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Bamboo Distribution Map for Planning the Development of Tourism Potential in Boon Pring Andeman Area

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ABSTRACT

Sanankerto is one of pilot projects for tourism villages in Indonesia due to its natural tourism potential with a 24-ha bamboo forest located in Boon Pring Andeman area. However, the distribution of existing bamboo has never been identified or mapped. Thus, the mana gement is facing difficulty in planning and developing tourism potential as well as spatial management in the area. Therefore, the objectives of this study were to identify and analyze the structure of bamboo vegetation in the Boon Pring Tourism village an d to perform vegetation mapping. The type of research was descriptive exploratory with a cluster sampling technique (i.e., a two-stage cluster) covering an area of ± 10 ha. Bamboo vegetation analysis was performed by calculating diversity index (H'), evenness index (E), and Species Richness index (R). Data were collected through observation and interviews with local people and the manager to determine zonation division. Mapping of bamboo vegetation based on zoning was processed into thematic maps using ArcG is 10.3. Micro climatic factors were measured with three replications for each sub -cluster. Data were analyzed descriptively and quantitatively. Nine species of bamboo identified. Diversity, evenness, and species richness indices differed at each location. Activities of local communities, tourists, and manager determined the presence, number, and distribution of bamboo species. These bamboo distribution maps in three zoning (utilization, buffer, and core) can be used by manager for planning and developing natural tourism potential.

Keywords: Bamboo, Conservation, Distribution, Management, Mapping

Introduction

The Boon Pring area is located in Sanankerto Village, one of 30 tourist villages in East Java. It is used as a pilot project for tourism villages by the Ministry of Village, Development of Disadvantaged Regions and Transmigration, Republic of Indonesia (Subekti & Damayanti, 2019). The development of a tourist village in Malang Regency is managed through a Village Owned Enterprise or known as BUMDes which is formed based on the Sanankerto Village Regulation No. 5 of 2009. The development of Boon Pring tourism village in Sanankerto Turen Village, Malang Regency is based on the village's potential with bamboo trees covering an area of ± 24 ha. In Javanese, Bamboo is known as Pring, while the term "Boon" is taken from th e Sanskrit language which means gift. The term Boon Pring is literally interpreted as a gift from a bamboo tree. This tourist village is better known as "Boon Pring Andeman" which has been managed since 2017. Overall, this tourism village offers natural tourism based on local potential as a tourist attraction. Thus, it is called eco-tourism (Diamantis, 2010).

The Boon Pring Andeman area has a water source. During the Dutch colonial period, this area was planted with coffee trees. After Indonesia's independence, local people have planted various bamboos to protect their water sources. Roots of bamboos are known to be able to bind soil and water while increasing the discharge of groundwater. The absorption of rain water by bamboo plants is 90% (Wong, 2004). In 1978, the community worked together to build a lake two meters deep known by its local name as an *Embung*. This lake holds water from sources around Boon Pring. Nine springs in this area

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are never dry because of bamboo vegetation. Therefore, Boon Pring was originally a water conservation area.

The community initially used the lake for irrigation. However, after the development of ecotourism services, this area has increased its function to become a tourism area with a focus on mass tourism, such as adding swimming pools, homestays, and playground areas. In 2017 and 2018, visitors to this eco-tourism amounted to 76,000 and 83,000, respectively. This ecotourism has a significant impact on local people's income (Rustantono *et al*., 2020). The village of Sanankerto was once isolated and poor. It was often the target of the village's disadvantaged program. However, it has now grown with improved creativity in utilizing its resources. Local people are using bamboos for making wicker (or *gedek* in Indonesian) and house fences. Young bamboo shoots are used as food. In addition, bamboo glasses, spoons, skewers, and chopsticks are made with limited production.

The Boon Pring Andeman area has a high natural potential. However, it can face threats if it is not manag ed properly. Mass tourism has a tendency to raise new problems. In the environmental sector, such problems include reduced natural resources, land degradation, decreased animal populations, and increased waste (Rustantono *et al*., 2020). The distribution of bamboo in the Boon Pring area has never been studied, including its mapping. This has resulted in less systematic management in this area with continuous improvement of facilities for tourism purposes. For this reason, the objective of this study was to identify and analyze the structure and mapping of bamboo vegetation in this area. This information can be used in the planning, management, and development of the Boon Pring Area while paying attention to the potential of the Area in the form of bamboo vegetation. We measured microclimate factors as initial information for the cultivation of bamboo species such as local bamboo, *Gigantochloa atter*, which has been reported to be difficult to be cultivated.

Materials and Methods

This research was conducted in 2018 - 2019 in the Boon Pring Andeman Area, Sanankerto Village, Turen District, Malang Regency, East Java, Indonesia. The type of research was descriptive exploratory. Plant species identification was carried out at the Ecology Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, State University of Malang, Indonesia.

Bamboo vegetation sampling was carried out by purposive sampling covering an area of ± 10 ha. The determination of the sampling area was based on results of interviews with the manager and the local community regarding the distribution of bamboo clumps, local name of the bamboo, and intensities of activities of the manager and the community in the Boon Pring area. Based on interview results, three zoning and eight sub-clusters were determined and used for sampling vegetation.

The method used was a two-stage cluster sampling modified from Henry *et al*. (2015). First, a zoning-based cluster (i.e., a core zone, a buffer zone, and a utilization zone) was determined. Second, from each zoning or cluster, the sampling point (sub-cluster) was determined. Sub-clusters 1 and 2 were located in the western and eastern parts of the utilization zone, respectively. Sub-clusters 3, 4, and 5 were located in the northern, central, and southern parts of the buffer zone, respectively. Sub-clusters 6, 7, and 8 were located in the northern, central, and southern parts of the core zone, respectively (Fig. 1).

Species identification and structures of bamboo vegetation and mapping of the distribution of bamboo vegetation were carried out using the cruising technique (Michael, 1984). In the exploration area, a cruising line was made in the form of a line in the sub-cluster (Fig. 2). Each clump of bamboo found was marked on the GPS (Garmin Montana 650). Its morphology was recorded for identification purposes and the number was counted. Furthermore, data in the GPS were matched with Google Earth Pro app-

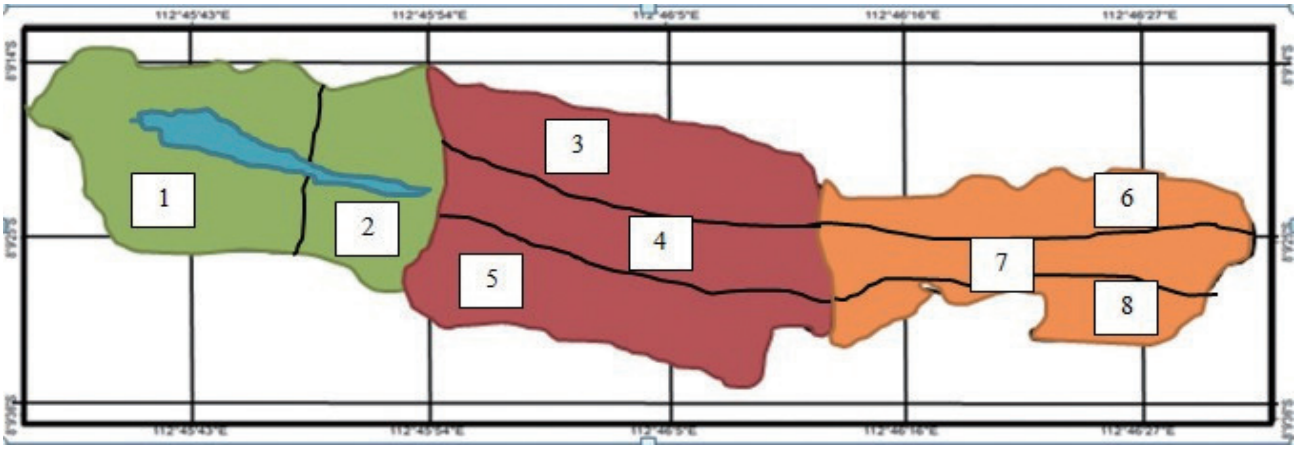


Fig. 1. Illustration of zoning map and cluster division in the Boon Pring Andeman area.

lication to determine the total area of bamboos. These data were processed into maps using the ArcGis 10.3 application. For each sub-cluster, microclimate factors including soil pH, soil moisture (%) (soil tester Takemura DM-5, Japan), soil temperature (°C, digital soil thermometer, USA), air temperature (°C), relative humidity (%, Elcometer 116C Sling Hygrometer, England), and light intensity using a lux meter (LX-1330B, USA) were measured (n = 3).

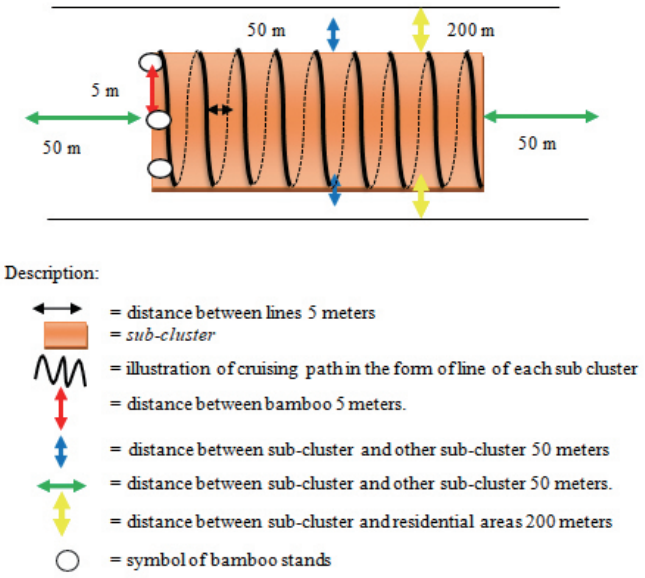


Fig. 2. Illustration of cruising line for each sub cluster.

Description and classification were then made for each bamboo. Data obtained were analyzed by Shannon Weiner's diversity index (H '), Pileou's similarity index (E), and Margalef's species richness index (R) according to Barbour *et al*. (1999). The identification of bamboo species based on morphological characterization was based on a book "Identification of Bamboo Types in Java" (Widjaja, 2001) and a journal "Bamboo, the Amazing Grass A Guide to The Diversity and Study of Bamboo in Southeast Asia" (Wong, 2 004). Spatial data were analyzed using ArcGis 10.3 and Google Earth. A bamboo vegetation distribution map was then made. Data for calculating the abiotic factor were analyzed using the analysis of variance followed by least significant difference (LSD) test at a significance level (a) of 5%.

Results

Species, classifications, and descriptions of bamboos in the Boon Pring area

Bamboos found in the Boon Pring Andeman area consisted of nine species (i.e., *Dendrocalamus asper, Bambusa variegata, Bambusa vulgaris* var. *Striata* Gamble, *Phyllostachys aurea, Gigantochloa atter, Gigantochloa atroviolacea, Gigantochloa apus, Bambusa blumeana, and Bambusa vulgaris*). Each species has special morphology characteristics (Table 1).

Bamboo species diversity in each zone and sub-cluster

Diversity, evenness, and species richness index were different in each zone and sub-cluster. The highest diversity index value was found in the utilization zone of sub-cluster one, which was included in the medium category (1 ≥ H '≤ 3). The highest index of evenness and species richness were also found in the same location. Meanwhile, sub-clustertwo, which was in the same zone as sub-cluster one, had the lowest values for these three indices. Overall, the diversity indices in the utilization zone and the core zone were in the medium category, while those in the core zone were classified as low. The similarity index was high (E ≥ 0.6) except for sub-cluster two. Species Richness indices for all sub-clusters were low (R ≤ 3.5) (Table 2).

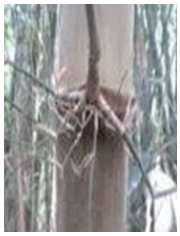
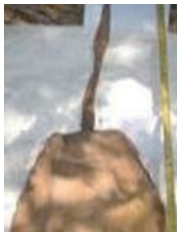
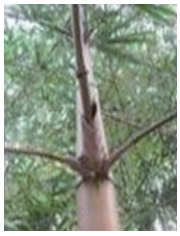
A biotic factor for each sub-cluster

There was a difference in soil pH between the core zone and the buffer zone. Soil pH in the core zone was lower than that in the buffer zone, but not different from the soil pH in the utilization zone. However, all sub clusters in the Boon Pring Andeman area had soil pH in the range of 6.2 to 6.5 (sub-acid category) (Gentili *et al*., 2018). Soil temperature and light intensity did not differ between sub-clusters, ranging from 29.35°C to 29.43°C and from 124 Lux to 133 Lux, respectively. Similar to soil pH, humidity and air temperature in sub-clusters of the core zone were different from those in sub-clusters of other zones. The humidity at this location was higher while the air temperature was lower. The temperature ranged from 28.20°C to 28.70°C and the humidity ranged from 87% to 95% (Table 3).

Bamboo vegetation distribution map

In this study, we divided the Boon Pring Andeman area into three zones ba sed on bamboo species found (Table 4) and activities of the community and manager in the Boon Pring area. These three zones were utilization zone, buffer zone, and core zone (Fig. 3). In cluster one (utilization zone) which consisted of sub-clusters 1 and 2, the following seven bamboo species were found: *Dendrocalamus asper, Bambusa variegata*, *Bambusa vulgaris* var *Striata* Gamble, *Phyllostachys aurea, Gigantochloa atter, Gigantochloa atroviolacea*, and *Bambusa vulgaris*. In the buffer zone, sub-clusters 3, 4, and 5 had four species: *Dendrocalamus asper*, *Gigantochloa atter*, *Gigantochloa apus*, and *Bambusa blumeana*. In the core zone, sub-clusters 6, 7, and 8 had three species: *Gigantochloa atter, Phyllostachys aurea*, and *Gigantochloa apus.*

Table 1. General and specific characteristics of bamboo species

Characteristics and Classification	Photo
Air roots are at the base to the top of the reed. Bamboo reeds are upright and curved at the top. The underside of young reeds is covered with velvety brown fur. The hairs/wax on the bamboo shoots are evenly distributed. Average number of reeds in clump 30-50. Growth form: Upright. Branch type: sympodial rhizoma. Color of stem: green, diameter: 20-30 cm. Leaf: green color, upright type. Reed diameter: 11-22 cm Famili: Poaceae Genus: *Dendrocalamus* Spesies: *Dendrocalamus asper* Backer ex.Heyne Local name: Bambu Petung	 Habitus  Trunk  Branch  Fronds
Erect bamboo at the bottom and top of the scraps, no visible reed midribs clearly. The part of the reeds is yellow with a shiny green line. Branch type: sympodial rhizoma, Stem: yellow, diameter: 8-10 cm. Leaf: green, lanceolate shape. Growth form: erect. The hairs / wax on the bamboo shoots are evenly distributed. Family: Graminae Genus: *Bambusa* Species: B*ambusa vulgaris* var. *Striata* (Lodd. ex Lindl.) Gambl	 Habitus  Trunk  Branch  Fronds
Erect bamboo at the bottom and top of the scraps, no visible reed midribs clearly. The reeds prickly. Branching: sympodial rhizoma. Stem: green, diameter: 9-10 cm. Leaf: green, lanceolate. Growth form: upright. The hairs on the bamboo shoots scattered in the middle of the leaf midrib. Number of reeds in clump: 50-55. Reed diameter: 7-10 cm Family: Graminae Genus: *Bambusa* Species: *Bambusa blumeana* Schult.f Local name: Bambu Duri.	 Habitus  Trunk  Branches  Fronds
Erect bamboo at the bottom and top of the scraps, no visible reed midribs clearly. The reeds are not spiny. Branching type: sympodial rhizome. Stem: green, diameter: 5-10 cm. Leaf: green, upright. Growth form: upright. The hairs / wax on the bamboo shoots are scattered in the middle of the leaf midrib. Average number of reeds in the clump: 15-60. Reed diameter: 7-10 cm. Family: Graminae Genus : *Bambusa* Species: *Bambusa vulgaris* Schard. J.C.Wendl Local name: Bambu Ampel	 Habitus  Trunk  Branches  Fronds
The books in the reed section are curved inward and consist of 2 branches. The midrib part of the reed is thin and does not have sprouted hair but if it is found, it will fall off easily. Branch type: monopodial rhizoma. Color of stem: green. Stem diameter: 6-10 cm Leaf color: green. Stem diameter: 6-10 cm. Family: Poaceae Genus: *Phyllotachys* Species: *Phyllostachys aurea* Local name: Bambu Jakarta	 Habitus  Trunk

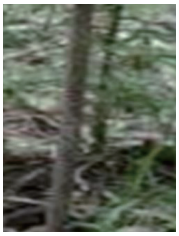
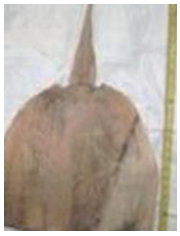
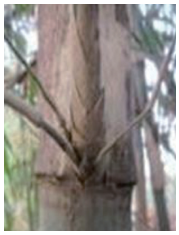
Characteristics and Classification	Photo
Upright bamboo at the bottom and top of the scraps, reed midribs are not clearly visible. Generally used as an ornamental plant. Average height: 3-4 m. Reed diameter: 1.5-3 cm. Has dense leaves. Branch type: monopodial rhizome. Color of stem: green. Leaf color: green Family: Poaceae Genus: *Bambusa* Species: *Bambusa variegata* Local name: Bambu parigata	 Habitus  Trunk
The middle reed is relatively long while the lower part is relatively short. Air roots on the reed found at the base of the reed. Branching: rhizoma sympodial. Stem: green, diameter 6-12 cm. Leaf: green, lanceolate. Growth form: upright. The hairs evenly distributed. Number of reeds in clump: 29-110. Reed diameter: 6-11 cm. Surface: stem midrib. Family: Bambuseae Genus: *Gigantochloa* Species: *Gigantochloa atter* (Hassk.) Kurz Local name: Bambu Jawa	 Habitus  Trunk  Branches  Fronds
The middle reed is relatively long while the lower part is relatively short. Air roots on the reed found at the base of the reed. Branching: sympodial rhizome. Stem: green, diameter: 6-12cm. Leaf: lanceolate. Growth form: upright. The hairs evenly distributed. Average number of reeds in clump: 29-110. Reed diameter: 6-11cm. Surface: stem midrib. Family: Bambuseae Genus: *Gigantochloa* Species: *Gigantochloa atroviolacea* Local name: Bambu Jawa Hitam	 Habitus  Trunk
The middle reed is relatively long, the lower part relatively short. Air roots on the reed found at the base. The midribs of the reeds do not fall off easily. Branch: sympodial rhizoma. Stem: green, diameter: 7-8 cm. Leaf color: green. Growth form: erect. The hairs evenly distributed. Number of reeds in clump: 29-93, diameter: 4-15 cm. Family: Bambuseae Genus: *Gigantochloa* Species: *Gigantochloa apus* Kurz Local name: Bambu Apus	 Habitus  Trunk  Branch  Fronds

Table 2. Diversity index, similarity index, and species richness in each zone of the Boon Pring area

Zone	Sub cluster	H'	E	R
Utilization	1	1.42	0.88	0.84
	2	0.26	0.24	0.45
Buffer	3	1.04	0.75	0.64
	4	1.18	0.85	0.62
	5	1.14	0.82	0.68
Core	6	0.69	0.63	0.44
	7	0.60	0.55	0.43
	8	0.46	0.66	0.21

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Table 3. Abiotic factors in each sub-cluster

Zone	Sub-cluster	Soil pH	Soil Temperature (°C)	Air Temperature (°C)	Light Intesity (Lux)	Humidity (%)
Utilization	1	6,27±0,10[a]	29,40±0,01[a]	28,43±0,20[b]	131,93±6,60[a]	88,00±1,00[ab]
	2	6,37±0,15[ab]	29,43±0,01[a]	28,60±0,10[b]	133,00±10,05[a]	89,67±1,53[b]
Buffer	3	6,50±0,00[b]	29,41±0,01[a]	28,47±0,06[b]	129,47±4,48[a]	87,00±1,00[a]
	4	6,50±0,00[b]	29,36±0,03[a]	28,47±0,15[b]	129,67±1,55[a]	87,67±0,58[a]
	5	6,47±0,06[b]	29,36±0,03[a]	28,60±0,15[b]	133,00±0,95[a]	89,67±1,15[b]
Core	6	6,20±0,00[a]	29,37±0,03[a]	28,70±0,10[b]	130,83±0,90[a]	91,67±1,53[b]
	7	6,27±0,06[a]	29,37±0,03[a]	28,20±0,06[a]	125,27±1,06[a]	92,67±0,58[b]
	8	6,27±0,06[a]	29,35±0,02[a]	28,23±0,20[ab]	124,33±4,24[a]	90,67±1,15[b]

In the column, the same letter above the number indicates that the value of the number is not significantly different based on the LSD test with a significant level of 5% (mean ± standard deviation; n = 3).

Table 4. Bamboo species detected (+) in each sub-cluster of the Boon Pring Area

Species	Sub cluster							
	1	2	3	4	5	6	7	8
Dendrocalamus asper Backer		+	+	+	+			
Bambusa variegata Siebold ex Miq.	+							
Bambusa vulgaris var. Striata Gamble	+							
Phyllostachys aurea Carrière ex A. Rivière & C.Rivière	+					+	+	+
Gigantochloa atter (Hassk.) Kurz	+	+	+	+	+	+	+	+
Gigantochloa atroviolacea Widjaja		+						
Gigantochloa apus Kurz				+			+	+
Bambusa blumeana Schult.f.			+		+			
Bambusa vulgaris Schard. Ex J.C.Wendl.	+							

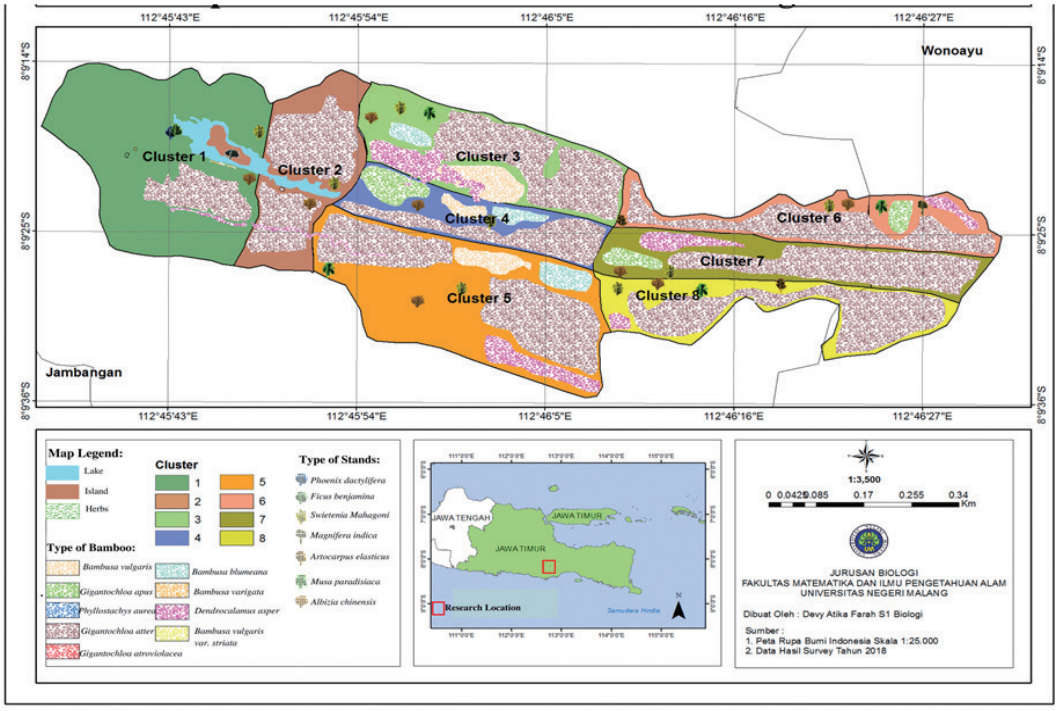

Fig. 3. Zonation and bamboo distribution at Boon Pring Andeman Area.

Discussion

Bamboo species in Boon Pring area and their characterization

Bamboo can be found in tropical and subtropical areas around the world, with the Asian continent having 65% of the world's bamboo species. It has been estimated that there are about 1250 - 1350 bamboo species in the world (Widjaja & Karsono, 2004). It is distributed in Indonesia, Burma, India, China, and Japan. There are 157 bamboo species in Indonesia, including those in the genera of *Bambusa, Dendrocalamus, Dinochloa*, and *Gigantrochloa* (Paridah, 2013; Widjaja & Karsono, 2004). Those genera are also found in the Boon Pring Andeman area. Bamboos are rhizome plants with reed-shaped stems and booklets that are hollow with branches. Bamboo culms are the easiest parts to distinguish them at species levels because they show variations in shape, size, and color (Razak *et al*., 2007). At the beginning of the rainy season, reeds will appear from creeping rhizomes (Sutiono *et al*., 1996). In Indonesia, sympodial bamboos are more common than monopodial ones (Sutarno *et al*., 1996). A sympodial rhizome system is a term to describe bamboo plants that grow in clumps (Chand *et al*., 2008) and develop horizontally with short distances in one clump. Each bamboo bud will develop into a new rhizome root that will grow upward to form bamboo shoots and become reeds (Widjaja, 1998). Knuckles at the base of several species of bamboo are covered by air roots. For example, *Dendrocalamus asper* is found in clusters 2, 3, 4, and 5. Surfaces of young reeds of *Dendrocalamus asper* have thick hair like velvet. *Gigantochloa atter* has black hair that spreads out over segments (Widjaja, 1987). Bamboo reeds are generally green, although they show differences in color levels. The color character of bamboo reeds changes along with the development of reeds. Each species of bamboo has special characteristics. *Gigantochloa atter* is a local bamboo species that is resistant to powder-post beetles attack (Krisdianto & Ismanto, 2006), which is a pest of bamboo plants. This explains why this species is found in all sub-clusters. Information about the classification and specific characteristics of each bamboo species is important to educate visitors so that ultimately all stakeholders can contribute to the conservation of bamboos. This will also assist the management and the protection of the Boon Pring area.

Bamboo species diversity, similarity, and richness index

The high diversity in sub-cluster one located in the utilization zone was because the management had deliberately planted various species of bamboo. *Bambusa varigata, Bambusa vulgaris* var. *striata*, and *Phyllostachys aurea* are used as ornamental plants. One benefit of planting bamboo is that bamboo is an ornamental plant (Pagad, 2016). *Phyllostachys aurea* is planted around the island of Putri Sekar Sari, one of ecotourism areas in Boon Pring Andeman. *Bambusa vulgaris* var. *striata* Gamble is planted at the front of the entrance as an ornamental plant. *Bambusa varigata* is grown around the playground area. Meanwhile, the diversity in sub-cluster two was due to its smaller size in area. It only had t hree species of bamboo. In the buffer zone, the management has maintained the existence of bamboo plants for the purpose of groundwater conservation (Hakim *et al*., 2002). Local people living around the Boon Pring area use natural water sources for household needs and for irrigating rice fields. In addition, *Dendrocalamus asper* as a bamboo species in this zone has a function as a boundary marker between the utilization zone and the buffer zone. The number of individuals was similar between species which caused a high evenness index except for sub-cluster two due to a smaller area in size. *Gigantochloa atroviolacea* at this location was found to have as many as three clumps. Species richness in the entire area was low. Not many species of bamboo clumps were found. The management focused on several species of bamboo for specific purposes. Of ± 10 ha, only nine species were found, with seven of them distributed in the utilization zone.

Abiotic factors support the presence of bamboo

Abiotic factors in the Boon Pring Andeman area are suitable for growing bamboos. This is due to its sub -acid soil. Bamboos are known to grow well in a soil with pH of 5.0-6.5 (Hedge, 2014). Temperature, humidity, soil temperature, and high light intensity in this area as characteristics of the tropics support the growth of bamboos. Humidity is one important determinant of vegetation growth in the tropics (Novianti *et al*., 2018). In the core zone, bamboo clumps are placed tightly. Thus, only a small amount of sunlight can reach the under story. When it rains, due to the tight canopy cover, the water would stay longer in the canopy. Likewise, the movement of water under the bamboo shade is slower. Thus, the humidity due to water under the bamboo shade will be of high value (Rabik & Brown, 2003). Meanwhile, the distance between clumps in the utilization zone was far due to the use of bamboo by the community and management for tourist purposes.

Bamboo vegetation distribution map in Boon Pring area

The zoning division was based on the Boon Pring Andeman area included in the Natural Tourism Park (Minister of Forestry Regulation, 2015). Thus, the management can divide the area into several zones. Zoning principle was applied to allow protection and human use.

With zoning, long-term goals in planning, management, and development can focus on preserving nature, especially bamboos, in addition to using them for tourism and education. We divide the area into three zones, namely the utilization zone, the buffer zone, and the core zone. The core zone is a zone that has high conservation value. It is vulnerable to disturbance or change. The buffer zone is a transition zone between the core zone and the utilization zone. In this zone, human activities are permitted through the agreement of an officer. In principle, the buffer zone aims to support the core zone so that if damage occurs in the utilization zone due to tourist/human activity, it will not affect the core zone. The utilization zone is a zone that has certain conservation values. However, it all ows all forms of utilization activities (Ebregt & Greve, 2000). This zoning is based on the use of the area by the community. Due to the planting of various species and the high intensity of human activity, we defined it as a utilization zone. In this area, there were seven species of bamboos. The tendency of humans to continue exploiting nature needs to be anticipated by creating a buffer zone. This zone is marked by *Dendrocalamus asper*. In the core zone, there is a species of *Gigantochloa atter* which is expected to be sustainable. This species is not easy to cultivate. Thus, damage or overuse can lead to its extinction. The diversity of species in the core zone needs to be enriched. Bamboo distribution maps in these three zones can be used for planning and developing natural tourism potential. All parties need to play a role in preserving bamboos known to have the ability to bind soil and water so that they can continue to provide services for organisms including humans.

Conflict of Interest

The authors declare that they have no competing interests.

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