigenous people around the corridor depend of plants as sources of food, medicines, building materials, equipment, firewood, fodder, and culture which can potentially create resource of conflicts between humans and elephants. Based on the importance and the availability of the plants, this study recommended 11 species that are important to be enriched in DGWC.

Keywords: Elephant Corridor; Ethnobotany; Forage plants; Index of cultural importance (ICS); Indigenous people.

Background

Indigenous people have utilized wild plants for various needs such as food, medicine, fuel, housing, and others since ancient times (Situmorang and Simanjuntak 2015; Goudie 2018). They generally depend on the natural environment, such as forests, to fulfil their necessities because forests contain abundant biodiversity that can support people's lives. These interactions are deeply rooted in traditional ecological knowledge, cultural practices, and sustainable resource management (Ladio and Lozada 2009). However, the exploitation of forests due to the expansion of agriculture and plantation areas and the development of infrastructure has caused the degradation of the forest ecosystem and created negative impacts on indigenous people. For indigenous people who used to depend on forest resources for living, forest losses decrease their livelihood and force them to search for forest products farther.

Bukit Tigapuluh Landscape (BTL) consists of Bukit Tigapuluh National Park (BTNP) and many types of land covers including primary forest, secondary forest, plantations, shrubs, and agriculture areas located in Sumatra Island, Indonesia. BTL has become a habitat for biodiversity including endangered species, such as the Sumatran elephant (*Elephas maximus* Sumatranus). Being one of the main habitats in the island, BTL is also the source of livelihood, well-being, and cultural practices for indigenous people living near the area. Indigenous people such as Malay (Melayu), Talang Mamak, and Anak Dalam (Suku Rimba) living in Bukit Tigapuluh depend on forest resources to support their livelihood (Setyowati and Wardah 2007; Yunianto 2020). They collect and sell forest products to support the economy, and they also use some products for household needs, medication, housing, and cultural ceremony practices.

The exploitation of forests in BTL has caused human and elephant conflicts (HECs). Habitat losses force elephants to enter human areas to find food (Kuswanda *et al.* 2018; 2022; Situmorang and Hussain 2022). From 2018 – 2021, 743 cases of elephant and human conflicts in BTL were reported by the Natural Resources Conservation Centre of Jambi or BBKSDA Jambi (Nofiandi *et al.* 2023). The reports of HEC cases in BTL were mostly crop raiding. However, some papers also mentioned that elephants destroyed houses to search for food which are mentioned in the study of Berliani *et al.* (2018) in Aceh Province and Yoza *et al.* (2023) in Pinggir District, Bengkalis Regency. HECs cause the declining elephant population and also have created negative impacts to local people (Hedge *et al.* 2015; Sitompul *et al.* 2010). In 2022, the Jambi Province Government has been trying to develop an elephant corridor in BTL named Datuk Gedang Wildlife Corridor (DGWC) to connect the fragmented habitats of elephants. The concentration of elephant movements in the corridor also has the purpose to reduce HECs. The DGWC covering an area of about 61.829,21 ha needs to be enriched because some of the areas, such as abandoned plantations, shrubs, agriculture, and open areas, have low vegetation (Jambi Governor 2022; Kuswanda *et al.* 2023). Identification of plants that are food to elephants and also utilized by local people is important to understand the intersection of those needs that potentially create conflicts of interest between them.

Quantitative approaches to value plant species are often used by ethnobiologists to assess the importance of useful plants extracted from natural areas (Hunn 1982; Situmorang *et al.* 2015). In DGWC, studies evaluating the cultural importance of plant species to indigenous people and the relation to elephant conservation are still absent. Previous studies mostly discussed the habitat condition in DGWC (Fikri *et al.* 2023; Kuswanda *et al.* 2021) and the conflicts between elephant and local people in and around the corridor (Wijeratna 2013; Bahari *et al.* 2022; Nofiandi *et al.*2023). Fikri *et al.* (2023) study mentioned that the carrying capacity of DGWC based on vegetation covering was only 39 % suitable for elephant habitat. Kuswanda *et al.* (2021) study in DGWC identified 179 plant species consumed by elephants. However, those studies did not evaluate the relation of the plants to people's needs. Some studies described the interaction of indigenous people in BTL and DGWC, such as Talang Mamak, Anak Dalam, and Malay (Melayu tua) and the impact of forest loss to the indigenous

livelihood (Ginting *et al.* 2022; Yunianto 2020; Wijeratna 2013). Indigenous people highly depend on forest resources, and the habitat loss has made the elephants come closer to their residential areas (Wijeratna 2013). Due to those research gaps, it is important to reveal the kinds of elephant food plant species utilized by indigenous people around DGWC to reduce conflicts of resource interest in the future. How the indigenous people utilize those plants and how the plant availability potentially causes resource conflicts in the future are also still not evaluated. Therefore, this study aimed to identify and assess the importance of useful plants to indigenous people around DGWC through the calculation of the plants' important cultural significance (ICS). The ICS valuation is important to provide recommendations for the Jambi Government regarding selection of plants for the habitat enrichment program in DGWC.

Materials and Methods

The research was conducted in Muara Kilis, Muara Sekalo, Suo-suo, Semambu, and Pemayungan villages. The map of DGWC is provided in Figure 1. Ethics approval regarding the involvement of human in the research, respecting human rights, and also voluntarily filling out the questionnaire was obtained from the Social Humanities Ethical Commission of the National Research and Innovation Agency (BRIN). Data and information collection were carried out from June to November 2022. Data collection was conducted through interviewing the key informants who recognize elephant food plants available in the corridor, installing the research plots in the corridor to identify the forage plants, and interviewing respondents to evaluate the importance of the forage plants to indigenous people. The key respondents consisted of government officers of The Environmental and Forestry Ministry who handle the forest area in BTNP, mahouts who handle captive elephants in the elephant conservation area in Tebo (near DGWC), and traditional leaders and elders who have contacts with elephants in their life.

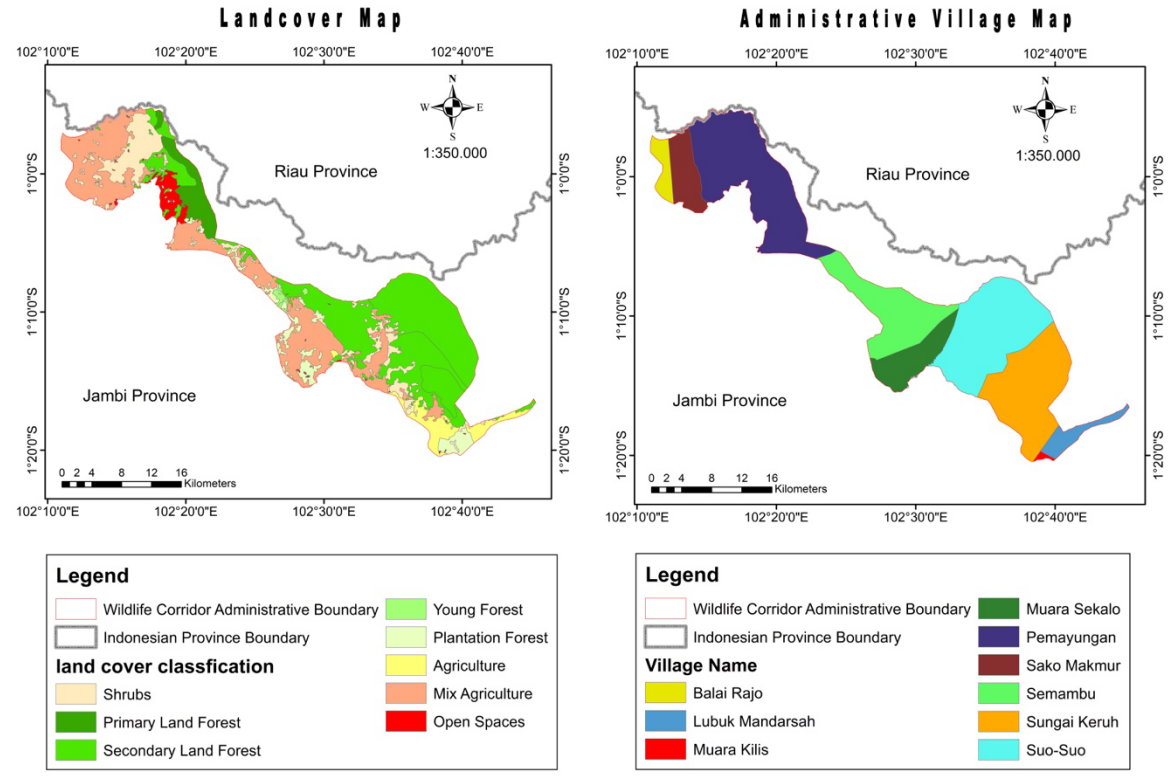

Figure 1. DGWC land cover map and research locations (a) the map of DGWC based on land covering, (b) the map of DGWC based on the village area

After drawing up the list of plants consumed by elephants obtained from the key respondents, the next step was the identification of forage plants in the corridor by installing the research plots. The identification employed a strip transect method, where the number and size of plots were determined based on different proportionate levels of plant growth. The plot size was 1 m × 1 m for the understorey level (grass, shrubs, and herbs), at the seedling level was 2 m × 2 m, and at the sapling level was 5 m × 5 m (Mandal and Joshi 2014; Kuswanda and Sunandar 2019). In total, there were 145 plots on six types of land cover in the corridor (primary forest, secondary forest, young forest, rubber plantation, industrial plantation, and open land), which consisted of 65 plots for saplings, 65 for seedling, and 15 for understorey. The detailed procedure is

available in our previous publication (Kuswanda *et al.* 2023). After getting the list of all forage plants based on the interview with key respondents and the exploration of the sample plots, the researchers took the plant samples to identify and record their taxa and botanical names. The identification was carried out in the Bogor Botanical Garden Herbarium and the Bogoriense Herbarium. The botanists used World Flora Online to verify the botanical names of the forage plants.

The further steps were the selection of the forage plants which are utilized by indigenous people living around the corridor, then followed by assessing their cultural importance by scoring the quality, intensity, and exclusivity of the plants. The valuation was submitted to 41 indigenous people consisting of the Malay, Talang Mamak, and Anak Dalam people. Those respondents were purposively selected by several criteria, such as having activities in the forest and having contact with elephants. The importance of plants to humans was assessed by calculating the Index of Cultural Significance (ICS) promoted by Turner (1988) shown in the formula (1). In this analysis, the ICS were grouped into five classes (very low: < 25; low 25-49; medium 50-74; high 75-99; very high 100 and above).

$$\text{ICS} = \sum_{i=1}^{n} (\text{q.i.e})\mu\text{i} \qquad (1)$$

where:

ICS = the sum of individual "use" value from 1 to n
μ = the value 1 through n
q = quality value.
i = intensity value
e = exclusivity value

The weighting of quality, intensity, and exclusivity of those plants follows this scoring:

- Quality value describes the need for plants for humans. It is scored by 5 (main food, main material), 4 (secondary/additional food/materials), 3 (other food material and medicines), 2 (cultural, ritual, mythological, recreational, and other uses), and 1 (unknown specifically).
- Intensity value figures the intensity of extraction of plants from natural areas. It is scored by 5 (very high), 4 (high), 3 (moderate), 2 (low), and 1 (very low).
- Exclusivity value is scored 2 (for the most preferred, the first choice, and no one-second option), 1 (the plants that can be substituted with other types), and 0.5 (secondary materials or low exclusivity) (Turner 1988; Stoffle *et al.* 1990).
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A cross-cultural analysis was then conducted to evaluate the intersection of plant utilization by the tribal communities. The analysis used a Venn diagram method to indicate the overlap of taxa as a cross-culture. The analysis followed the study of Abidin *et al.* (2022). Cross-cultural analysis is performed to understand the cultural similarity or diversity of the ethnic societies in the study area (Siram *et al.* 2023).

Results

Elephant food plants in the DGWC

Based on the interview with the key respondents, it was listed 158 local names of elephant food plants that could be found in DGWC. This information was used as the basis to explore and identify the forage plants in the 145 plots installed in the corridor. The results of identification show that there were 125 plants that are food to elephants found in the sample plots. Most of the plants were in the seedling class (98 species), followed by the understorey and sapling classes (64 species). The forage plants based on the variety number (total species) were mostly found in secondary forest (36 species at seedling and understorey levels and 31 species at sapling level). However, based on the number of individuals, the denser area was in the open/shrub areas (167 individuals/ha). Parts of plants that are mostly consumed by elephants were leaves (preferably young leaves) amounting to 41.6%, a combination of leaves and bark (15.2%), and all parts of the plant (usually herbs and shrubs) amounting to 14.4%.

Indigenous people around DGWC and characteristics of the respondents

Indigenous people have been living in BTL for a long time. Based on the study of Yunianto (2020), the traditional tribes such as Anak Dalam, Talang Mamak, and Malay (Melayu Tua or Old Malay) inhabit the buffer forest zone of Bukit Tigapuluh National Park (BTNP). Anak Dalam also known as Suku Rimba (Jungle Tribe) and Talang Mamak mostly stay in the remote areas of BTNP, such as Muara Kilis and Suo Suo Villages. They used to depend on forest resources for their livelihood. While

Malay people live in the outer area of the forest and have been connected to public facilities developed by the government. The administrative location of the village in the corridor can be seen in Figure 1.

The indigenous people around the corridor still use many kinds of plants to fulfil their household necessities and to support their economy. Assessment of the plants extracted from DGWC is important to value the plant species to the community, and this valuation was done by 41 indigenous people living around DGWC. The demography of the respondents is available in Table 1. Table 1 describes that most of the respondents are Malay Tribe. Tebo citizens are dominated by Malay people, while, Talang Mamak and Anak Dalam populations in Tebo are quite small, and they mostly live in the buffer zone of forest. Based on the educational level, the Malay people are most educated among the others. Even, 55% of the Talang Mamak respondents do not have education at any level, and all (100%) Anak Dalam respondents never had education.

Based on their livelihood, Malay people mostly depend on the farming sector, however, some of them still go into the nearby forests to collect forest products. Unlike Malay people, Talang Mamak and Anak Dalam people near BTL, for the most part, still depend on forest products for their livelihood. They can live in the forests for days to look for products to sell. Some of them already practice traditional and nomadic farming. They grow some crops on their land with limited modern agricultural practices, such as no fertilizer, pesticide, and mechanical tools. Anak Dalam and Talang Mamak people mostly still live a traditional life and are bound by a strong culture.

Table 1. Demography of the respondents

Descriptions		Frequency (f)	Percentage (%)
Village	Muara Kilis	5	12.20
	Muara Sekalo	6	14.63
	Suo suo	9	21.95
	Semambu	13	31.71
	Pemayungan	8	19.51
Tribes	Talang Mamak	9	13.64
	Anak Dalam	9	13.64
	Malay	23	34.85
Gender	Male	35	85.37
	Female	6	14.63
Educational level	No school/not graduate	15	36.59
	Primary school	10	24.39
	Junior high school	9	21.95
	Senior high school	6	14.63
	College	1	2.44

The elephant forage plants utilized by indigenous people identified in the corridor

Based on the list of forage plants gained from the key respondents, 139 elephant forage plant species are useful to indigenous people living near the corridor. From the research plots, we collected plant samples and sent them to the herbarium for identification. The identification results show that the useful plants are categorized into 51 families, and most of the plants are in the family Euphorbiaceae, followed by Fabaceae and Poaceae (Figure 2). Family Euphorbiaceae known as the spurge family is a diverse group of flowering plants that consists of over 8,000 species distributed worldwide with the majority of the species in tropical and subtropical areas. It is established as an important source of medicines and toxins (Ramalho *et al.* 2018). Fabaceae, also known as Leguminosae, is a family of flowering plants that includes around 19,000 species distributed worldwide. Fabaceae are important for their economic and ecological significance, as they are used as food crops, timber, fodder, and medicinal plants. This family includes some of the world's most important food sources such as beans, peas, lentils, and peanuts (Rubatzky *et al.* 1997). Poaceae is a grass family also known formerly as Gramineae. It is a monocotyledon family which is annual or perennial herbs, but a few genera of which (e.g. the bamboos) are woody. From an ecological viewpoint, Poaceae includes the cereal grasses, including wheat, barley, oats, maize, rice, and millet, making it economically important as a food source. Many grasses are also important sources of fibres (Smith 2014; Kellogg 2015).

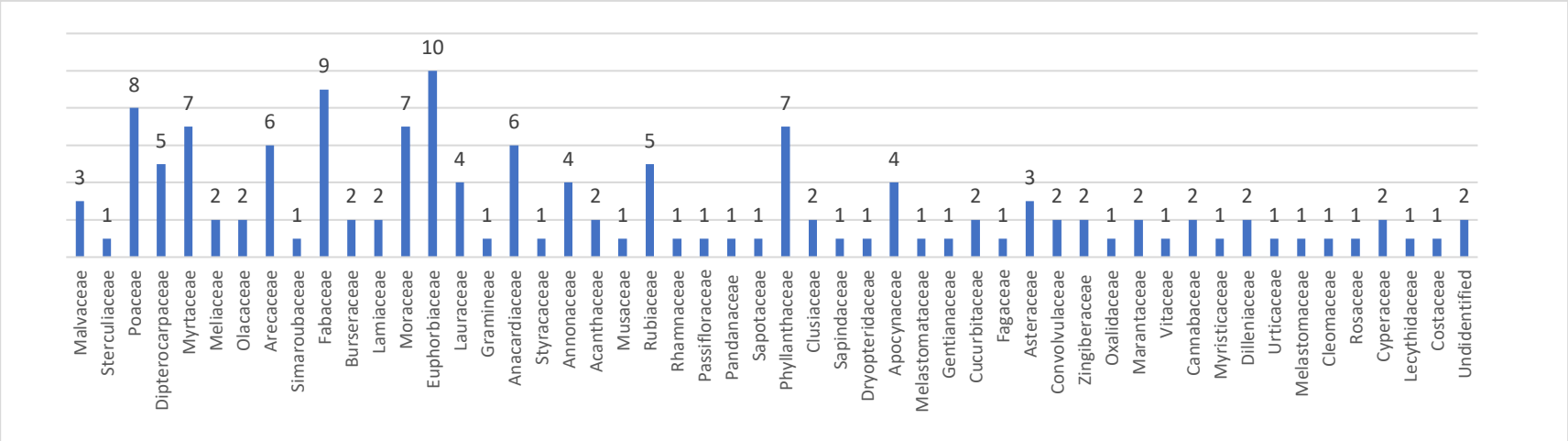

Figure 2. Number of plant species based on families used by indigenous people around elephant corridor in BTL

Based on its utilization, the indigenous people mostly utilize the wood, fruits, and leaves of the plants (Figure 3). Wood is used for building houses, making furniture, and household and agricultural appliances. Fruits are mostly for food, while leaves are used for foods and traditional medicines.

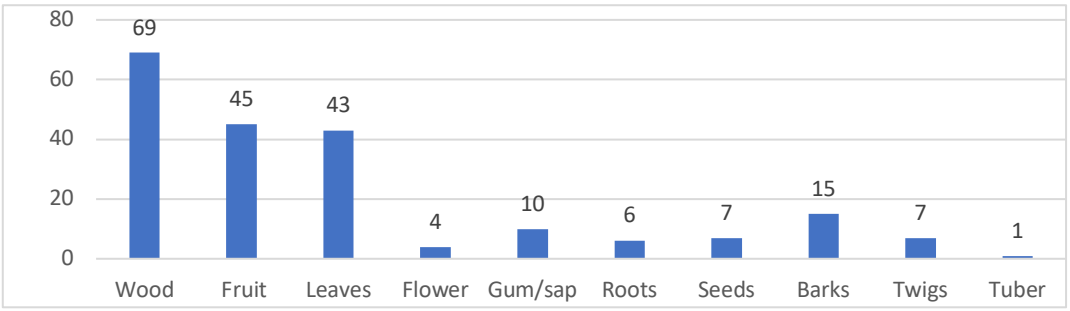

Figure 3. Number of plant species based on the use of parts of plants

Talang Mamak people mostly utilize the plants to support their daily lives and also for the economy (Figure 4). They use those plants as the source of food, traditional medicines, firewood, and material for culture. They also sell the useful parts of plants such as damar gum, rattan, and kinds of fruits and vegetables for livelihood. Similar to Talang Mamak, Anak Dalam people also utilize the plants mostly as the source of food, traditional medicines, firewood, material for culture, and also to sell to market. The Malay people mostly recognize and utilize woods for building and household appliance materials and for animal feed.

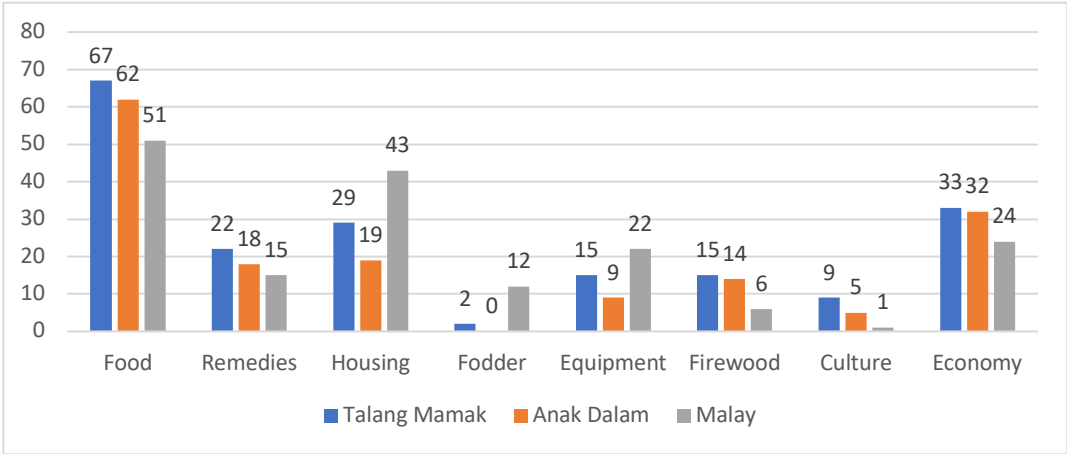

Figure 4. Number of plant species based on their utilization

Cultural importance significance (ICS) of elephant forage plants for Indigenous people

To evaluate the cultural significance of the 139 useful plants utilized by indigenous people in the corridor, the ICS index was calculated by scoring the quality, intensity of extraction, and exclusivity of each plant. The names of the plants, utilization, and the ICS value are presented in Table 2. The results in Table 2 show 2 species plants with very high importance (ICS 100 and above), namely Durian Hutan (*Durio zibethinus*) and Semangkuk (*Sterculia longifolia);* 11 species plant species with high importance (ICS 75 - 99.99) i.e: Buluh or bamboo (*Gigantochloa apus);* Damar (*Dipterocarpus crinitus),* Jambu biji or guava (*Syzygium fastigiatum),* Rumbai (*Scirpodendron ghaeri),* Kulim (*Scorodocarpus borneensis);* Rotan or rattan (*Calamus sp.),* Pasak Bumi or long jack (*Eurycoma longifolia),* Jengkol (Archidendron pauciflorum), Sibekal (*Santiria apiculate),* Kabau (*Archidendron bubalinum)* and Sungkai *(Peronema canescens);* 34 species with medium importance; and 91 species with low and very low importance.

Table 2. List of elephant forage plant species utilized by indigenous people around the elephant corridor in BTL

Botanical name	Local name	Family	Parts of plants consumed by elephants	Utilization by indigenous people		Uses/Preparation	ICS	ICS Classes
Durio zibethinus L.	Durian hutan	Malvaceae	Fruit, leaf	Wood	Housing	Wood for constructions	109.22	Very high
				Fruit	Food	Eating fresh fruit		
				Seed	Food	Seed are boiled until it is soft		
Sterculia longifolia Vent.	Semangkuk	Malvaceae	Leaf, bark, twig	Leaf	Remedy	Dried/fresh leaves/flower/seed are boiled in water until half part is remaining and then consumed twice up to three times a day to treat sore throat	105.33	Very high
				Flower	Remedy			
				Seed	Remedy			
				Fruits	Food	Eating fresh fruit		
Gigantochloa apus (Schult. & Schult.f.) Kurz ex Munro	Buluh	Poaceae	Shoots, young stem	Stem	Housing, equipment,	Round stems made for constructions (poles) and split stems for fences and equipment	99.36	High
				Shoots, young stem	Food	Slicing or chopping bamboo shoots into small pieces to cook as vegetables		
Dipterocarpus crinitus Dyer	Damar	Dipterocarpaceae	Leaf	Gum	Firewood	The wood contains essential oil that can be used to starting fire	93.13	High
					Industrial material	Dried gum is sold to traditional market		
Syzygium fastigiatum (Blume) Merr. & L.M.Perry	Jambu Biji	Myrtaceae	Leaf, fruit	Fruit	Food	Eating fresh fruit	82.42	High
				Leaf	Remedy	* 2-3 young fresh leaves are chewed to cure diarrhoea. * 5-7 young fresh leaves are boiled in 1 litre water until it remains half and drink around 20-50 ml two times per day to cure diarrhoea.		
Scirpodendron ghaeri (Gaertn.) Merr.	Rumbai	Cyperaceae	Leaf	Leaf	Equipment material	Leaves are dried and pressed and they are woven to make household equipment (mat, pouch, basket, etc.)	82.20	High
	Kulim	Olacaceae	Leaf, bark	Wood	Housing	Wood for constructions	80.13	High

Scorodocarpus borneensis (Baill.) Becc.				Fruits	Food	Eating fresh fruit		
Calamus sp.	Rotan	Arecaceae	Leaf, young stem	Stems	Equipment, furniture	Stems are shaped or woven to make furniture and equipment	79.53	High
Eurycoma longifolia Jack	Pasak bumi	Simaroubaceae	Leaf, bark	Roots	Remedies	roots are boiled for 1 hour (until the water turns dark), and then drink	79.41	High
Archidendron pauciflorum (Benth.) I.C.Nielsen	Jengkol	Fabaceae	Leaf	Fruit	Food	Eaten as fresh fruit, or can be cooked as vegetable	78.89	High
Santiria apiculata A.W.Benn.	Sibekal	Burseraceae	Young leaf	Wood	Housing	Wood for constructions	78.84	High
				Bark	Remedy	Bark is boiled in 1 litre water until it remains half and drink around 50-100 ml per day for 3 days as an anthelmintic		
				Young leaves	Food	Young leaves are cooked as vegetables		
Archidendron bubalinum (Jack) I.C.Nielsen	Kabau	Fabaceae	Leaves	Fruit	Food	The fruit (seed) can be eaten fresh and cooked	77.92	High
Peronema canescens Jack.	Sungkai	Lamiaceae	Leaf, bark	Wood	Housing	Wood is utilized for constructions	76.51	High
				Bark and leaf	Remedies	Bark the size of half a palm or 10-15 dried leaves are boiled in 1 litre water until it remains half and drink around 50-100 ml two until three times per day to relief fever (Covid, malaria).		
Ficus luschnathiana Miq	Semantung	Moraceae	Leaf, fruit	Wood	Housing	Wood for constructions	72.69	Medium
				Leaf	Fodder	Fresh plants for animals		
				Sap	Remedy	Sap collected from bark is drunk to treat coughs		
Unidentified	Nilau	*Unidentified*	Leaf, bark, twig	Wood	Housing, equipment	Wood for constructions and furniture	84.32	High
				Bark	Remedy	Dried/fresh leaves and are boiled in water until half part is remaining and then consumed twice up to three times a day to relief fever		

Mallotus paniculatus Müll.Arg.	Balik angin	Euphorbiaceae	Leaf, bark, twig	Wood	Equipment	Wood is utilized to make furniture (tables, chairs)	68.91	Medium
Litsea monopetala (Roxb.) Pers.	Medang	Lauraceae	Leaf	Leaf	Food	Young leaves are cooked as vegetables		
Macaranga gigantea (Rchb.f. & Zoll.)	Melabai	Euphorbiaceae	Leaf, bark	Wood	Housing, equipment	Wood for constructions and furniture	68.08	Medium
Müll.Arg.				Bark	Remedy	Bark at the size of half a palm is boiled in 1 litre water until it remains half and drink around 50-100 ml two until three times per day to cure diarrhoea		
				Leaves	Equipment	Leaves are put on floor to store paddy at home		
Unidentified	Senjanit	Gramineae	Whole parts	Leaf	Food	Young fresh leaves are eaten as vegetable	67.54	Medium
					Remedy	5-8 leaves are boiled in 1 litre water until it remains half and drink around 50-100 ml two until three times per day to cure dysentery		
Macaranga lowii King ex Hook.f.	Mahang	Euphorbiaceae	Leaf, bark	Wood	Housing	Wood for constructions	67.40	Medium
Artocarpus elasticus Blanco	Terap	Moraceae	Leaf, bark, fruit, twig	Wood	Housing	Wood for constructions	66.12	Medium
				Fruit	Food	Eaten as fresh fruit		
				Gum	Culture	Gum is put near cages to trap wild birds		
Richetia gibbosa (Brandis) P.S.Ashton & J.Heck.	Meranti	Dipterocarpaceae	Leaf	Wood	Housing, furniture	Wood for constructions and equipment	64.26	Medium
				Gum	Industrial material	Dried gum is sold to traditional market		
Areca catechu L.	Pinang	Arecaceae	Leaf	Seed	Remedy	A quarter of seed of pinang are crushed and eaten to cure diarrhoea and dysentery and as an anthelmintic	63.46	Medium
					Culture	The size of a thumbnail of betel nuts mixed with betel leaf to be chewed		
Mangifera foetida Lour.	Bacang	Anacardiaceae	Young leaf, fruit	Fruit	Food	Eaten as fresh fruit	62.50	Medium
Styrax benzoin Dryand.	Kemenyan	Styracaceae	Leaves	Gum	Industrial material	Dried gum is sold to traditional market	61.40	Medium

					Ritual/culture	The gums are burnt and mixed with other offerings for praying		
Campnosperma auriculatum (Blume) Hook.f.	Terentang	Anacardiaceae	Leaf	Wood Bark	Equipment Remedy	Wood made for equipment Bark the size of half a palm is boiled in 1 litre water until it remains half and drink around 50-100 ml two times per day to cure asthma	61.00	Medium
Drepananthus biovulatus (Boerl.) Survesw. & R.M.K.Saunders	Antui	Annonaceae	Leaf, bark, twig	Wood	Housing	Wood is used for the floor of stilt house	60.36	Medium
Senna alata (L.) Roxb	Sebusuk	Fabaceae	Leaf	Wood Bark	Housing Remedy	Wood for constructions 5-8 leaves are boiled in 1 litre water until it remains half and drink around 50-100 ml two until three times per day to cure diarrhoea	59.82	Medium
Artocarpus integer (Thunb.) Merr.	Cempedak	Moraceae	Leaves, bark, fruit, twig	Fruit	Food	Eaten as fresh fruit	59.19	Medium
Justicia gendarussa Burm.f.	Ganda Ruso	Acanthaceae	Whole parts	Leaf	Remedy	A handful of leaves are crushed and applied on a broken or sprained bone and bruised skin	59.00	Medium
				Roots	Remedy	A handful of roots are boiled and the water is consumed to cure constipation		
Musa sp.	Pisang hutan	Musaceae	Whole parts	Leaf Fruit Flower	Equipment Food Food	Fresh leaves used as food packaging Eaten as fresh fruit Banana blossom is chopped and cooked as vegetables	58.54	Medium
Coffea canephora Pierre ex A.Froehner	Kopi	Rubiaceae	Leaves, fruit	Seed	Food	The dried coffee beans are grounded and then the flour is brewed to drink	58.33	Medium
Ziziphus mauritiana Lam.	Bidaro hutan	Rhamnaceae	Leaf	Wood Fruit	Housing Food	Wood made for constructions Eaten as fresh fruit	56.67	Medium
Calamus scipionum Lour.	Semambu	putrat	Leaf	Stem	Equipment, furniture	Stems are shaped or woven to make furniture and equipment	56.22	Medium

Licuala spinosa Wurmb	Lipai	Arecaceae	Leaf, twig	Leaf	Housing	Leaves are arranged to make the roof of the hut	55.32	Medium
Aglaia korthalsii Miq.	Kasai	Meliaceae	Leaf, bark, twig	Wood Fruit	Housing Food	Wood for constructions Eaten as fresh fruit	55.12	Medium
Adina eurhyncha (Miq.) Å.Krüger & Löfstrand	Brumbung	Rubiaceae	Young leaf	Wood Bark	Housing Remedy	Wood made for constructions 5-8 leaves are boiled and consumed around 50-100 ml two until three times per day to cure malaria	54.24	Medium
Passiflora foetida L.	Ciplukan	Passifloraceae	Whole parts	All parts	Remedy	All plants (fresh and dried) are utilized to cure fever and to lower high blood pressure.	53.50	Medium
Pentaspadon motleyi Hook.f.	Plaju	Anacardiaceae	Leaf	Wood Fruit	Housing Food	Wood for constructions Eaten as fresh fruit	52.94	Medium
Streblus elongatus (Miq.) Corner	Tempinis	Moraceae	Leaf	Wood	Housing	Wood for constructions	52.93	Medium
Pandanus spinosissimus Ridl.	Pandan	Pandanaceae	Leaf	Leaves	Equipment	Leaves are dried, pressed, and woven to make equipment (mat, pouch, basket, etc.)	52.63	Medium
Palaquium gutta (Hook. f.) Baill.	Balam	Sapotaceae	Leaf, bark, twig	Wood Fruit Gum	Housing Food Industrial material	Wood for constructions Eaten as fresh fruit Dried gum picked from the trunk are sold to traditional market	52.57	Medium
Spondias dulcis Parkinson	Kedongdong	Anacardiaceae	Leaf, bark, twig, fruit	Wood Fruit	Firewood Food	Branches and twigs are dried to be used as firewood Eaten as fresh fruit	52.30	Medium
Baccaurea motleyana (Müll.Arg.) Müll.Arg.	Rambe	Phyllanthaceae	Leaf	Fruit	Food	Eaten as fresh fruit	52.15	Medium
Garcinia caudiculata Ridl.	Kandis	Clusiaceae	Leaf, bark, twig	Wood Fruit	Housing Food	Wood for constructions The fruit is sliced and then dried. The dried fruit is used to enhance sour taste of food	51.72	Medium
Colocasia esculenta (L.) Schott	Keladi	Araceae	Leaf, young stem	Tuber	Food	The taro is cooked until it soft.	50.95	Medium

Syzygium fastigiatum (Blume) Merr. & L.M.Perry	Jambu air	Myrtaceae	Leaf, fruit	Fruit	Food	Eaten as fresh fruit	50.00	Medium
Dysoxylum parasiticum (Osbeck) Kosterm.	Langsat	Meliaceae	Leaf, fruit	Fruit	Food	Eaten as fresh fruit	49.33	Low
Xerospermum noronhianum (Blume) Blume	Rambutan	Sapindaceae	Leaf, fruit	Fruit	Food	Eaten as fresh fruit	49.01	Low
Dryopteris insularis Kodama	Pakis	Dryopteridaceae	Leaf, stem	Leaf	Food	The young leaf is cooked as vegetable	48.85	Low
Alstonia scholaris (L.) R. Br.	Pulai	Apocynaceae	Leaf, bark, twig	Wood	Housing	Wood for constructions	48.13	Low
				Leaf	Remedy	Leaf to cure asthma		
Artocarpus heterophyllus Lam	Nangka	Moraceae	Leaves, bark, twig	Fruit	Food	Eaten as fresh fruit	47.14	Low
Eugenia griffithii Duthie	Kelat	Myrtaceae	Leaves	Wood	Housing	Wood for constructions	46.84	Low
Garcinia atroviridis Griff. ex T.Anderson	Asam gelugur	Clusiaceae	Leaf, bark, twig, fruit	Fruit	Food	The fruit is sliced and then dried. The dried fruit is used to enhance sour taste of food	46.67	Low
Ochanostachys amentacea Mast.	Petaling	Olacaceae	Leaf	Wood	Housing	Wood for constructions	46.31	Low
				Fruit	Food	Eaten as fresh fruit		
Memecylon sp,	Temeras	Melastomataceae	Leaf	Wood	Housing	Wood for constructions	44.46	Low
Fagraea fragrans Roxb.	Tembesu	Gentianaceae	Leaf, bark	Wood	Housing	Wood for constructions	43.92	Low
Momordica charantia L.	Pare	Cucurbitaceae	Whole parts	Fruit	Food	The fruit is cooked as vegetable	43.85	Low
Quercus robur subsp. Robur	Putaran	Fagaceae	Leaf, young stem	Fruit	Food	Eaten as fresh fruit	43.57	Low
Dehaasia caesia Blume	Kelumpang	Lauraceae	Leaf	Seed	Food	The seeds are roasted then eaten	43.33	Low
Vitex pinnata L.	Laban	Lamiaceae	Leaf, bark, twig	Wood	Housing	Wood for constructions	42.53	Low

Mikania micrantha Kunth	Rumput PKI	Asteraceae	All parts	Leaf	Fodder	Fresh leaves for animals	42.25	Low
					Remedy	2-3 fresh leaves are crushed and placed on the wound to stop bleeding		
Dialium indum var. indum	Keranji	Fabaceae	Leaf, bark, twig	Wood	Housing	Wood for constructions	41.79	Low
Camonea vitifolia (Burm.f.) A.R.Simões & Staples	Akar kritang	Convolvulaceae	Leaf, bark, twig	Leaf	Fodder	Fresh leaves for animals	41.67	Low
				Root	Remedy	Half a handful of roots are boiled in 1 litre water until it remains half and drink around 20-50 ml to increase stamina		
Baccaurea bracteata Müll.Arg.	Tempunek	Phyllanthaceae	Leaf, bark	Fruit	Food	Eaten as fresh fruit	41.52	Low
Parkia speciosa Hassk.	Petai	Fabaceae	Leaf, bark, twig	Fruit/bean	Food	Eaten as fresh fruit/bean	40.24	Low
Goniothalamus malayanus Hook.f. & Thomson	Seburu	Annonaceae	Leaf, twig	Bark	Agriculture	The barks are burnt to get smokes used for taking honey	40.22	Low
				Leaf	Agriculture	The leaves are burnt and used as insecticide/pesticide		
Hevea brasiliensis (Willd. ex A.Juss.) Müll.Arg.	Rubber tree	Euphorbiaceae	Leaf, bark, root	Sap	Industrial material	the sap is dried and sold to market/ rubber company	40.00	Low
Antiaris toxicaria (J.F.Gmel.) Lesch.	Siluk	Moraceae	Leaves	Bark	Remedy, culture	The bark is chopped and mixed with betel leaves to be chewed	40.00	Low
Etlingera megalocheilos (Griff.) A.D.Poulsen	Puar	Zingiberaceae	Whole parts	Fruit	Food	Eaten as fresh fruit	38.90	Low
				Leaf	Fodder	Fresh leaves for animals		
Averrhoa carambola L.	Belimbing	Oxalidaceae	Young leaf, fruit	Fruit	Food	Eaten as fresh fruit	38.46	Low
Phyllanthus acidus (L.) Skeels	Keremai	Phyllanthaceae	Whole parts	Fruits	Food	Eaten as fresh fruit	38.00	Low
				Leaf		Fresh leaves are cooked as vegetable		
Donax canniformis (G.Forst.) K.Schum.	Bemban	Marantaceae	Leaf, young stem	Wood	Equipment	The wood is shaped to be box used for catching fish	36.99	Low

Baccaurea macrocarpa (Miq.) Müll.Arg.	Tampui	Phyllanthaceae	Leaf, bark, fruit, twig	Fruit	Food	Eaten as fresh fruit	36.98	Low
Unidentified	Balar	Unidentified	Leaf	Gum	Industrial material	Dried gum is picked from the trunk and sold to traditional market	36.96	Low
Rhodamnia cinerea Jack	Marapuyan	Myrtaceae	Leaf, twig	Wood	Housing	Wood for constructions	36.00	Low
				Leaf	Food	Fresh leaf as vegetable		
Macaranga gigantea (Rchb.f. & Zoll.) Müll.Arg.	Merkubung	Euphorbiaceae	Leaf, bark	Wood	Housing	Wood for constructions	36.00	Low
Syzygium borneense (Miq.) Miq.	Kayu serai	Myrtaceae	Leaf	Wood	Housing	Wood for construction materials	35.52	Low
				Leaf	Food	Leaves are cooked as vegetable		
Willughbeia tenuiflora (Dyer ex Hook.f.) Kuntze	Gitan	Apocynaceae	Leaf	Fruit	Food	Eaten as fresh fruit	35.20	Low
Anacardium occidentale L.	Jambu monyet	Anacardiaceae	Leaf, fruit	Fruit	Food	Eaten as fresh fruit	35.00	Low
Cotylelobium melanoxylon (Hook.f.) Pierre	Raru	Dipterocarpaceae	Leaf	Bark	Food	Mixed with palm sab as alcoholic drink	33.26	Low
Dyera costulata (Miq.) Hook. f	Jelutung	Apocynaceae	Leaf	Gum	Industrial material	Picking dried gum from the trunk	33.12	Low
Leea indica (Burm. f.) Merr.	Mali-mali	Vitaceae	Leaf, bark, twig	Wood	Firewood	Dried barks, branch, and twig for firewood	31.90	Low
Aporosa octandra (Buch.-Ham. ex D.Don) Vickery	Pelangas	Phyllanthaceae	Leaf, bark, twig	Wood	Housing	Wood for constructions	31.12	Low
Cenchrus purpureus (Schumach.) Morrone	Rumput gajah	Poaceae	Whole parts	Leaf	Fodder	Fresh leaves/grass for animals	31.31	Low
Macaranga lowii King ex Hook.f.	Sekubung	Euphorbiaceae	Leaf, bark	Wood	Housing, remedies	Wood for constructions and firewood	30.36	Low
Asystasia gangentica (L.) T.Anderson	Bayaman	Acanthaceae	All parts	Leaf	Food, fodder	Leaves can be eaten as vegetables (cooked) and also given to animals	30.32	Low
Aporosa elmeri Merr.	Selurah	Phyllanthaceae	Leaf, bark	Wood	Housing	Wood for constructions	30.25	Low

Calamus draco Willd.	Jernang	Arecaceae	Leaf, fruit	Seed	Remedy	4-5 seeds are boiled and drunk to cure diarrhoea	30.00	Low
Leptochloa chinensis (L.) Nees	Rumput Sebantun	Poaceae	Leaf	Leaf	Fodder	Fresh leaves/grass for animals	29.75	Low
Trema orientalis (L.) Blume	Angrung	Cannabaceae	Leaf, bark, twig	Wood Bark	Housing Equipment	Wood for constructions The barks are sliced and used as rope	29.48	Low
Durio sp.	Durian hantu	Malvaceae	Fruit, leaf	Wood Fruit	Housing Food	Wood for constructions and equipment (machete handle) Eaten as fresh fruit	29.50	Low
Dryobalanops aromatica C.F.Gaertn	Kayu kapur	Dipterocarpaceae	Young leaf	Wood	Housing	Wood for constructions	28.89	Low
Parashorea malaanonan (Blanco) Merr.	Tebalun	Dipterocarpaceae	Leaf, bark	Wood	Housing	Wood for constructions	28.89	Low
Pterospermum javanicum Jungh.	Bayur	Malvaceae	Leaf	Wood	Housing	Wood for constructions	27.50	Low
Buchanania arborescens Blume	Pagar-pagar	Anacardiaceae	Leaf	Wood	Housing	Wood for constructions	26.25	Low
Myristica maxima Warb.	Darah-darah	Myristicaceae	Leaf, bark	Bark	Housing	The bark is soaked to extract brown/red colours that can be used as a dye that gives a permanent brown stain of constructions, furniture	25.92	Low
Uncaria lanosa f. *sumatrana* Rid sdale	Akar kait-kait	Rubiaceae	Young leaf	Leaf	Remedy	4-8 fresh/dried leaves are boiled and consumed to reduce high blood pressure	25.39	Low
Dillenia indica L.	Simpur	Dilleniaceae	Leaf, bark, twig	Wood	Housing	Wood for constructions	25.00	Low
Etlingera hemisphaerica (Blume) R.M.Sm.	Laos	Zingiberaceae	Leaf, young stem	Rhizome	Food	Laos has function as a spice	24.34	Very low
Pterocarpus indicus Willd.	kacang-kacang	Fabaceae	Leaf, young stem	Wood Fruit	Housing Food	Wood for constructions Eaten as fresh fruit	22.50	Very low
Eugenia griffithii Duthie	Kelat	Myrtaceae	Leaf	Wood	Housing	Wood made for constructions	22.50	Very low

Ottochloa nodosa (Kunth) Dandy	Rumput sarang buaya	Poaceae	Whole parts	Leaf	Fodder	Fresh leaves for animals	20.74	Very low
Ficus racemosa L.	Aro	Moraceae	Leaf, bark, twig	Fruit	Food	Eaten as fresh fruit	20.00	Very low
Baccaurea macrocarpa (Miq.) Müll.Arg.	Bernai	Phyllanthaceae	Leaf, bark	Fruit	Food	Eaten as fresh fruit	20.00	Very low
Dendrocnide stimulans (L.f.) Chew	Jelatang	Urticaceae	Leaf, young stem	Leaf	Remedy	The leaves are crushed and the water is extracted and then applied to the skin of pets (dogs, cats) affected by ringworm or itching	20.00	Very low
Neolamarckia cadamba. (Roxb.) Bosser	Jabon	Rubiaceae	Leaf	Wood	Housing	Wood for constructions	20.00	Very low
Rhodamnia cinerea Jack	Merelang	Myrtaceae	Leaf	Wood	Housing	Wood for constructions	20.00	Very low
Clidemia hirta (L.) D.Don (green); *Melastoma malabathricum* L. (red)	Senduduk	Melastomaceae		Fruit Leaf	Food Remedy	Eaten as fresh fruit The leaves are boiled and consumed to cure diabetic	18.87	Very low
Imperata cylindrica (L.) Raeusch	Alang-alang	Poaceae	Whole parts	Leaf	Housing	Leaves are arranged in a row to make roof of hut	18.35	Very low
Eusideroxylon zwageri	kayu bulian	Lauraceae	Leaf	Wood	Housing	Wood for constructions	19.00	Very low
Cleome rutidosperma DC.	Cabe-cabe	Cleomaceae	All parts	Leaf	Remedies	The leaves are crushed and then applied to the skin to relieve itching	17.11	Very low
*Austroeupatorium inulifolium (*Kunth) R.M.King	Putihan	Asteraceae	Leaves	Wood Fruit	Housing Food	Wood for constructions Eaten as fresh fruit	16.00	Very low
Axonopus compressus (Sw.) P.Beauv.	Rumput pahitan	Poaceae	All parts	All parts	Fodder	Fresh leaves for animals	16.00	Very low
Mezzettia parviflora Becc.	Banitan	Annonaceae	Leaf, bark	Wood	Housing, furniture	Wood for constructions and furniture	15.00	Very low

Neonauclea calycina (Bartl. ex DC.) Merr.	Bengkal	Rubiaceae	Leaf, bark	Wood	Equipment	Wood for household equipment (machete and hoe handle)	15.00	Very low
Dacryodes incurvata (Engl.) H.J.Lam	Kayu bengkal	Burseraceae	Leaf	Wood	Housing, furniture	Wood for constructions and furniture	15.00	Very low
Dillenia albiflos (Ridl.) Hoogland	Gawal-gawal	Dilleniaceae	Leaf	Wood	Housing	Wood for constructions	15.36	Very low
Coccinia grandis (L.) Voigt	Mentimun mencit	Cucurbitaceae	Whole parts	Fruit	Food	Eaten as fresh fruit	13.00	Very low
Gironniera subaequalis Planch.	Akar dani	Cannabaceae	Leaf, bark, twig	Leaf	Food Remedy	Young leaf is cooked as vegetable The leaves are boiled and consumed by postpartum mothers for quickly recovering	12.00	Very low
Ipomoea obscura (L.) Ker Gawl.	Kentangan	Convolvulaceae	Whole parts	Leaf	Fodder	Fresh leaves for animals	12.00	Very low
Ageratum conyzoides (L.) L.	Bandotan	Asteraceae	Whole parts	Leaf	Fodder	Fresh leaves for animals	11.25	Very low
Prunus sp.	Cire	Rosaceae	Leaf, fruit, young stem	Leaf	Remedy	5-8 fresh leaves are boiled in water and then consumed to cure vaginal discharge	11.00	Very low
Willughbeia sp.	Akar bulu	Apocynaceae	Leaf	Leaf	Fodder	Fresh leaves for animals	10.69	Very low
Cyperus rotundus L.	Rumput kait-kait	Cyperaceae	Leaf	Leaf	Remedy Fodder	5-8 fresh/dried leaves are boiled in 1 litre water and consumed to cure diabetic Fresh leaves for animals	10.40	Very low
Mallotus mollissimus (Geiseler) Airy Shaw	Lisau-lisau	Euphorbiaceae	Leaf, bark	Wood	Housing	Wood made for constructions	10.37	Very low
Dehaasia caesia Blume	Kelepang	Lauraceae	Leaf	Fruit	Food	Eaten as fresh fruit	10.11	Very low
Clitoria ternatea L.	Kembang kerabu	Fabaceae	Whole parts	Flower	Remedy	Fresh/dried flower is brewed in hot water and consumed as herbal tea (to prevent cancer, diabetic, high blood pressure)	10.00	Very low
Leptochloa chinensis (L.) Nees	Rumput Sebantun	Poaceae	Leaf	Leaf	Fodder	Fresh leaves for animals	10.00	Very low
Balakata baccata (Roxb.) Esser	Ludai	Euphobiaceae	Leaf, bark	Wood	Firewood	Branch and twig used for firewood	10.00	Very low
Fissistigma latifolium (Dunal) Merr.	Akar padi-padi	Annonaceae	Whole parts	Seed	Equipment	The seeds are sued for toys (played as top)	10.00	Very low

Erythrina subumbrans (Hassk.) Merr.	Dadap	Fabaceae	Leaf	Leaf	Food	Young leaves are cooked as vegetable	10.00	Very low
Acacia mangium Willd	Akasia	Fabaceae	Bark	Wood	Firewood	Branch and twig used for firewood	9.50	Very low
Neoscortechinia kingii (Hook.f.)	Punggur	Euphorbiaceae	Leaf, bark	Fruit	Food	Eaten as fresh fruit	8.00	Very low
Planchonia valida (Blume) Blume	Putat	Lecythidaceae	Whole parts	Leaf	Food Remedy	Young leaves are cooked as vegetable Consumed by a postpartum mother	8.00	Very low
Lophatherum gracile Brongn.	Rumput Sialaan	Poaceae	Leaf, young stem	Leaf	Remedies Fodder	The leaves are crushed and then applied to the wound skin to stop bleeding Fresh leaves for animals	8.00	Very low
Hellenia speciosa (J.Koenig) S.R.Dutta	Akar pancingan	Costaceae	Leaf	Leaf	Fodder	Fresh leaves for animals	7.50	Very low
Calathea Sp.	Delik	Marantaceae	Leaf	Wood	Housing	Wood for constructions	5.00	Very low
Aporosa Sp.	Semasam	Phyllanthaceae	Leaf	Wood	Housing	Wood for constructions	5.00	Very low

Note: * The plants are unidentified due to broken samples when arrived in the herbarium

A high ICS score indicates that the plants are culturally very important to indigenous people shown by the quality utilization of the species as a source of food, as primary material for making buildings, and as the primary ingredient for making traditional medicines. The cultural importance also will increase when the frequency of extraction from natural resources is high, indicating that people highly need them. The plants with multipurpose possess a high ICS, indicating that the plants are culturally important to support local people's life. In this study, Durian Hutan (*D. zibethinus*) and Semangkuk (*S. longifolia)* are the most important plants in the DGWC (ICS above 100). Durian is favourable to local people, the intensity of extraction is high, and the exclusivity is also high because of its special taste. Other parts such as seed and wood are also useful, and it increase their ICS score. Seeds of Durian are also edible, particularly to Talang Mamak and Anak Dalam people, and the wood has been widely used for construction and household appliances. Semangkuk is utilized mostly for medications, and the demand for this plant is very high. Semangkuk fruit can be eaten as fresh fruit. Fruits, seeds, and flowers are utilized to cure the inflammation of the mouth and throat, fever, cough, and malaria. The fruiting season of Semangkuk is very long (around 5 years). Therefore, when the fruiting season comes, local people will search them intensively in the forest for self-using and selling.

Eleven plants categorized as high ICS in Table 2 are utilized for multiple purposes, such as for food, construction materials, remedies and culture which are used at home and also to earn money. They are bamboo, Rumbai, and rattan that are mostly used to make home appliances as tables, chairs, ladle handles, baskets, and mats; guava, Kulim, bamboo shot, Jengkol, and Kabau that are consumed as fresh fruit or cooked as vegetables; rattan and gum of damar that are commonly collected by indigenous people to sell; and Pasak Bumi or long jack and Sungkai used for traditional medicines. Pasak Bumi is well known as a medicine for various diseases, such as increasing body immunity, malaria, fever, and diabetes, and also for increasing body's immune and male vitality. Sungkai is used to relieve fever and also can be combined with Pasak Bumi to cure malaria. Recently, local people in Tebo used Sungkai leaves for COVID-19 medication. Malaria is a common disease in the study area and the traditional knowledge to cure malaria is important for the development of medicines. The medicine plants are mostly prepared through boiling the leaves/barks in water until the remaining water is left around half.

Some species with low ICS are popular for construction materials with medium ICS and also are preferred for house construction (walls, house stilts, and door and window frames). They are also used as materials to make huts, scaffolding for construction, stilts for cultural events, livestock pens, as well as fences for small plants in plantations. Lipai (*L. spinosa*) leaves are utilized for making roofs of huts. Some plants with medium utilization are commonly consumed as fresh fruit and are used for medication.

Cross-cultural analysis

Talang Mamak, Anak Dalam, and Malay people live in the same region and this condition can create the same or similar utilization of various types of plants around them. It can be seen from the intersecting taxonomic group utilized for many purposes as shown in Figure 5. The utilization of the same plants as the sources of food is dominant among the other utilizations, followed by utilization for housing materials, and also for medicine. As many as 46 plant species are edible for all the tribes, eight of them are utilized by Talang Mamak and Anak Dalam, and five of them are used by Talang Mamak and Malay. Those edible plants are fruit, and young leaves, which are used as fresh fruits, vegetables and spices, such as Durian, Semangkuk, bamboo shot, Jambu Biji or guava, Kulim, Kabau, Jengkol, etc. In utilizing food sources from the forest, Talang Mamak and Anak Dalam tribes have greater similarities compared to the Malay tribe. The long-standing coexistence and interaction among the tribes, such as buying and selling foods collected from the forest, can influence the fusion of knowledge and culture among the tribal groups.

For medication, eight plant species altogether were used by the three ethnics including Semangkuk, Pasak Bumi, Sungkai, Pinang, Resak, Kembang Kerabu, Ciplukan, and Balik Angin. The treatment and method of preparing these medicines also seem similar through boiling the medicinal ingredients (leaves and stems) and then drinking the extract. Talang Mamak and Anak Dalam tribes have more similarities compared to the Malay in the utilization of natural resources for traditional medication.

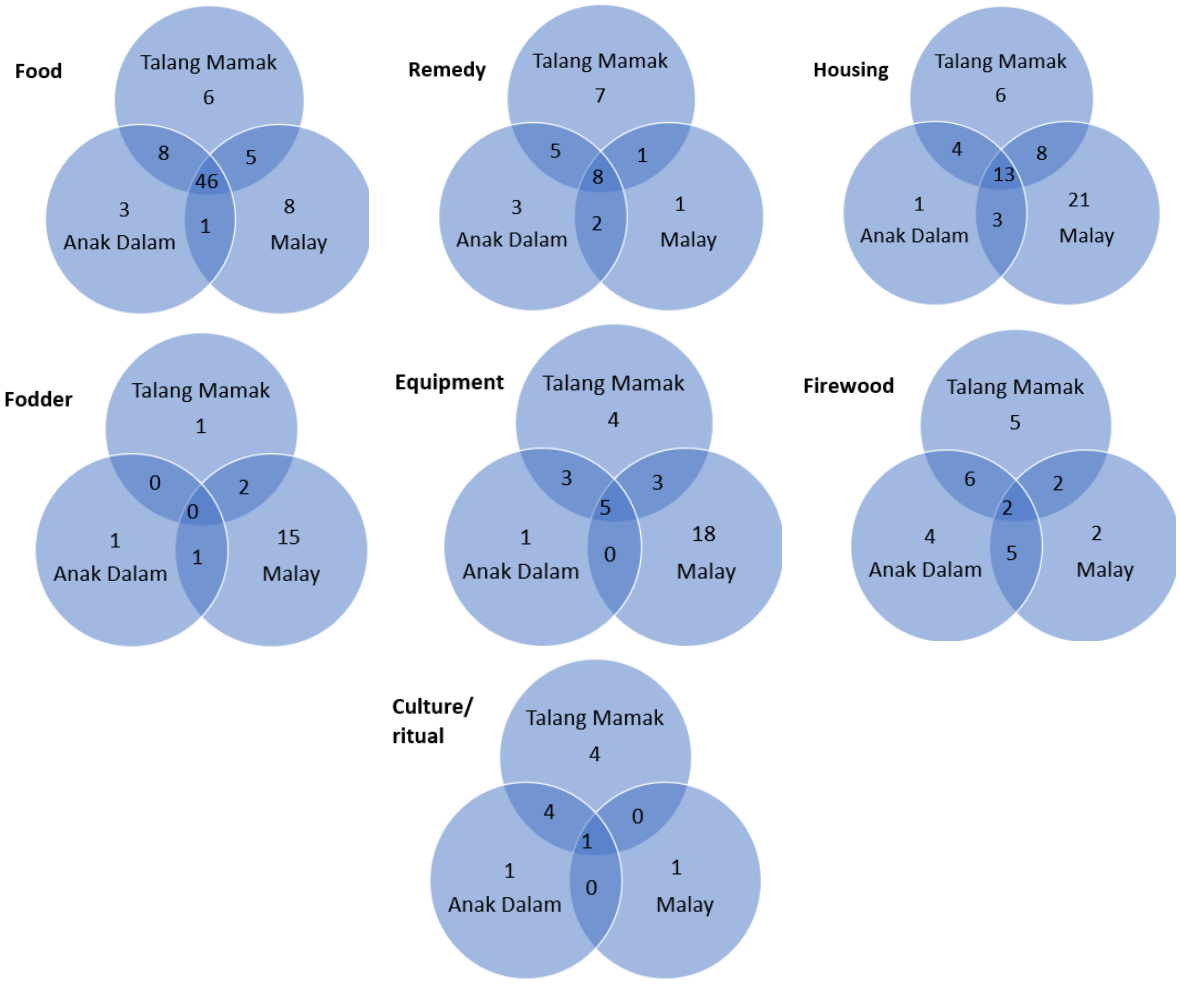

Figure 5. Overlap diagram indicating cross-cultural utilization of plant species by Talang Mamak, Anak Dalam, and Malay people in the study area

Utilization of plants for building materials is mostly implemented by the Malay people. Among the plants, 13 species of them are utilized by all the ethnics, including 12 wood plants as materials for buildings (Kulim, bamboo, Mahang, Medang, Meranti, Nilau, Pelangas, Sekubung, Tembesu, Temeras, and Kempinis), and one species as material for roof (leaf of Lipai). The Malay and Talang Mamak people have more similarities to utilize plants to make constructions compared to the Anak Dalam people. The sedentary lifestyle of the Malay and Talang Mamak people has resulted in them using wood more intensively to build houses or huts. A similar condition also happens in the utilization of plants for making equipment, as Malay people utilize more kinds of plants from the corridor for making household. Five plant species are similarly utilized by the three tribes to make equipment, such as bamboo and rattan to make tables, chairs, baskets, and kitchen tools; Rumbai, Pandan, and Melabai leaves to make mats, baskets, and purses.

Cross-cultural practices to utilize plants for culture and ritual practice is more similar between Talang Mamak and Anak Dalam people. The use of plants in culture and ritual by the Talang Mamak and the Anak Dalam people is often associated with medicinal culture. Even though some of Anak Dalam people have embraced religions such as Islam and Christianity, there are still many of them who believe in the power of ancestral spirits. This is also influenced by remote settlements in the forest that cause the exposure to modern culture is still low. Some parts of plants such as Kemenyan (frankincense) resin, Pinang (betel nut), Siluk, and Lisau-lisau are used for ritual purpose.

Discussions

Knowledge and utilization of useful plants from the elephant corridor by indigenous people

Utilization of part of plants by native people of the Tebo regency living near the elephant corridor is varied. Talang Mamak people seem to most utilize those 139 elephant forage plant species among the two other tribes, particularly as the source of food, medication, firewood, and economic as presented in Figure 4. Living in a remote area and the buffer zone of BTNP has made them depend on natural resources to support their household needs and also to support their economy (Ginting *et al.* 2022; Muntaza 2022). Similar to Ot Danum Dayak indigenous people living in Central Kalimantan, Indonesia (Herianto *et al.* 2018), the vast majority of subsistence and society's income is from forest plant products. Even though they have practiced agriculture, forests are the main source of livelihood for the Talang Mamak people (Charin and Hidayat 2019; Setyowati and Wardah 2007). The interaction with forests has created knowledge and culture to utilize plants around them for food, medication, and home utensils and appliances (Ladio and Lozada, 2009; Prasetyo *et al.* 2024). For economic, Talang Mamak people collect forest products such as Damar, rattan, Jengkol, Kabau, Petai, and many kinds of fruit and sell them to traditional markets, and sometimes the collectors come to their village to buy their products.

Customs that have been practiced and passed down from generation to generation by Talang Mamak people have made them deeply rooted in traditional ecological knowledge and the use of natural materials for medication. The study on Talang Mamak people living in Bukit Tigapuluh National Park in Riau Indonesia conducted by Setyowati and Wardah (2007), also stated that Talang Mamak people depend on natural resources for medication. They identified 78 plant species for traditional medications. The distance makes the people could not access public health facilities and makes them relay on traditional medications (Awoyemi *et al.* 2017). However, culture and knowledge of traditional medication that have been practiced for centuries cannot make the aboriginal people leave traditional medication practices (particularly the elder people), even though access to health facilities has opened, as practiced by the Karo Tribe living in mountain areas of North Sumatra Indonesia (Situmorang *et al.* 2015), the people of Puranchaur in Kaki District Nepal (Gautam and Timilsina 2022), and the tribal communities living in Shahapur and Jawhar forest in India (Kolhe *et al.* 2021).

Anak Dalam people known as Suku Rimba (meaning Jungle Tribe or Jungle People) are indigenous people that purely have traditional life compared to the other two tribes. They mostly live in nearby forests with the difficult access. Their lifestyle is semi-nomadic (nomadic) with a source of livelihood from hunting and gathering forest products, as also stated by Sulasmi *et al.* (2012) and Yuniato (2020) in their study. A tight interaction with forests has created knowledge and culture in recognizing and utilizing many kinds of plants for food, and household equipment (Astarika *et al.* 2019). For livelihood, the same as Talang Mamak, Anak Dalam people collect forest products such as Damar, Rattan, Jengkol, Kabau, Petai, and many kinds of fruit to support their economy. They sell forest products to traditional markets, and sometimes they still practice a barter method, which was to exchange products for other products.

Anak Dalam people live in simple huts made from materials found in the forest. For building houses, they used wood for the pillars and floor, leaves for the roof, and tied using rattan. Anak Dalam people are known to have difficulty interacting with outsiders (Triana and Putri 2022). Those who had started living outside the forest and interacting with outsiders began to build semi-permanent and use household equipment that did not come from nature, such as plastic tarpaulins for roofs of their houses or huts. However, compared to Talang Mamak, Anak Dalam people less utilize the kinds of plants to build permanent houses, to make household equipment, and to support farming activities.

Malay people is the second order in the utilization of plants from the elephant habitat. As the most developed culture compared to the others, Malay people mostly utilize kinds of wood to build their houses, to install huts and cages for their agriculture and livestock, and to make furniture and household appliances. The houses in Tebo are dominated by wooden houses. Therefore, building materials to make poles, walls, doors, and window frames are usually taken from forests. Malay people around DGWC have also developed extensive plantations such as oil palm and rubber. To protect plants from animal attacks and to divide fields, they usually need various types of wooden stakes to make fences. Apart from that, using wood to build a hut also requires wood for the walls, floor, and roof. Malay people around DGWC also utilize a lot of kinds of plants such as fruit food, vegetable material, spices, and medical ingredients that are mostly for self-consumption and self-using. Even though Malay people in Tebo have practiced agriculture, they still need to go to the forest to take various fruits such as Durian, jackfruit, Rambutan, Rambe, etc. This is because most of their agricultural land is planted with plantation crops such as oil palm and rubber. They also take many kinds of plants for their animals, such as goats and cows. While Talang mamak people rarely practice the semi or full-cage livestock. Even Anak Dalam people mostly do not keep livestock. According to ancestral teaching, slaughtering their livestock is the same as eating their children (Triana and Putri 2022). Therefore, the ICS of fodder plants in this study was mostly valued by Malay respondents.

The cross-culture among different ethnics in utilizing plants for many purposes also exists in the communities around the Elephant corridor, for example, to utilize plants for food, medication, equipment, and construction materials. Jha and Smith-hall (2023) explain that a cross-culture among people and plant is described as in a model called plant-ailment-tribe. A particular plant can be utilized by people from different tribes and for one or more than one purpose both same and different to particular tribes. The role of knowledge sharing when the tribal people live in the same region is significant to cause cross cultural, particularly in medication practices (Kazancı *et al.* 2020; Siram *et al.* (2023). The history and background of the ethnicity also may affect the cross culture (Pieroni *et al.* 2011; Kazancı *et al.* 2020). Cross culture in utilizing plants from the elephant corridor mostly exists between Talang Mamak and Anak Dalam Tribes. The similarities in living habits which still depend on forests possibly make this happen. For example, similar plants used for medication such as Melabai (*M. gigantea*) and Senjanit to cure diarrhoea, as well as the using of Sungkai (*P. canescens*), Brumbung (*A. eurhyncha*), and Pulai (*A. scholaris*) to heal fever and to cure malaria. For livelihood, the previous study conducted by Yuniato (2020) also found that Talang Mamak and Anak Dalam people mostly collect Damar (*D. crinitus*), rattan (*Calamus sp*.), and Jernang (*C. draco*).

Conservation actions and recommendation

The study results showing that a huge number of plants utilized by both elephants and humans indicate that HECs potentially happen if the availability of the plants is limited in nature. Conflicts may happen because of the same interests of elephants and humans in the same plants. People utilize many kinds of plants for many purposes, while elephants consume huge food every day. Elephants consume around 273 types of edible plants, and from those numbers, elephants consume around 50 to 95 types of plants per day to support life and metabolism (Joshi and Singh 2008; Sitompul *et al.* 2011; Meytasari *et al.* 2014). Adult elephants consume about 200-300 kg/day which is around 10 % of the body weight kg (Joshi and Singh 2008; Sitompul *et al.* 2011). Because of this enormous food need, it is reasonable that elephants will search for food outside their home range even in human areas if the food supply is not enough in their natural habitat.

The main purpose of corridor establishment in Tebo is to rehabilitate the buffer zone of BTNP that is relatively flat and most suitable for elephant life (Kuswanda *et al.* 2023), and also to connect the fragmented habitat that can connect elephant pathways to browse the wider areas. However, the elephant habitat quality in DGWC is low. Based on the remote sensing data in 2021, as many as 33.62 % of the DGWC areas are industrial plantations, agriculture, bush, and open areas that show forest cover change. On the other side, local people also depend on the natural resources from the area.

This study has identified the useful forage plants for indigenous people from DGWC that consist of 2 plants with high importance, 11 species with high importance, and 34 plants with medium importance (in total 47 species). The previous study of Kuswanda *et al.* (2023) identified the habitat characteristics and quality of DGWC and found that only four of those 47 species that are abundance in the DGWC. Those species are Semangkuk *(S. longifolia)* and Rotan or rattan *(Calamus sp.)* at the category high ICS, and Balik Angin *(M. paniculatus)* and Tempinis *(S. elongatus)* at the category medium ICS*, w*hile the rest are short.

Degradation of forests in the elephant corridor is mostly caused by the expansion of oil palm and rubber industrial plantations particularly since from the 2000's (Charin and Hidayat 2019), which may cause the rarity of species in the corridor. The biodiversity loss is a threat to biodiversity conservation, the elephant population, and indigenous people's culture and livelihood. Preserving biodiversity is also preserving the existence of indigenous people's culture. Therefore, the conservation of the elephant corridor in BTL particularly 66% of the DGWC area needs to be enhanced through both natural growth and man-made methods to increase the quality of the elephant habitat. Rehabilitation of the degraded areas is also very important to avoid elephants entering human areas and reduce the conflict of interest in natural resources between humans and elephants (Sitompul *et al.* 2013).

Based on this study result, we recommend the useful forage plants particularly 11 plants with high utilization to be enriched in DGWC which their availability in DGWC is limited. The plant species are Durian Hutan *(D. zibethinus),* Buluh *(G. apus),* Damar *(D. crinitus),* Jambu Biji *(Z. fastigiatum),* Rumbai *(S. ghaeri),* Kulim *(S. borneensis),* Pasak Bumi *(E. longifolia),* Jengkol *(A. pauciflorum),* Sibekal *(S. apiculate),* Kabau *(A. bubalinum)* and Sungkai *(P. canescens)*. Replanting various useful plants that are also useful to traditional people could support the existence of traditional people's live and culture particularly those who depend on forest resources for living. Therefore, the Jambi Government should seriously handle the conservation actions in the DGWC. Eleven high-value plants that can be utilized by people should be enriched through man-made methods through a forage plant enrichment program. The reforestation program should involve indigenous people and migrant people who live around the corridor. The involvement also can increase the people knowledge and awareness of local people on the conservation of elephants around their area.

Limitation of the study

This research carried out an overall evaluation of elephant food plants utilized by three ethnic groups in and around the elephant corridor area. These findings show that there are many types of plants, so there are limitations to exploring and identifying these plants in detail. Therefore, research that focuses more on one specific use, for example, plants as a source of food, medicine, cultural practice, etc. will reveal a more detailed presentation of those tribal people. Besides that, Anak Dalam and Talang Mamak people are the indigenous tribes living in the buffer zone of the forests in Bukit Tigapuluh who still practice traditional life and depend on the forest. Thus, research that focuses more on these two tribes will be very important in highlighting the local wisdom in interacting with nature and their coexistence with wildlife.

Conclusions

Talang Mamak, Anak Dalam, and Malay indigenous people living around the wildlife corridor DGWC utilize 139 kinds of plants from the DGWC for food, buildings, equipment, traditional medicines, culture and livelihood. Talang Mamak people utilize more plants compared to Anak Dalam and Malay. Cross-cultural analysis showed that Talang Mamak and Anak Dalam People more similarly utilize the plants, particularly as a source of food, medication, and culture. The continuous use of plants between humans and elephants without knowing the level of their cultural importance and their availability in nature can lead to resource conflicts and can threaten the preservation of elephants and human safety. Calculating the ICS of forage plants and ethnobotanical study can help to reveal the number of plants that need to be conserved and enriched in the wildlife corridor DGWC, as one of the elephant habitats in Tebo. Based on the ICS valuation and the species availability in the habitat, this study recommends 11 elephant forage plant species to be included in the habitat enrichment program by the Jambi Government. They are Durian *(D. zibethinus),* Buluh *(G. apus),* Damar *(D. crinitus),* Jambu Biji *(Z. fastigiatum),* Rumbai *(S. ghaeri),* Kulim *(S. borneensis),* Pasak bumi *(E. longifolia),* Jengkol *(A. pauciflorum),* Sibekal *(S. apiculate),* Kabau *(A. bubalinum)* and Sungkai *(P. canescens)*.

Declarations

List of abbreviations: BTL: Bukit Tigapuluh Landscape; BTNP: Bukit Tigapuluh National Park; DGWC: Datuk Gedang Wildlife Corridor***;*** HEC: Human and elephant conflicts; ICS: Index of cultural significance

Ethics approval and consent to participate: This research has obtained ethical clearance from the Social Humanities Ethical Commission of the National Research and Innovation Agency (BRIN), Number 03/KE.01/SK/9/2022.

Consent for publication: Not applicable

Availability of data and materials: datasets have not been deposited in public repositories. Data will be provided by the authors upon reasonable request.

Competing interest: The authors declare that there are no competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions: All authors declare to have made equal, direct, and intellectual contributions and have approved the current work for publication in this journal. R.O.P.S., W.K., M.H.S., H.H., and P.H.P.P. collected the data, analysed the data, and wrote the manuscript.

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Appendix 1.

QUESTIONAIRRE

Date : Location : Code/Number :

1. Activities in the forest/corridor t in the last 6 months *(Choose the most appropriate answer)*
   a. 7 – 5 times per week b. 4-2 times per week c. 1 time per week d. 1 time per 2 weeks e. 1 time per month
   f. 1 time for more than 1 month g. Never
2. Various purposes for utilizing forest plants (*Put √ mark in the column for selected answer*)
   1 = Never 2 = 1 time a month or more
   3 = 1 time per 2 weeks 4 = 1-2 times per week
   5 = 3 – 7 times per week

Plants taken from forest/ elephant corridor	Purpose														
	Household needs (Self use)					Economy (sale/farm business)					Religion/ cultural activities				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Food															
Spices															
Firewood															
Construction / building materials															
Agricultural/household tools															
Compost															
Traditional medicines															
Animal feed															
Decorative plants															
Others ……															

3. Various types of elephant food plants which are also used by the indigenous people taken from the forest/corridor
(*Respondents will be shown a list of elephant food plant names that has been recorded from the key respondents, then they will be asked to fill in the columns for the parts used and their uses, and put a tick (√) mark in the weight column. It is also possible for respondents to fill a certain types of elephant food plants that are used by them but they are not available the list.*
Note: *(1) The information on how to value the plants is provided in the below the table; (2)* one plant can be used for many purposes.

No.	**Name of plants** (Local name or general name)	**Parts of plants that are used** (Leaf, fruit, seed, flower, root, wood, barks, gum, Sap, etc.)	**Utilization** (Food, spices, remedy, firewood, building materials, household/ agriculture tools, religion, culture, economy, etc.	Preparation / utilization method	Quality score (Scored 5 to 1)					Intensity score (Scored 5 to 1)					**Exclusivity value** (Scored 2, 1, and 0.5)			
					1	2	3	4	5	1	2	3	4	5	2	1	Exchange plant name	0.5
1. (exp.)	Plant 1 …..	Leaf	Remedy of …. To cure …..	Dried leaves are boiled ….				√					√			√		
		Fruit	Food	Eaten as fresh fruit					√				√		√			
		Wood	Construction	……		√			√		√							√
2.	Plant 2 …….	……	……	……														
		……	……	……														
3.	Plant 3 …….	……	……	……														

Remarks:

Quality value: Score of plants usage
5 : Food or main material
4 : Secondary material
3 : Additional material
2 : Ritual material
1 : Do not know the specific function

Intensity value: intensity of use/extraction of plant species from forest/corridor
5 : Very high intensity
4 : high intensity
3 : moderate intensity
2 : Low intensity
1 : Very low intensity

Exclusivity value
2 : Most preferred, main choice, the only one or no other choice
1 : There are several other plants as an option if the plant is not available
0.5 : The favourability value is low

Appendix 2

Ethical clearance certificate

KOMISI ETIK BIDANG SOSIAL HUMANIORA
BADAN RISET DAN INOVASI NASIONAL
Gedung B.J. Habibie Lantai 8 Jalan M.H. Thamrin No. 8, Jakarta Pusat 10340
Laman: https://klirensetik.brin.go.id/, klirensetik@brin.go.id

SURAT KEPUTUSAN KLIRENS ETIK
Riset Bidang Sosial Humaniora
Nomor: 303/KE.01/SK/9/2022

Komisi Etik Bidang Sosial Humaniora BRIN menerangkan bahwa,

Judul Riset	:	Eksplorasi Jenis Tumbuhan Pakan Gajah (Elephas Maximus Sumatranus) dan Bernilai Guna Bagi Masyarakat Tradisional di Kabupaten Tebo, Jambi
Nomor Usulan	:	19082022000002
Unit/Lembaga	:	Pusat Riset Ekologi dan Etnobiologi, Organisasi Riset Hayati dan Lingkungan BRIN
Koordinator Periset	:	Wanda Kuswanda

Telah disidangkan pada tanggal 22 September 2022.

Berdasarkan hasil sidang tersebut, Komisi Etik Bidang Sosial Humaniora BRIN memutuskan: **Riset dengan Nomor Usulan di atas telah memenuhi persyaratan Klirens Etik dengan jangka waktu riset dari bulan September s.d Desember 2022.**

Periset tetap berkewajiban untuk:

a. Mematuhi protokol kesehatan terkait Pandemi Covid-19 yang berlaku di lokasi riset.
b. Mengajukan permohonan baru apabila ada amandemen rancangan atau subyek riset
c. Memberikan laporan apabila riset lapangan telah selesai
d. Memberikan informasi bila ada perubahan lokasi, waktu riset dan/atau dihentikan sebelum waktunya.

Komisi Etik Bidang Sosial Humaniora BRIN mempunyai hak untuk melakukan pemantauan selama riset berlangsung.

Jakarta, 23 September 2022

Ketua Komisi Etik
Bidang Sosial Humaniora BRIN,

TT ELEKTRONIK

Dr. Augustina Situmorang, M.A.

Dokumen ini ditandatangani secara elektronik menggunakan sertifikat dari BSrE, silahkan lakukan verifikasi pada dokumen elektronik yang dapat diunduh dengan melakukan scan QR Code