RESEARCH ARTICLE

MEDIA KONSERVASI
SCIENTIFIC JOURNAL IN CONSERVATION OF NATURAL RESOURCES AND ENVIRONMENT

The Morphology, Standing Stock and Habitat Distribution of Several Bamboo Species in the Reok Sub-District, Manggarai Regency, East Nusa Tenggara Province, Indonesia

Orlando C. Apu[a], Fadlan Pramatana[a,b], Maria M. E. Purnama[a] and Pamona Silvia Sinaga[a]

[a] Department of Forestry, Faculty of Agriculture, University of Nusa Cendana, Kupang 85228, Indonesia
[b] Archipelagic Drylands Laboratory, University of Nusa Cendana, Kupang 85228, Indonesia

Article Info:
Received 26 January 2024
Revised 20 June 2024
Accepted 8 July 2024

Corresponding Author:
Fadlan Pramatana
Department of Forestry,
Faculty of Agriculture,
University of Nusa Cendana
E-mail:
fadlan.pramatana@staf.undana.ac.id

Abstract

Bamboo plays a vital role in preventing soil erosion and conserving water. In East Nusa Tenggara Province, many communities rely on bamboo species, making its cultivation a priority due to the region's favorable biophysical conditions and available support from Non-Governmental Organization as facilitators. Approximately 387 villages have undergone assessment and socialization processes aimed at developing bamboo villages, including the Reok sub-district. One of the next steps in this process is conducting an inventory of bamboo standing stock in the area.This study aims to assess the species diversity and standing stock of bamboo in Reok sub-district. Research was carried out at 11 randomly selected sampling points across six villages, using the single circular plot method (radius of 17.9 m), with a total of 55 plots. Each plot was surveyed to identify and quantify clumps and culms, categorized by age (young, medium, and old). Four bamboo species were identified: *Bambusa spinosa*, *Bambusa vulgaris*, *Gigantochloa atter*, and *Dendrocalamus asper*. *Gigantochloa atter* was the most prevalent species, found at nearly all survey points, and had the highest number of clumps and culms. The estimated standing stock of bamboo in the Reok sub-district is 57,496 clumps, with a total of 3,692,890 culms. *Gigantochloa atter* accounted for the majority, with 35,526 clumps and 1,815,593 culms. This standing stock holds significant potential for further development, as bamboo is a key non-timber forest product (NTFP) in the region, with the potential to enhance the local economy.

Keywords: bamboo species, bamboo diversity, *Bambusa spinosa*, *Bambusa vulgaris*, *Gigantochloa atter*

1. Introduction

Bamboo is a plant that belongs to the grass family (Poaceae) and can grow naturally on all continents [1–4]. According to Canavan et al. [5], bamboo generally spreads in tropical and semi-tropical areas, typically Asia and Central and South America. Bamboo is a fast-growing plant that can grow on marginal land, which is beneficial for soil and water conservation [6,7]. Bamboo forests can help ecological functions by controlling soil erosion, water conservation, land rehabilitation, and carbon sequestration [8–13]. Canavan et al. [5] reported 1,662 bamboo species worldwide. In Indonesia, Widjaja [14] stated that there were 176 bamboo species, with 105 endemic species.

The East Nusa Tenggara Province is located on the Lesser Sunda Islands. Damayanto et al. [15] reported that the Lesser Sunda Islands contain more than 40 bamboo species, with ten endemic species. Through Governor Decree Number 404 of 2018, the provincial government of East Nusa Tenggara makes bamboo one of the superior types of Non-Timber Forest Products (NTFPs). The Governor Regulation Number 26 of 2021 in East Nusa Tenggara Province also regulates bamboo development centers. Considering the importance of utilizing this commodity in the East Nusa Tenggara province, it has been strengthened again by Governor Regulation Number 73 of 2022, which regulates bamboo agroforestry villages.

The utilization of bamboo processing is often found in Indonesia. Bamboo could be used to make layered bamboo, laminated bamboo, cement board, bamboo charcoal, pulp, handicrafts, chopsticks, furniture, house buildings, food ingredients, and musical instruments [16–19]. The use of bamboo in building construction will have a positive impact on the

environment [20–22]. Furthermore, Xu et al. [8] reported that bamboo requires less energy and produces less carbon dioxide than other building materials.

The community uses bamboo in East Nusa Tenggara Province, including Sita village in the Ranamese sub-district. It is used in food, building materials, living fences, and other handicrafts [23]. Komarudin et al. [24] reported that East Nusa Tenggara is one of the provinces with strong bamboo traditions and culture, resulting in a set of *Wiragawi* bamboo musical instruments being produced. Mali [25] also reported the use of bamboo as a musical instrument for learning bamboo flute music in Belu, East Nusa Tenggara.

In addition, bamboo is also used traditionally for carrying out ceremonies; Sada and Jumari [26] reported that bamboo was used in ceremonies for the *Ngadha* ethnic group, specifically for *Bambusa vulgaris*, *Gigantochloa atter*, *Dendrocalamus asper*, and *Schizostachyum lima*. This result is supported by Ekawati et al. [27], who stated that in the Ngada district, there are 15 species of bamboo, and the people there are highly dependent on this commodity. Furthermore, Ekawati et al. [27] identified driving factors in bamboo development in the Ngada Regency: resource potential, biophysical conditions, and non-governmental organizations (NGOs) facilitating bamboo development.

The Environmental Bamboo Foundation (Yayasan Bambu Lestari/YBL) is an NGO formed in 1993 and is engaged in developing the use of bamboo within the community. In the East Nusa Tenggara province, approximately 387 villages have been recorded that have at least through the assessment and socialization stages for development as bamboo villages [28]. Reok District, Manggarai Regency, has been through the assessment and socialization stages, so one of the following stages is an inventory of the bamboo standing stock at that location. This research aims to determine the species diversity and standing stock of bamboo in the Reok sub-district.

2. Materials and Methods

2.1. Data collection

The survey points from YBL are randomly selected from the bamboo distribution database in the Reok sub-district, with 11 sampling points across six villages: Robek, Wangkung, Watu Tango, Bajak, Salama, and Ruis (Figure 1). The bamboo inventory method used involves a single circular plot with a radius of 17.9 meters. At each survey point, five plots were recorded to form a cluster, meaning data from 11 survey points were collected across 55 plots. In each plot, the bamboo species were identified, the number of clumps per species was recorded, and the number of culms per clump—categorized as young, medium, and old—was counted. This study also adopted a similar methodology to assess the bamboo potential by calculating the number of clumps per species and the number of culms per clump, subsequently converting these values into area units [1,29–31].

2.2. Data analysis

The data obtained, based on its characteristics, was matched with the description contained in the identification guideline and online database [32,33]. Jannah et al. [34] calculate the estimated potential for the average culms per clump, clumps per community land, and clumps per hectare. Data analysis refers to these calculations by adjusting the estimated potential for the total area of bamboo distribution in Reok sub-district with the following equation.

$$Cp_a = \frac{\sum \mathrm{Cp}}{\sum \mathrm{a}} \quad (1)$$

Description: Cp_a = the total number of bamboo clumps per hectare, $\sum Cp$ = the total number of bamboo clumps, $\sum a$ = the entire sample area.

$$C_a = \frac{\sum \mathrm{Cy} + \sum \mathrm{Cm} + \sum \mathrm{Co}}{\sum \mathrm{a}} \quad (2)$$

Description: C_a = the total number of bamboo culms per hectare, $\sum Cy$ = the total number of young bamboo culms, $\sum Cm$ = the total number of medium-aged bamboo culms, $\sum Co$ = the total number of old bamboo culms, $\sum a$ = the entire sample area.

$$PCp = Cp_a \,.\, BD_a \quad (3)$$

Description: *PCp* = the potential of bamboo clumps in the Reok sub-district, Cp_a = the total number of bamboo clumps per hectare, BD_a = the total area of bamboo distribution in the Reok sub-district (2,571 ha).

$$PC = C_a \,.\, BD_a \quad (4)$$

Description: *PC* = the potential of bamboo culms in the Reok sub-district, C_a = the total number of bamboo culms per hectare, BD_a = the total area of bamboo distribution in the Reok sub-district (2,571 ha).

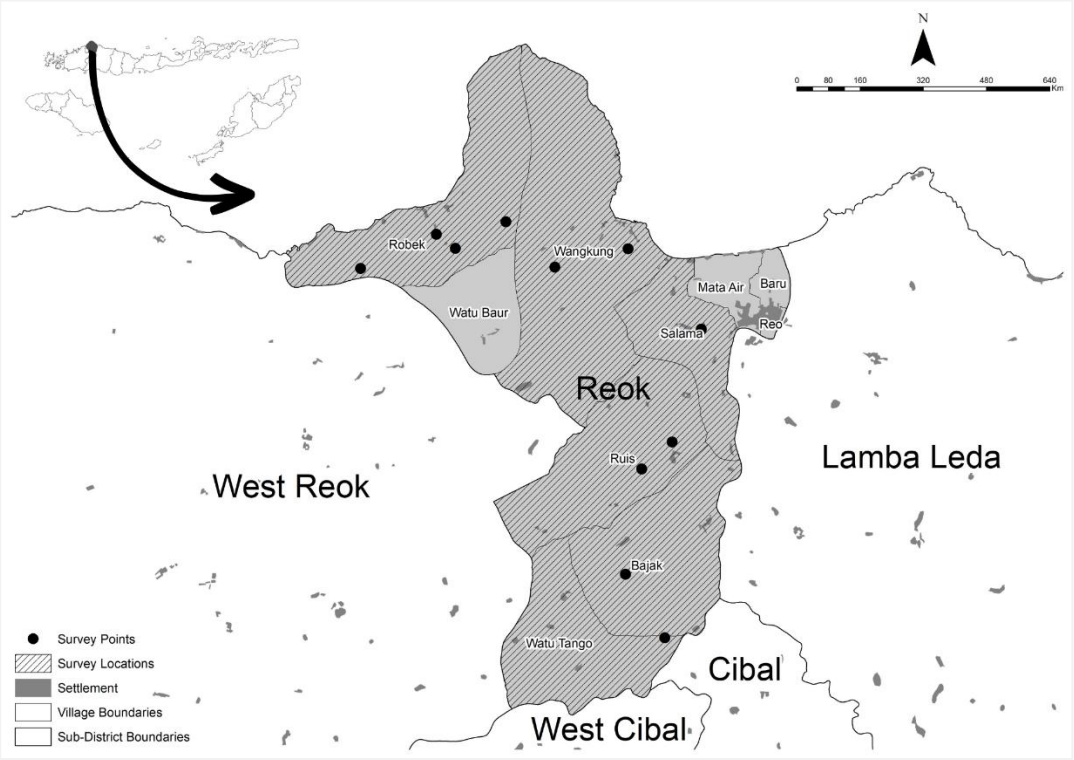


Figure 1. Research site map

3. Results and Discussion

Four bamboo species were recorded in the Reok sub-district area, namely *Bambusa spinosa*, *Bambusa vulgaris*, *Dendrocalamus asper*, and *Gigantochloa atter*.

3.1. Description of Thorny bamboo (*Bambusa spinosa* / *Bambusa blumeana*)

Thorny bamboo (*Bambusa spinosa* / *Bambusa blumeana*) is known by the local community as *To'e* (Figure 2). This species grows in damp or dry places and acidic soil. This type is suitable for growing in dry areas [35]. Thorny bamboo is characterized by thorns on its branches, which form dense clumps. Clump circumference 10–25 m. Culms are dark green and smooth, 8–20 m long and 5–10 cm in diameter. The clumps are very dense, and branching starts from the base of the reed. There is a crust on medium and old bamboo. The older the bamboo, the thicker the crust. Branches appear throughout the nodes and are covered with erect or curved spines; one branch is larger than the others.

The distribution of *B. spinosa* in the Reok sub-district and several areas in East Nusa Tenggara is also quite large. Unfortunately, this type is rarely used by the public because its spikes are full of thorns, making it challenging to harvest. But beyond that, this bamboo thorn also has benefits as a substitute for wood in making pulp. *B. spinosa* has good potential to be used as a raw material for making dissolving pulp. Thorny bamboo is classified as a long fiber with an average fiber length of 2.46 mm [36].

In Indonesia, this species is widely used by the community. For example, Fathiya et al. [35] reported this species uses traditional medicine, fertilizer, household utensils, crafts, and construction materials. This is also supported by Wicaksono et al. [37], who report that this species can be used as an erosion barrier, building construction material, and household equipment. Pradipta et al. [38] also note that this species can be used as active carbon and pellets along with four other types of bamboo (*G. atter, G. apus, S. zollingeri, B. vulgaris*). Other studies also report that this species is used for food and paper-making [39].

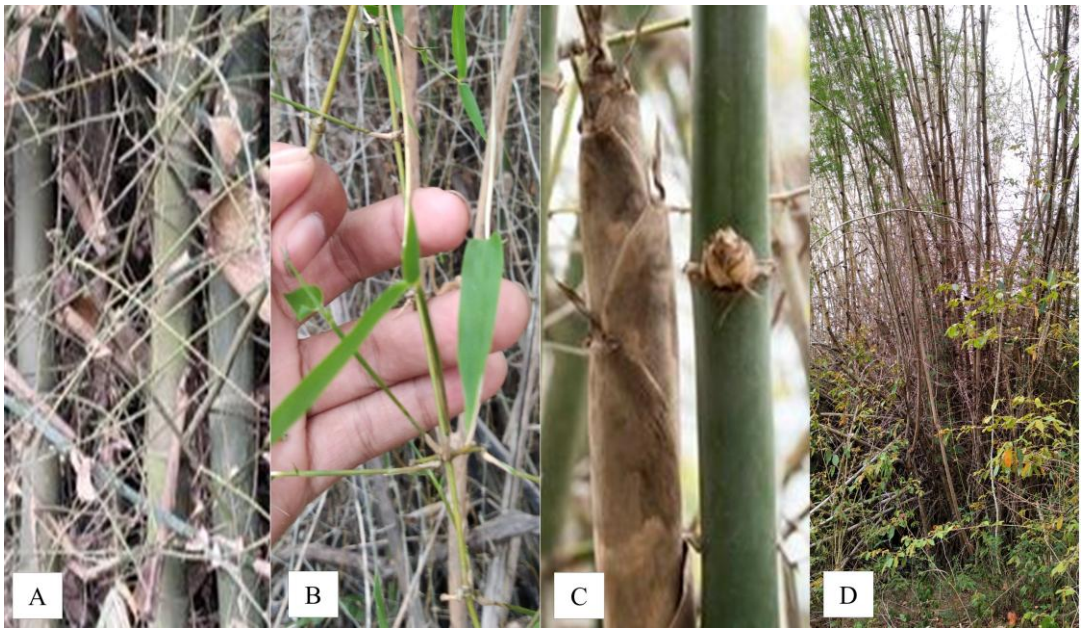


Figure 2. Morphology of *B. spinosa*: a) reeds; b) leaf; c) fronds; d) stature

3.2. Description of Common bamboo (*Bambusa vulgaris*)

Common bamboo has the scientific name *Bambusa vulgaris* and is known by the local community as *Gurung* / *Ampel* bamboo (Figure 3). Habitat *ampel* bamboo grows in damp and dry areas [40,41]. This type is often found on riverbanks [42,43]. This type has a large number of culms in each clump. The number can reach 200 spikes in one clump and is very dense. There is a crust on medium and old loons in several clumps. Surround the clump 10–20 m. Culms are green, upright, and smooth, 8–15 m long and 5–10 cm in diameter.

The fronds are triangular, have black, slightly brown hair, and shed quickly. The fronds are upright, and the front tip is pointed. Sympodial branching, which consists of 6–7 branches. The vertical green leaves are lanceolate in shape, have a smooth, hairy surface with pointed leaf tips measuring 32–37 cm x 2.5–3 cm, and the vein structure is visible. *Ampel* bamboo could grow throughout the pantropical area at an altitude above sea level up to 1,200 m above sea level [44]. This green, clumpy plant grows naturally on the banks of rivers, on roadsides, and in fields.

There are three varieties of *B. vulgaris*: *B. vulgaris* var. *vulgaris* (green reed), *B. vulgaris* var. *striata* (yellow reed with green stripes), and *B. vulgaris* var. *Wamin* (reed is green and inflated when grown in dry areas or pot cultivation) [45,46]. Of these three varieties, only one is at the research location, *B. vulgaris* var. *vulgaris*. Like other bamboo, *B. vulgaris* can be used as a building material for houses, huts, fences, bridges, transportation equipment (rafts), water pipes, props, furniture, and various household equipment, as well as raw material for paper pulp [37–39]. The young shoots can be eaten and used as a medicine for the liver or hepatitis and swelling [47–50]. Bamboo groves can potentially preserve the environment; their growth is fast, and their roots can maintain the soil and reduce erosion [7]. The leaves of *B. vulgaris* are usually used as a fever-reducing medicine and sudorific agent. Meanwhile, the sap is used to treat fever and hematuria [51].

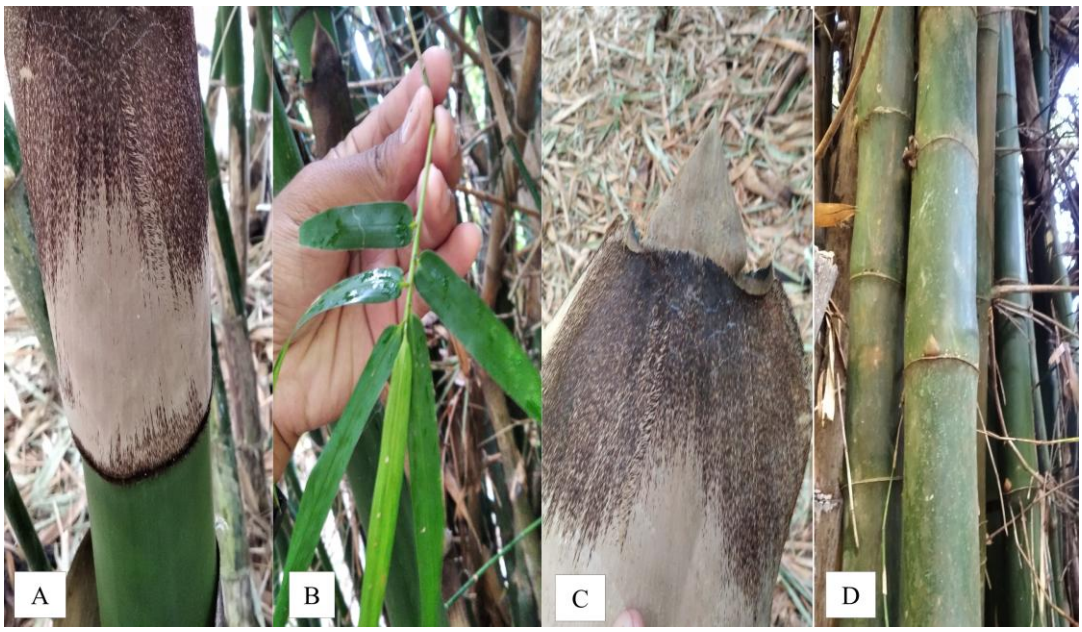


Figure 3. Morphology of *B. vulgaris*: a) reeds; b) leaf; c) fronds; d) stature.

In building construction, *ampel* bamboo also has the potential to be a substitute natural material for wood. The results of experiments by Rohimah and Walujodjati [52] prove that *ampel* bamboo meets the standards for replacing iron bones in building construction. The average tensile strength of *ampel* bamboo is 396.10 MPa and meets the standards for plain iron reinforcement (minimum tensile strength of 350 MPa), and the flexural strength capacity of the concrete plate obtained by replacing iron reinforcement with *ampel* bamboo is 1.16 KNm [52].

3.3. Description of Giant atter (*Gigantochloa atter*)

Giant atter bamboo has the scientific name *Gigantochloa atter* and is usually called *Pering* bamboo by the local community (Figure 4). The habitat of giant ater bamboo is that it grows in humid and dry areas and from lowlands to the highlands [14,53–55]. This bamboo is often found scattered along riverbanks in the research area. The fibrous roots of *pering* bamboo appear above the white surface of the soil. The green stems are upright and smooth. The length ranges from 10–25 m, and the stem diameter ranges from 8–13 cm. Febriyanti et al. [56] said that *pering* bamboo can reach a height of 30 m.

The midrib of the stem is an isosceles triangle, has black hairs, sheds quickly, and the midrib leaves are upright [56,57]. Sympodial branching, which consists of 7–11 culms. There is a crust on medium and old bamboo. The thicker the crust, the older the bamboo. The dark green leaves are lanceolate in shape with pointed leaf tips measuring 41–44 cm x 5–7 cm, and the vein structure is visible. The cone-shaped shoots are brown, and the base of the midribs is brown.

Pering bamboo is a type found throughout almost all of Indonesia and is widely used by people daily. *G. atter* can be utilized in several derivative products by the community. This species can be used as raw material for pulp in making paper [58], helps in the conservation of river borders [59], and as a traditional medicine [60]. This species is reportedly used as a charcoal fuel [61]. According to Rochim et al. [62], *G. atter* can also be used as a reinforcement for soil conservation. One of the journals explains the use of atter bamboo as a substitute for wood in Asmat carvings. The research results show that ater bamboo with an average thickness of 0.8 cm can be processed using the through-hole carving technique with promising results [63].

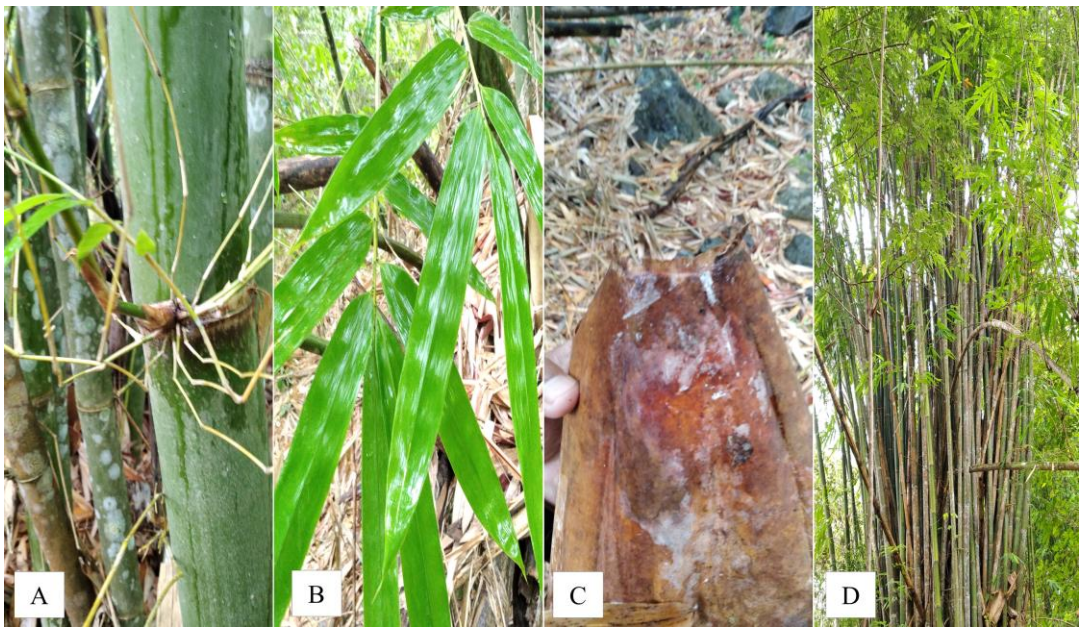


Figure 4. Morphology of *G. atter*: a) reeds; b) leaf; c) fronds; d) stature.

3.4. Description of Rough bamboo (*Dendrocalamus asper*)

Rough bamboo has the scientific name *Dendrocalamus asper*, also known as *Beto* / *Betung* bamboo by the local community (Figure 5). *Betung* bamboo's habitat grows in damp and wet areas and from lowlands to the highlands [64]. In the research area, this bamboo is the least common. *Betung* bamboo is characterized by brown velvety hairs on the underside of the young reeds, while the top is covered in white wax, which disappears when it gets old. In terms of stature, *betung* bamboo has a larger reed size than the other three types. The reed can reach a height of 10–20 m, a diameter of 8–20 cm, a length of 40–60 cm, and a wall thickness of up to 1 cm [64,65]. *Betung* bamboo is a strong bamboo with a large diameter reaching 200 mm [64,66]. According to Kaminski et al. [67], bamboo with a 50-200 mm diameter can be used for structural purposes.

Another study that explains the characteristics of *betung* bamboo has a segment length at the base of 39.4–45.8 cm, middle section 46–49 cm and tip length 46.4-57 cm; culm diameter at the base 6.69–9.25 cm, central part 5.79–8.32 cm and tip 5.06–7.99 cm; The thickness of the stem wall at the base is 1.62–2 cm, the middle part is 1.16–1.57 cm and the tip is 0.85–1.09 cm. This bamboo is suitable for use in construction with previous preservation treatment, bridges, and certain parts of furniture and crafts [68].

Betung bamboo is a type that has better physical and mechanical properties than several other types. This makes the *betung* bamboo type widely used as a building material. The results of research from Nugroho et al. [69], which measured the strength of *betung* bamboo, stated that *betung* bamboo has a 5% lower limit value for the average strength of parallel compression, parallel tension, and perpendicular tension of *betung* bamboo fiber, respectively at 38.1 N mm^{-2}, 61.8 N mm^{-2}, and 0.60 N mm^{-2}. *Betung* bamboo has relatively high compressive strength parallel to the fibers compared to several other types of bamboo.

Another research that explains the use of *betung* bamboo in construction is carried out by Riski and Nurhidayatullah [70] regarding the use of *betung* bamboo fiber as an additional material for the flexural strength of beams. This research concludes that *betung* bamboo fiber is a natural material that can be used as a concrete mixture. Apart from helping the workability of bamboo *betung* fiber, it also influences the flexural strength of concrete. *Betung* bamboo fiber is a natural material with high tensile strength and good flexibility so that *betung* bamboo fiber can be used as a reinforced concrete mixture. *Betung* bamboo fiber is very suitable for use in concrete mixtures, as evidenced by the flexural strength value, which increases with increasing percentage of the *betung* bamboo fiber mixture [70].

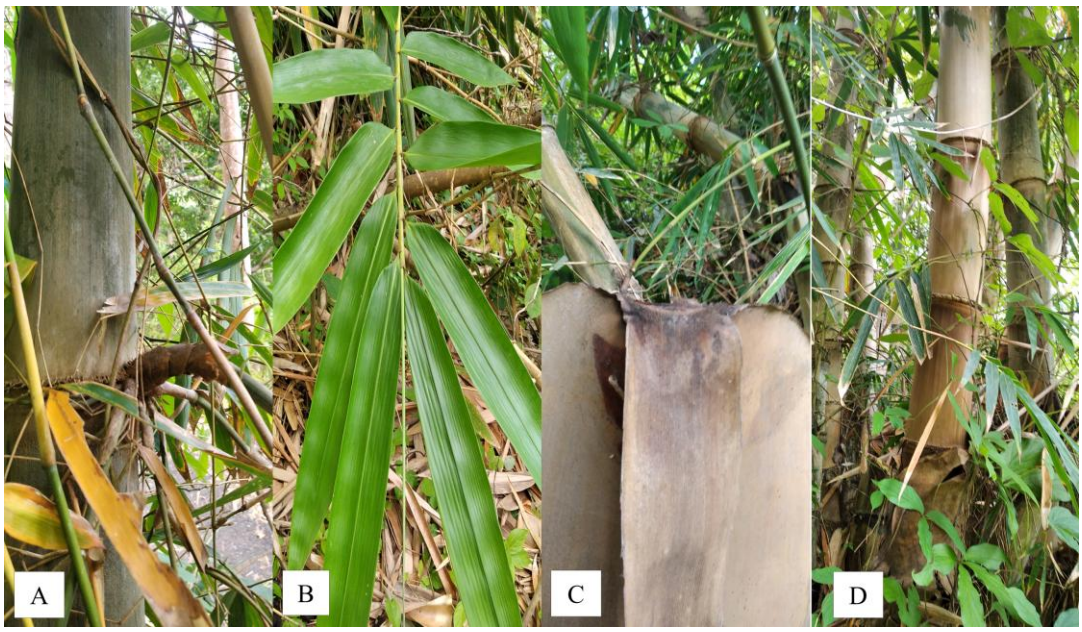


Figure 5. Morphology of *D. asper*: a) reeds; b) leaf; c) fronds; d) stature.

3.5. Habitat and standing stock of bamboo

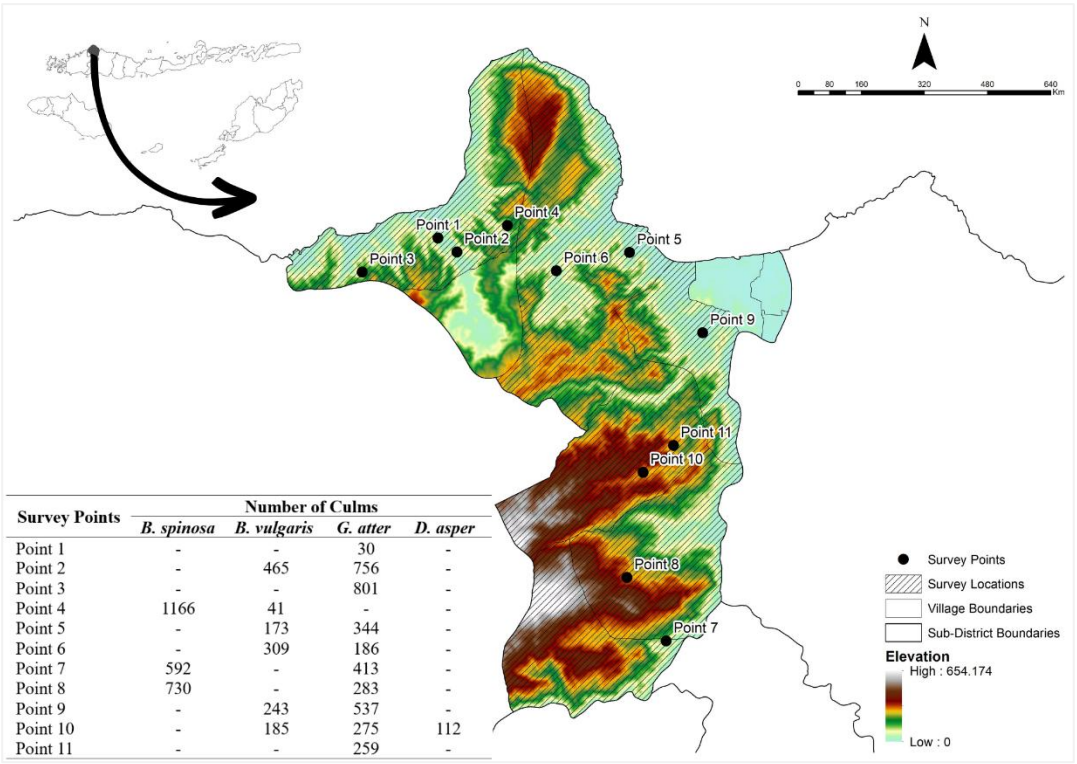
Apart from internal factors such as bamboo genetics, external factors such as environmental conditions also influence the type and distribution of bamboo in the Reok sub-district Area. The elevation of Reok sub-district is from 0–654 m above sea level. If overlaid with survey points, the elevation values distribution is 17–278 m above sea level (Figure 6).

The altitude of an area certainly dramatically influences the temperature and humidity of the air due to differences in air pressure. Temperature variations in the Indonesian archipelago depend on altitude, and the air temperature will be lower as the height above sea level increases [71,72]. The temperature decreases by around 0.6°C for every 100 m of elevation. Based on the research results, the distribution of *D. asper* bamboo does not grow optimally compared to the other three species. The number of wet and dry seasons in the Reok sub-district is the same for six months, with the average temperature at 25.9°C (Figure 7) [72].

Meanwhile, in the Bajawa sub-district, the number of wet seasons is eight months, one month of humid and three dry months, with the average temperature at 24.8°C [72]. This makes growing the *D. asper* type challenging because it is more suited to growing in damp areas. Furthermore, the *B. spinosa* species is often found in the Reok sub-district because this species is more suited to living in dry soil. The other two species can grow in dry or humid areas [14,35,40,41,53–55,64].

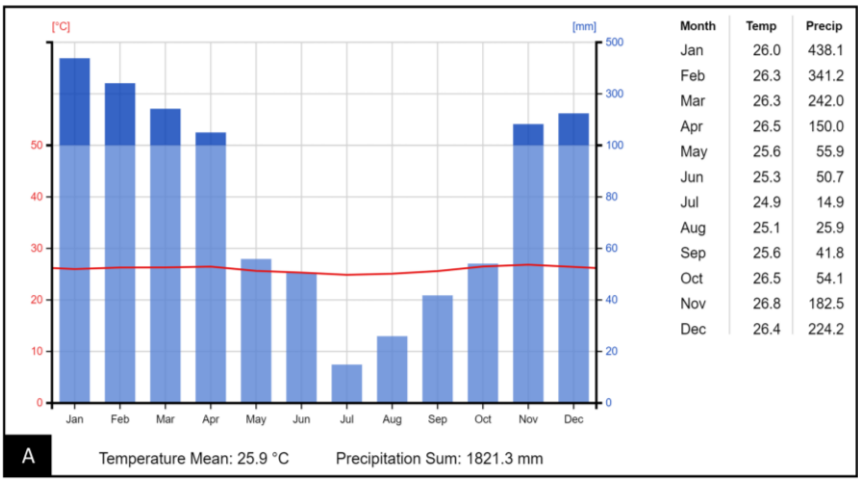
The air temperature at the research location as a bamboo growing habitat ranges from 25–32°C, air humidity ranges between 67–100%, and soil pH ranges from 7–7.5. The growth of bamboo is influenced by its environmental conditions [73,74]. Therefore, it is necessary to pay attention to the factors that require the development of bamboo plants, which include the type of climate and type of soil. An environment suitable for bamboo plants is a temperature of around 8.8–36°C. Bamboo can grow in acidic soil with a pH of 3.5 and is generally close to soil with a pH of 5.0 to 6.5. Bamboo plants will grow well on fertile soil because their nutrition needs are met [2,54].

Based on the bamboo standing stock at 11 survey points, the estimated potential for bamboo clumps of the four species in the Reok sub-district is 57,496 clumps, with a potential of 3,692,890 culms. This figure is higher than the average number of bamboo culms across 12 sub-districts in Ngada Regency, which is 2,359,027 per sub-district. The highest number of culms is found in the Bajawa sub-district, with 10,906,598 culms, while the lowest number is in the Soa sub-district, with 27,698 culms [75].



Survey Points	Number of Culms			
	B. spinosa	*B. vulgaris*	*G. atter*	*D. asper*
Point 1	-	-	30	-
Point 2	-	465	756	-
Point 3	-	-	801	-
Point 4	1166	41	-	-
Point 5	-	173	344	-
Point 6	-	309	186	-
Point 7	592	-	413	-
Point 8	730	-	283	-
Point 9	-	243	537	-
Point 10	-	185	275	112
Point 11	-	-	259	-

Figure 6. Distribution of survey points and number of culms for each bamboo species based on elevation values.



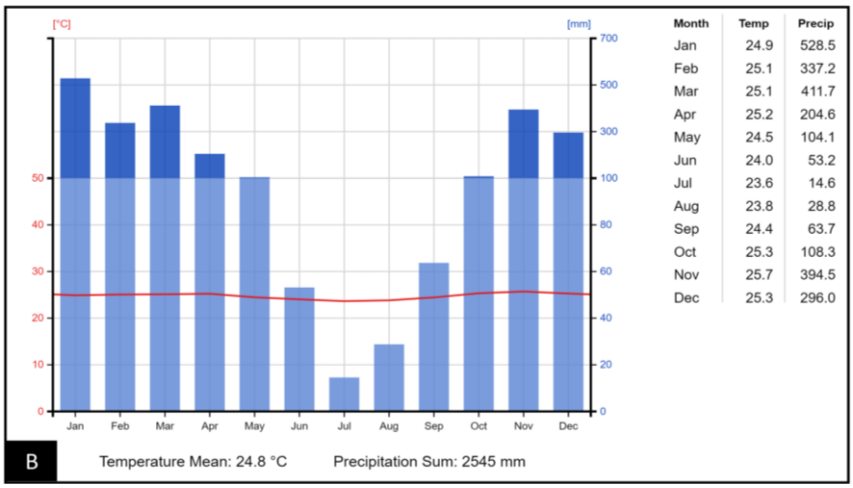


Figure 7. Temperature and precipitation [72]. a) Reok sub-district; b) Bajawa sub-district.

The Ministry of Environment and Forestry, through Regulation Number P.19/Menhut-II/2009 on strategies for developing non-timber forest products, classifies bamboo standing stock as low if it is below 200 clumps per hectare. Based on this classification, the four bamboo species found in the Reok sub-district are considered to have low standing stock. However, despite this classification, bamboo's standing stock can still be developed, as it is one of the key non-timber forest products (NTFPs) in East Nusa Tenggara province, with the potential to improve the local economy. More detailed data on the estimated bamboo standing stock is presented in Table 1

Table 1. Standing stock of bamboo species in the Reok sub-district

Species	Cp	C			Cp ha^{-1}	C ha^{-1}	PCp	%	PC	%
		Young	Medium	Old						
B. spinosa	27	1,576	483	429	4.91	452.36	12,621.27	21.95	1,163,026.91	31.49
B. vulgaris	18	1,138	257	21	3.27	257.45	8,414.18	14.63	661,915.64	17.92
D. asper	2	62	33	17	0.36	20.36	934.91	1.63	52,354.91	1.42
G. atter	76	3,284	533	67	13.82	706.18	35,526.55	61.79	1,815,593.45	49.16
Total	123	6,060	1,306	534	22.36	1,436.36	57,496.91	100.00	3,692,890.91	100.00

Notes: Cp = Clumps; C = Culms; PCp = Potential of clumps; PC = Potential of culms

G. atter is a species that is found in almost all survey locations. This species also has the most significant clumps and culms compared to the other three species. According to Wulandari [76], *Gigantochloa* is the genus with the most significant clumps, consisting of *G. apus* with 68 clumps and *G. atter* with 63 clumps compared to other bamboo species found at the research location. *G. atter* can grow well in various habitat types, including tropical humid and dry areas in the lowlands to the highlands [14,53–55]. Firdausi [77] also reported encountering five species of bamboo at his research location, namely *B. vulgaris*, *B. blumeana*, *G. atter*, *G. apus*, and *D. asper*, with results showing that *G. atter* was the species with the most encounters and had a wide distribution.

4. Conclusions

Four bamboo species were identified in the Reok sub-district: Bambusa spinosa, *Bambusa* vulgaris, Gigantochloa atter, and Dendrocalamus asper. The Gigantochloa atter species was found at nearly all survey points and exhibited the highest number of clumps and culms compared to the other three species. The estimated standing stock potential for bamboo in the Reok sub-district is 57,496 clumps and 3,692,890 culms, with the highest potential found in Gigantochloa atter, which accounts for 35,526 clumps and 1,815,593 culms. Environmental conditions influence the habitat and distribution of the four species of bamboo found. In the Reok sub-district with the same number of wet as dry months in 17-278 meters above sea level, ***G. atter*** can grow and spread well because it can adapt to humid and dry areas and from lowlands to highlands. ***D. asper*** has challenges growing and spreading because it has a suitable habitat in wet areas, while the other two species can still grow and spread because they can still grow in dry or damp areas.

Author Contributions

OCA: Conceptualization, Methodology, Acquisition of data, Analysis, Interpretation, Drafting; **FP**: Conceptualization, Supervision, Software, Interpretation, Writing - Review & Editing; **MMEP**: Conceptualization, Supervision, and **PSS**: Conceptualization, Supervision.

Conflicts of interest

There are no conflicts to declare.

Acknowledgements

The authors are grateful to the Executive Director and the staff of the Environmental Bamboo Foundation for the permission and information support provided, as well as to Prof. Elizabeth Anita Widjaja and the Environmental Bamboo Foundation GIS team, who supported information and data as well as guidance to the author.

References

1 . Tripathi, H.K.; Somasundaram, P.; Kumar, R.; Lakchaura, P. Assessment of Bamboo Resources of India. *Bamboos in India*. *ENVIS Centre on Forestry, Dehradun, India* **2015**, 15–26.

2. Ahmad, Z.; Upadhyay, A.; Ding, Y.; Emamverdian, A.; Shahzad, A. Bamboo: Origin, habitat, distributions and global prospective. In *Biotechnological Advances in Bamboo: The "Green Gold" on the Earth*; Ahmad, Z., Ding, Y., Shazhad, A., Eds.; Springer: Singapore, 2021; pp. 1–31, ISBN 978-981-16-1310-4.

3. Akinlabi, E.T.; Anane-Fenin, K.; Akwada, D.R. Bamboo taxonomy and distribution across the globe. In *Bamboo: The Multipurpose Plant*; Akinlabi, E.T., Anane-Fenin, K., Akwada, D.R., Eds.; Springer: Cham, Switzerland, 2017; pp. 1–37, ISBN 978-3-319-56808-9.

4. Akinlabi, E.T.; Anane-Fenin, K.; Akwada, D.R. *Bamboo: The Multipurpose Plant*, 1st ed.; Springer: Cham, Switzerland, 2017; ISBN 978-3-319-56808-9.

5. Canavan, S.; Richardson, D.M.; Visser, V.; Le Roux, J.J.; Vorontsova, M.S.; Wilson, J.R.U. The Global Distribution of Bamboos: Assessing Correlates of Introduction and Invasion. *AoB Plants* **2017**, *9*, 1–18, doi:10.1093/aobpla/plw078.

6. Damayanto, I.; Mulyani, S.; Wahidah, B.F. Inventarisasi, Kunci Identifikasi, Pemetaan, dan Rekomendasi Pengelolaan Jenis-Jenis Bambu di Ecology Park, Pusat Konservasi Tumbuhan, Kebun Raya–LIPI, Kabupaten Bogor, Jawa Barat. *Jurnal Arsitektur Lansekap* **2019**, *5*, 114–124, doi:10.24843/JAL.2019.v05.i01.p13.

7. Sharma, R.; Wahono, J.; Baral, H. Bamboo as an Alternative Bioenergy Crop and Powerful Ally for Land Restoration in Indonesia. *Sustainability* **2018**, *10*, 1–10, doi:10.3390/su10124367.

8. Xu, X.; Xu, P.; Zhu, J.; Li, H.; Xiong, Z. Bamboo Construction Materials: Carbon Storage and Potential to Reduce Associated CO2 Emissions. *Science of the Total Environment* **2022**, *814*, 152697, 1–13, doi:10.1016/j.scitotenv.2021.152697.

9. Wu, W.; Liu, Q.; Zhu, Z.; Shen, Y. Managing Bamboo for Carbon Sequestration, Bamboo Stem and Bamboo Shoots. *Small-scale Forestry* **2015**, *14*, 233–243, doi:10.1007/s11842-014-9284-4.

10. Vogtländer, J.G.; van der Velden, N.M.; van der Lugt, P. Carbon Sequestration in LCA, a Proposal for a New Approach Based on the Global Carbon Cycle; Cases on Wood and on Bamboo. *Int J Life Cycle Assess* **2014**, *19*, 13–23, doi:10.1007/s11367-013-0629-6.

11. Gu, L.; Zhou, Y.; Mei, T.; Zhou, G.; Xu, L. Carbon Footprint Analysis of Bamboo Scrimber Flooring—Implications for Carbon Sequestration of Bamboo Forests and Its Products. *Forests* **2019**, *10*, 1–14, doi:10.3390/f10010051.

12. Kaushal, R.; Kumar, A.; Patra, S.; Islam, S.; Tomar, J.M.S.; Singh, D.V.; Mandal, D.; Mehta, H.; Chaturvedi, O.P.; Durai, J. In Situ Soil Moisture Conservation in Bamboo for The Rehabilitation of Degraded Lands in Himalayan Foothills. *Ecol Eng* **2021**, *173*, 106437, 1–8, doi:10.1016/j.ecoleng.2021.106437.

13. Singh, A.K.; Kala, S.; Dubey, S.K.; Rao, B.K.; Gaur, M.L.; Mohapatra, K.P.; Prasad, B. Evaluation of Bamboo Based Conservation Measures for Rehabilitation of Degraded Yamuna Ravines. *Indian Journal of Soil Conservation* **2014**, *42*, 80–84, doi:10.5555/20143235786.

14. Widjaja, E.A. *The Spectacular Indonesian Bamboos*; PT. Gudang Garam: Kediri, Indonesia, 2018; ISBN 6025232601.

15. Damayanto, I.; Rustiami, H.; Miftahudin, M.; Chikmawati, T. Endemic Bamboo (Poaceae, Bambusoideae) of the Lesser Sunda Islands. *Jurnal Biodjati* **2023**, *8*, 13–28, doi:10.15575/biodjati.v8i1.25015.

16. Arsad, E. Teknologi Pengolahan dan Manfaat Bambu. *Jurnal Riset Industri Hasil Hutan* **2015**, *7*, 45–52, doi:10.24111/jrihh.v7i1.856.

17. Chaowana, P.; Barbu, M.C. Bamboo: Potential material for biocomposites. In *Lignocellulosic Fibre and Biomass-based Composite Materials*; Jawaid, M., Tahir, P.M., Saba, N., Eds.; Woodhead Publishing: Cambridge, England, 2017; pp. 259–289, ISBN 978-0-08-100959-8.

18. Akinlabi, E.T.; Anane-Fenin, K.; Akwada, D.R. Applications of Bamboo. In *Bamboo: The Multipurpose Plant*; Akinlabi, E.T., Anane-Fenin, K., Akwada, D.R., Eds.; Springer: Cham, Switzerland, 2017; pp. 179–219, ISBN 978-3-319-56808-9.
19. Zhaohua, Z.; Wei, J. *Sustainable Bamboo Development*; CABI: Wallingford, England, 2018; ISBN 1786394014.
20. Chang, F.-C.; Chen, K.-S.; Yang, P.-Y.; Ko, C.-H. Environmental Benefit of Utilizing Bamboo Material Based on Life Cycle Assessment. *J Clean Prod* **2018**, *204*, 60–69, doi:10.1016/j.jclepro.2018.08.248.
21. Syeda, A.; Shrujal, B.; Kumar, J. A Case Study on Bamboo as Green Building Material. *Int J Eng Adv Technol* **2014**, *4*, 78–82.
22. Xu, P.; Zhu, J.; Li, H.; Wei, Y.; Xiong, Z.; Xu, X. Are Bamboo Construction Materials Environmentally Friendly? A Life Cycle Environmental Impact Analysis. *Environ Impact Assess Rev* **2022**, *96*, 106853, 1–16, doi:10.1016/j.eiar.2022.106853.
23. Sushardi, S.; Nugroho, B.A. Potensi dan Teknologi Pemanfaatan Bambu di Kabupaten Manggarai. *In Proceedings of the Prosiding Seminar INSTIPER Tahun 2018: Perkembangan Penelitian INSTIPER dalam Menanggapi Era Teknologi Maju Bidang Perkebunan I*, *Yogyakarta*, *Indonesia*, 19 September 2018; Krisdiasrto, A.W., Wijayanti, Y., Ajianto, Y., Eds.; Institut Pertanian STIPER: Yogyakarta, Indonesia, 2018.
24. Komarudin, K.; Ramlan, L.; Laras, M.F.; Wiresna, A.G.; Saepudin, A. Musik Bambu Wiragawi: Representasi Komodifikasi Bambu dari Hasil Strukturasi di Tiga Locus. *Resital: Jurnal Seni Pertunjukan* **2021**, *22*, 158–179, doi:10.24821/resital.v22i3.6188.
25. Mali, R.Y. Pembelajaran Ansambel Musik Suling Bambu pada Kegiatan Ekstrakurikuler di SMPN 1 Lamaknen, Belu, Nusa Tenggara Timur. Undergraduate Thesis, Institut Seni Indonesia Yogyakarta, Yogyakarta, 2021.
26. Sada, M.; Jumari, J. Etnobotani Tumbuhan Upacara Adat Etnis Ngadha di Kecamatan Jerebu'u Kabupaten Ngada, Provinsi Nusa Tenggara Timur. *Jurnal Saintek Lahan Kering* **2018**, *1*, 19–21, doi:10.32938/slk.v1i2.503.
27. Ekawati, D.; Karlinasari, L.; Soekmadi, R. Drivers, Barriers, and Strategies in the Community-Based Supply of Bamboo for Industrial-Scale Bamboo Utilization in Ngada Regency, East Nusa Tenggara, Indonesia. *Sustainability* **2022**, *14*, 1–22, doi:10.3390/su14105970.
28. Environmental Bamboo Foundation. One Map Bamboo. Available online: https://onemap.bambuvillage.org/ (accessed on 1 February 2024).
29. Almarief, A.Z. Analisis Potensi Tegakan Hasil Inventarisasi Hutan KPHP Nunukan Unit IV di Kabupaten Nunukan Provinsi Kalimantan Utara. *Jurnal Agrifor* **2018**, *17*, 20–28, doi:10.31293/af.v17i1.3068.
30. Azhar, I.; Nasution, Z.; Sidabukke, S.; Sianipar, M.; Srena, M.F. The Distribution of Non-Timber Forest Products in the Protected Areas (Case Study at PT Toba Pulp Lestari Concession). *IOP Conference Series: Earth and Environmental Science* **2019**, *374*, 1–10, doi:10.1088/1755-1315/374/1/012048.
31. Nugroho, N.P.; Octavia, D. Inventarisasi Jenis Tanaman Penghasil Hasil Hutan Bukan Kayu di Hutan Nagari Paru, Sijunjung, Sumatera Barat. *Jurnal Penelitian Hutan dan Konservasi Alam* **2020**, *17*, 21–33, doi:10.20886/jphka.2020.17.1.21-33.
32. Vorontsova, M.S.; Clark, L.G.; Dransfield, J.; Govaerts, R.; Baker, W.J. *World Checklist of Bamboos and Rattans*; International Network of Bamboo and Rattan: Beijing, China, 2016; ISBN 978-92-95098-99-2.
33. Damayanto, I.P.G.P.; Fastanti, F.S.; Dalimunthe, S.H. Pemanfaatan Portal Basis Data Daring Dalam Validasi Nama Ilmiah Jenis Dan Suku Tumbuhan. *Berkala Ilmu Perpustakaan dan Informasi* **2020**, *16*, 170–183, doi:10.22146/bip.v16i2.770.
34. Jannah, M.; Baharuddin, B.; Taskirawati, I. Potensi dan Pemanfaatan Tanaman Bambu pada Lahan Masyarakat di Desa Kading Kabupaten Barru. *Perennial* **2019**, *15*, 87–92, doi:10.24259/perennial.v15i2.7455.
35. Fathiya, N.; Qariza, M.H.; Nazhifah, S.A.; Diah, H. Karakteristik Morfologi dan Pemanfaatan Bambu Duri (*Bambusa blumea*) di Wilayah Pesisir Desa Jambo Timu, Kecamatan Blang Mangat, Kota Lhokseumawe. *Jurnal Jeumpa* **2022**, *9*, 767–776, doi:10.33059/jj.v9i2.6314.
36. Purwita, C.A.; Sugesty, S. Pembuatan dan Karakterisasi Dissolving Pulp Serat Panjang dari Bambu Duri (*Bambusa blumeana*). *Jurnal Selulosa* **2018**, *8*, 21–32, doi:10.25269/jsel.v1i01.232.
37. Wicaksono, D.; Rizky, F.A.; Khairunnisa, H.; Pratiwi, V.M.R.; Hermawan, W.G. Identifikasi Persebaran Bambu pada Daerah Aliran Sungai Pepe Desa Sawahan. *Nusantara Hasana Journal* **2023**, *2*, 349–373.
38. Pradipta, N.N.; Prakosa, G.G.; Masykurrahmat, F.H.; Basuseno, G.D. Pembuatan Karbon Aktif dan Biopelet dari Bambu Lokal Malang. *Indonesian Journal of Forestry Research* **2023**, *41*, 35–44, doi:10.55981/jphh.2023.680.

39. Silalahi, M. Pemanfaatan Bambu oleh Masyarakat Lokal di Indonesia dan Usaha Konservasinya. *Jurnal Pro-Life* **2015**, *2*, 56–62.
40. Darwis, A.; Iswanto, A.H. Morphological Characteristics of *Bambusa vulgaris* and the Distribution and Shape of Vascular Bundles Therein. *Journal of the Korean Wood Science and Technology* **2018**, *46*, 315–322, doi:10.5658/WOOD.2018.46.4.315.
41. Banik, R.L. Morphology and growth. In *Bamboo: The Plant and its Uses*, 1st ed.; Liese, W., Köhl, M., Eds.; Springer: Cham, Switzerland, 2015; pp. 43–89, ISBN 978-3-319-14133-6.
42. Fitmawati, Pranata, S.; Juliantari, E.; Yahya, V.J.; Aldafi, A.; Owen, Y.R.; Kurnia, H.B. Bamboo Spreading Impacts as a Watershed Conservation Strategy in Upstream Area of Three Big Rivers of Sumatra. *Journal of Bamboo & Rattan* **2022**, *21*, 125–137.
43. Akpa, E.A.; Bello, O.S.; Olim, D.M. Evaluation of Fertility Status of Soils under Bamboo (*Bambusa vulgaris*) in Akamkpa and Odukpani Local Government Areas of Cross River State, Nigeria. *Journal of Experimental Agriculture International* **2019**, *31*, 1–9, doi:10.9734/jeai/2019/v31i130063.
44. Putro, D.S.; Jumari, J.; Murningsih, M. Keanekaragaman Jenis dan Pemanfaatan Bambu di Desa Lopait Kabupaten Semarang Jawa Tengah. *Jurnal Akademika Biologi* **2014**, *3*, 71–79.
45. Rini, D.S.; Wulandari, F.T.; Aji, I.M.L. Studi Jenis dan Sebaran Bambu di Kawasan Hutan dengan Tujuan Khusus (KHDTK) Senaru. *Jurnal Sangkareang Mataram* **2017**, *3*, 37–41.
46. Ritonga, M.A.; Syamsuardi, S.; Nurainas, N.; Damayanto, I.P.G.P. Bamboo Diversity in Weh Island, Aceh, Indonesia. *Biodiversitas* **2023**, *24*, 2563–2567, doi:10.13057/biodiv/d240508.
47. Anghore, D.; Kulkarni, G.T. Hepatoprotective Effect of Various Extracts of *Bambusa vulgaris* Striata on Carbon Tetrachloride-Induced Liver Injuries. *International Journal of Pharmaceutical Research and Allied Sciences* **2016**, *5*, 16–22.
48. Fitri, A.; Asra, R.; Rivai, H. Overview of the Traditional, Phytochemical, and Pharmacological Uses of Gold Bamboo (*Bambusa vulgaris*). *World J Pharm Pharm Sci* **2020**, *9*, 21, doi:10.20959/wjpps20208-16877.
49. Panjaitan, R.G.P.; Yuliana, Y.G.S. Ethno-Medicinal Plants Used for Medication of Jaundice by The Chinese, Dayak, and Malays Ethnic in West Kalimantan, Indonesia. *Pharmacognosy Journal* **2021**, *13*, doi:10.5530/pj.2021.13.118.
50. Ritonga, M.A.; Syamsuardi, N.; Putu, I.; Damayanto, G.P. Ethnobotany of Bamboo on Weh Island, Aceh, Indonesia. *Ethnobotany Research and Applications* **2023**, *26*, 1–19, doi:10.32859/era.26.75.1-19.
51. Handagala, J.K.; Kumarasinghe, N.P.; Goonasekara, C.L.; Kuruppu, A.I. A Preliminary Study Conducted on a Traditional Formulation Used for the Treatment of Dengue. Presented at the The 15th International Research Conference (IRC) 2022 of General Sir John Kotelawala Defence University (KDU-IRC), Colombo, Sri Lanka, September 2022.
52. Rohimah, R.S.; Walujodjati, E. Eksperimen Pelat Beton Bertulang Bambu Ampel. *Jurnal Konstruksi* **2022**, *20*, 281–288, doi:10.33364/konstruksi/v.20-2.1211.
53. Syauqi, M.F.; Chikmawati, T.; Ariyanti, N.S. Diversity, Ecology and Habitat Suitability of Gigantochloa in Central Sumatra. *Agriculture and Natural Resources* **2023**, *57*, 343–352.
54. Clark, L.G.; Londoño, X.; Ruiz-Sanchez, E. Bamboo Taxonomy and Habitat. In *Bamboo: The Plant and its Uses*, 1st ed.; Liese, W., Köhl, M., Eds.; Springer: Cham, Switzerland, 2015; pp. 1–30; ISBN 978-3-319-14133-6.
55. Damayanto, I.P.G.P.; Rustiami, H.; Chikmawati, T. A Synopsis of Bambusoideae (Poaceae) in Lombok, Indonesia. *Biodiversitas* **2020**, *21*, 10, doi:10.13057/biodiv/d211004.
56. Febriyanti, F.; Kandowangko, N.Y.; Ahmad, J. Identification Morphology of Bamboo, and Traditional Use in Gorontalo. *Jurnal Biodjati* **2023**, *8*, 347–364, doi:10.15575/biodjati.v8i2.29714.
57. Jaidan, J.; Wardenaar, E.; Tavita, G.E. Keanekaragaman Jenis Bambu Di Desa Sarang Burung Kolam Kecamatan Jawai Kabupaten Sambas. *Jurnal Hutan Lestari* **2020**, *8*, doi:10.26418/jhl.v8i2.39789.
58. Marsoem, S.N.; Setiaji, F.; Kim, N.-H.; Sulistyo, J.; Irawati, D.; Nugroho, W.D.; Pertiwi, Y.A.B. Fiber Morphology and Physical Characteristics of *Gigantochloa atter* at Three Different Ages and Heights of Culms for Better Utilization. *Journal of the Korean Wood Science and Technology* **2015**, *43*, 145–155, doi:10.5658/WOOD.2015.43.2.145.
59. Mentari, M.; Mulyaningsih, T.; Aryanti, E. Identifikasi Bambu Di Sub Daerah Aliran Sungai Kedome Lombok Timur Dan Alternatif Manfaat Untuk Konservasi Sempadan Sungai. *Jurnal Penelitian Pengelolaan Daerah Aliran Sungai (Journal of Watershed Management Research)* **2018**, *2*, 111–122, doi:10.20886/jppdas.2018.2.2.111-122.

60. Febrianti, Y.; Krisnawati, Y.; Riastuti, R.D. Pengetahuan Masyarakat terhadap Pemanfaatan Bambu sebagai Tumbuhan Obat. *BIOEDUSAINS: Jurnal Pendidikan Biologi dan Sains* **2022**, *5*, 221–234, doi:10.31539/bioedusains.v5i1.3616.

61. Salim, R.; Cahyana, B.T.; Prabawa, I.D.G.P.; Hamdi, S. Potensi Bambu untuk Pemanfaatan sebagai Bahan Bakar Arang dengan Metode Pengarangan Retort Tungku Drum. *Indonesian Journal of Industrial Research* **2019**, *11*, 230–241, doi:10.26578/jrti.v13i2.5284.

62. Rochim, A.; Latifah, K.; Supriyadi, B. Characterization of Compression and Tensile Properties of Bamboo Jawa (*Gigantochloa atter*) and Bamboo Apus (*Gigantochloa apus*) for Application as Soil Reinforcement. *IOP Conference Series: Earth and Environmental Science* **2020**, *498*, 1–8, doi:10.1088/1755-1315/498/1/012040.

63. Eskak, E. Bambu Ater (*Gigantochloa atter*) sebagai Bahan Substitusi Kayu pada Ukiran Asmat. *Dinamika Kerajinan dan Batik* **2016**, *33*, 55–66, doi:10.22322/dkb.v33i1.1039.

64. Zulkarnaen, R.N.; Andila, P.S.R.I. *Dendrocalamus* spp.: Giant Bamboo of Bogor Botanic Garden Collections. In Proceedings of the Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia, Yogyakarta, Indonesia, 31 March 2015; pp. 534–538.

65. Jihad, A.N.; Budiadi, B.; Widiyatno, W. Growth Response of *Dendrocalamus asper* on Elevational Variation and Intra-Clump Spacing Management. *Biodiversitas* **2021**, *22*, 3801–3810, doi:10.13057/biodiv/d220925.

66. Bakri, I.G. Eksplorasi Bambu Sebagai Material Berkelanjutan Pada Bangunan. *Journal of Green Complex Engineering* **2024**, *1*, 69–78, doi:10.59810/greenplexresearch.v1i2.92.

67. Kaminski, S.; Lawrence, A.; Trujillo, D. Structural Use of Bamboo - Part 1: Introduction to Bamboo. *The Structural Engineer* **2016**, *94*, 40–43, doi:10.56330/PNSC8891.

68. Wulandari, F.T. Karateristik dan Sifat Fisik Bambu Petung (*Dendrocalamus asper.* Backer) di Kawasan Hutan Kemasyarakatan (HKM) Desa Aik Bual, Provinsi Nusa Tenggara Barat. *Buletin Loupe* **2019**, *15*, 44–49, doi:10.51967/buletinloupe.v15i01.27.

69. Nugroho, N.; Bahtiar, E.T.; Lelono, A.B. Kekuatan Bambu Betung (*Dendrocalamus asper* Backer Ex K. Heyne) Menahan Gaya Normal Tekanan dan Tarikan. *Jurnal Penelitian Hasil Hutan* **2022**, *40*, 37–48, doi:10.20886/jphh.2022.40.1.37-48.

70. Riski, D.K.; Nurhidayatullah, E.F. Pemanfaatan Serat Bambu Betung sebagai Bahan Tambahan Terhadap Kuat Lentur Balok. Undergraduate Thesis, Universitas Teknologi Yogyakarta, Yogyakarta, Indonesia, 2019.

71. Fick, S.E.; Hijmans, R.J. WorldClim 2: New 1-km Spatial Resolution Climate Surfaces for Global Land Areas. *International Journal of Climatology* **2017**, *37*, 4302–4315, doi:10.1002/joc.5086.

72. Zepner, L.; Karrasch, P.; Wiemann, F.; Bernard, L. ClimateCharts. Net–an Interactive Climate Analysis Web Platform. *Int J Digit Earth* **2021**, *14*, 338–356, doi:10.1080/17538947.2020.1829112.

73. Fitmawati; Ikhsan, M.; Kurniawan, H.; Yundika, Z.; Wahyuda, B.; Pranata, S.; Kholifah, S.N.; Sofiyanti, N.; Wahibah, N.N.; Adnan, A. Species Diversity and Environmental Effects on Bamboo (Bambusoideae) in Estuaries along the East Coast of Sumatra. *SABRAO J Breed Genet* **2021**, *53*, 403–416.

74. Aribal, L.G.; Parlucha, J.A.; Gelaga, J.N.; Aguinsatan, R.G. Influence of Abiotic Factors on Growth and Development of Giant Bamboo (*Dendrocalamus asper*) in Bukidnon, Philippines. *Journal of Tropical Forest Science* **2022**, *34*, 63–73, doi:10.26525/jtfs2022.34.1.63.

75. Noywuli, N. Potensi Sumberdaya dan Teknik Budidaya Bambu Ngada untuk Fungsi DAS Aesesa Flores yang Berkelanjutan. In Proceedings of the Prosiding Seminar Nasional Pertanian, 2020; pp. 254–270.

76. Wulandari, F.T. Deskripsi Sebaran Jenis dan Sifat Fisika Bambu di Kawasan Hutan Dengan Tujuan Khusus (KHDTK) Senaru. *Jurnal Hutan Tropis* **2021**, *9*, 1–12, doi:10.20527/jht.v9i1.10463.

77. Firdausi, M.R. Keanekaragaman dan Distribusi Spasial Bambu Menggunakan Sistem Informasi Geografis di Ekowisata Boonpring Kabupaten Malang. Undergraduate Thesis, Universitas Islam Negeri Maulana Malik Ibrahim, Malang, Indonesia, 2019.

