



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 management 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 and 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 ArcGis 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

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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 the 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 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 managed 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).

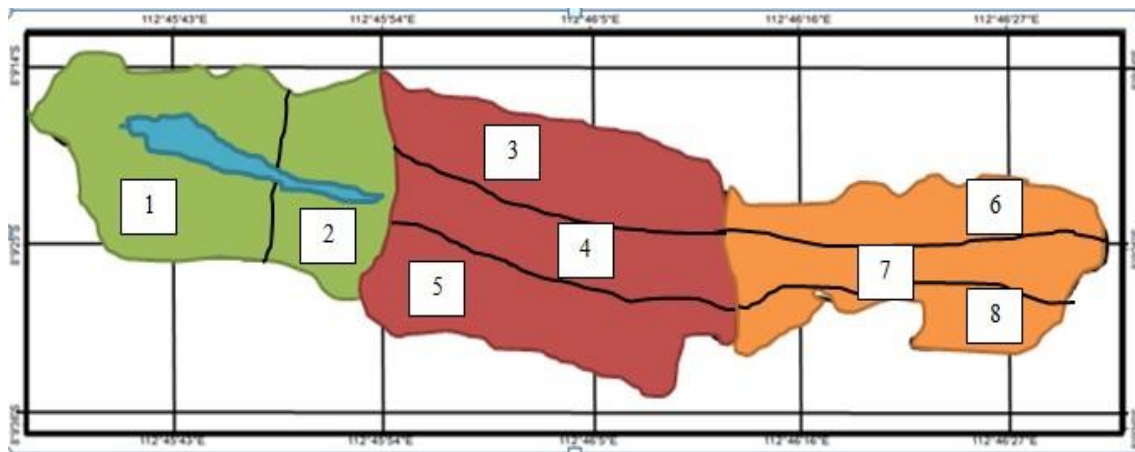


Fig. 1. Illustration of zoning map and cluster division in the Boon Pring Andeman area.

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 application 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 ($^{\circ}\text{C}$, digital soil thermometer, USA), air temperature ($^{\circ}\text{C}$), relative humidity (%), Elcometer 116C Sling Hygrometer, England), and light intensity using a lux meter (LX-1330B, USA) were measured ($n = 3$).

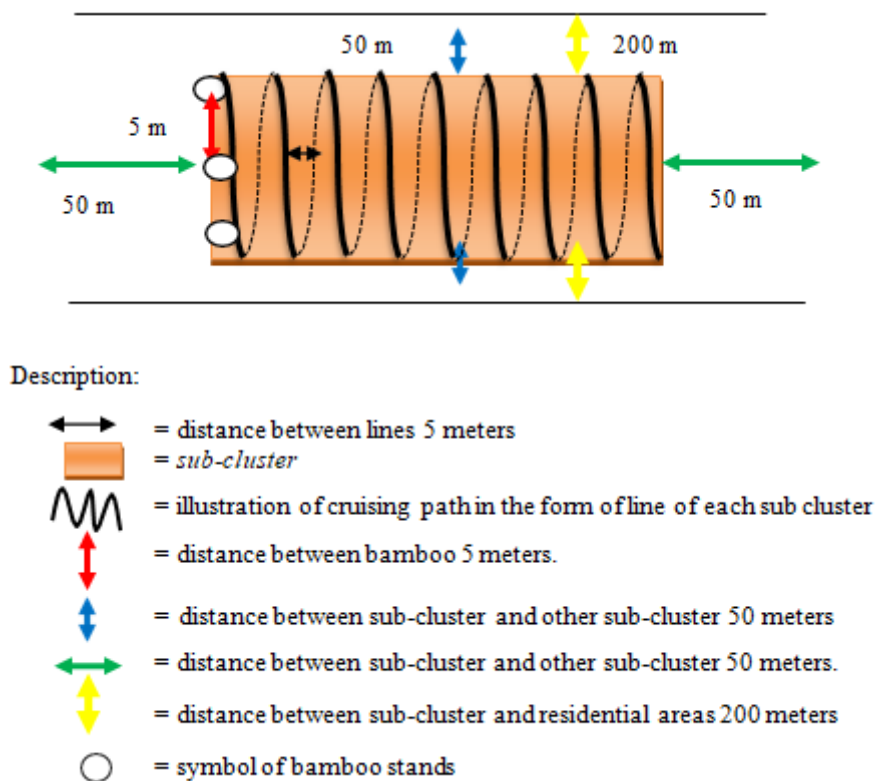


Fig. 2. Illustration of cruising line for each sub cluster.









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, 2004). 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 (α) 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).

Table 1. General and specific characteristics of bamboo species

Characteristics and Classification	Photo			
<p>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</p> <p>Family: <i>Poaceae</i> Genus: <i>Dendrocalamus</i> Species: <i>Dendrocalamus asper</i> Backer ex. Heyne Local name: Bambu Petung</p>	 <p>Habitat</p>	 <p>Trunk</p>	 <p>Branch</p>	 <p>Fronds</p>
<p>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.</p> <p>Family: <i>Graminae</i> Genus: <i>Bambusa</i> Species: <i>Bambusa vulgaris</i> var. <i>Striata</i> (Lodd. ex Lindl.) Gamble</p>	 <p>Habitat</p>	 <p>Trunk</p>	 <p>Branch</p>	 <p>Fronds</p>

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



Fronks

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



Fronks

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: *Phyllostachys*
 Species: *Phyllostachys aurea*
 Nama lokal: Bambu Jakarta



Habitus



Trunk

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- 12 cm. Leaf: lanceolate. Growth form: upright. The hairs evenly distributed. Average number of reeds in clump: 29-110. Reed diameter: 6-11 cm. 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



Habitat



Trunk



Branches



Fronds

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 ($1 \geq H' \leq 3$). The highest index of evenness and species richness were also found in the same location. Meanwhile, sub-cluster two, 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 ($E \geq 0.6$) except for sub-cluster two. Species Richness indices for all sub-clusters were low ($R \leq 3.5$) (Table 2).

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

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).

Table 3. Abiotic factors in each sub-cluster

Zone	Sub-cluster	Soil pH	Soil Temperature (°C)	Air Temperature (°C)	Light Intensity (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).

Bamboo vegetation distribution map

In this study, we divided the Boon Pring Andeman area into three zones based 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 4. Bamboo species detected (+) in each sub-cluster of the Boon Pring Area

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

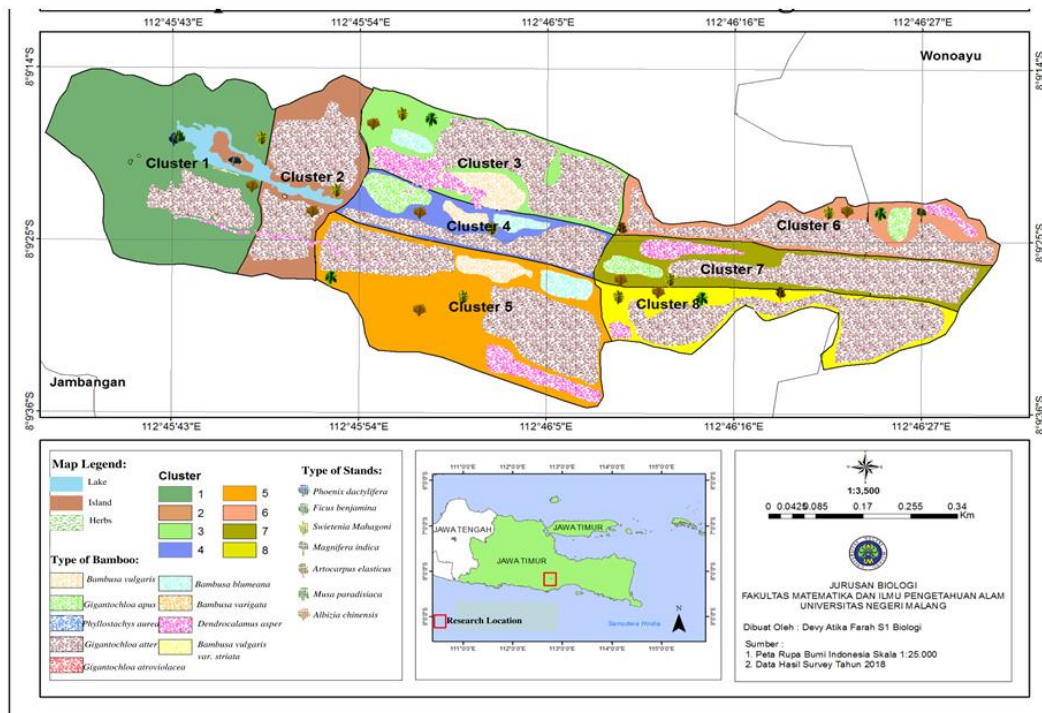


Fig. 3. Zonation and bamboo distribution at Boon Pring Andeman Area.

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 *Gigantochloa* (Paridah, 2013; Widjaja & Karsono, 2004). Those genera are also found in the Boon Pring Andaman 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 Andaman. *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 three 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 Andaman 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 understory. 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 Andaman 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 allows 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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References

- Barbour, M.G., Burk, J.H., Pitt, W.D., Gilliam, F.S., and Schwartz, M.W. (1999). *Terrestrial Plant Ecology*, 3rd ed. Boston: Addison Wesley Longman, Inc.
- Chand, M., Shukla, M., and Sharma, M.K. (2008). Analysis of mechanical behaviour of bamboo (*Dendrocalamus strictus*) by using FEM. *Journal of Natural Fibers*, 5, 127-137. doi:10.1080/15440470801928970
- Diamantis, D. (2010). The concept of ecotourism: evolution and trends. *Current Issues in Tourism*, 2, 93-122. doi:10.1080/13683509908667847
- Ebregt, A., and de Greve, P. (2000). *Buffer zones and their management: Policy and best practices for terrestrial ecosystems in developing countries*. Wageningen: National Reference Centre for Nature Management, International Agricultural Centre.
- Gentili, R., Ambrosini, R., Montagnani, C., Caronni, S., and Citterio, S. (2018). Effect of soil pH on the growth, reproductive investment and pollen allergenicity of *Ambrosia artemisiifolia* L. *Frontiers in Plant Science*, 9. doi:10.3389/fpls.2018.01335
- Hakim, L., Nakagoshi, N., and Isagi, Y. (2002). Conservation ecology of *Gigantochloa manggong*: an endemic bamboo at Java, Indonesia. *Journal of International Development and Cooperation*, 9, 1-16. doi:10.15027/14387

- Hedge, R. (2014). Agroforestry and Ecosystem Services. In A.J. Ray, and S.B. Lal (Eds.). *Agroforestry: Theory and Practice* (pp. 54-66). Jodhpur: Scientific Publisher.
- Henry, D., Dimnycki, A.B., Mohatt, N., Allen, J., and Kelly, J.G. (2015). Clustering methods with qualitative data: A mixed methods approach for prevention research with small samples. *Prevention Science*, 16, 1007-1016. doi:10.1007/s11121-015-0561-z
- Krisdianto, S.G., and Ismanto, A. (2006). *Sari of Bamboo Research Results*. Jakarta: Ministry of Forestry.
- Michael, P. (1984). *Ecological methods for field and laboratory investigations*. New York: Tata McGraw-Hill.
- Minister of Forestry Regulation. (2015). *Regulation of The Minister of Forestry of The Republic of Indonesia*, Number: P.46/Menlhk-Setjen/2015. Retrieved July 30, 2020 from <http://pika.ksdae.menlhk.go.id/assets/pdf/PERMEN%20LHK%20NO%20P%2076%20TAHUN%202015%20%20tentang%20kriteria%20zona%20dan%20blok%20tn%20ca%20sm%20tahura%20twa.pdf>
- Novianti, V., Marrs, R.H., Choesin, D.N., Iskandar, D.T., and Suprayogo, D. (2018). Natural regeneration on land degraded by coal mining in a tropical climate: Lessons for ecological restoration from Indonesia. *Land Degradation & Development*, 29, 4050–4060. doi:10.1002/ldr.3162
- Pagad, S. (2016). *Bamboos and invasiveness-identifying which bamboo species pose a risk to the natural environment and what can be done to reduce this risk*. Inbar working paper, p. 77.
- Paridah, M.T. (2013). *Bonding with Natural Fibres Serdang*. Serdang: Universiti Putra Malaysia Press.
- Rabik, A., and Brown, B. (2003). *Towards Resilient Bamboo Forest: A reference Guide for Improved Management of Clumping Bamboo for Timber Bamboo*. USAID Environmental Service Program.
- Razak, W., Janshah, M., and Hashim, W.S. (2007). Morphological & anatomical characteristics of managed natural bamboo stands - *Gigantochloa scortechinii*. *Journal of Bamboo & Rattan*, 6, 2-8.
- Rustanto, H., Sotjipto, B.E., Wahjpoedi, and Sunaryanto. (2020). Strategies for increasing competitive advantages of rural tourism in Boon Pring tourism, Malang Regency, Indonesia. *Journal of Talent Development and Excellent*, 12.
- Sutarno, H., Hardijadi, S.S., and Sutyono. (1996). *Participatory Model Package: Bamboo Cultivation to Increase Land Productivity*. Bogor: Prosea Indonesia.
- Sutiono, H., Marfu'ah, and Ihak. (1996). *Bamboo Cultivation Techniques*. Bogor: Forest Products Research and Development Center.
- Subekti, T., and Damayanti, R. (2019). Application of the smart village model in village development tourism: study on the tourism village of boon pring sanankerto turen, malang regency. *Journal of Public Administration and Local Governance*, 3, 18-28. doi:10.31002/jpalg.v3i1.1358
- Widjaja, E.A. (1987). A revision of malesian gigantochloa (Poaceae - Bambusoideae). *Reinwardtia*, 10, 291-380. doi:10.14203/reinwardtia.v10i3.274
- Widjaja, E.A. (1998). Bamboo genetic resources in Indonesia. In K. Vivekanandan, A.N. Rao, and V.R. Rao (Eds.). *Bamboo and Rattan Genetic Resources in Certain Asian Countries*. New Delhi: International Network for Bamboo and Rattan (INBAR).
- Widjaja, E.A., and Karsono K. (2004). Bamboo diversity in Sumba Island. *Journal Biodiversitas*, 6, 95-99. doi:10.13057/biodiv/d060205
- Widjaja, W.A. (2001). *Identification of Bamboo Types in Java*. Bogor: Center for Biological Research & Development.
- Wong, K.M. (2004). *Bamboo the amazing grass: A guide to the diversity & study of bamboo in Southeast Asia*. Serdang: International Plant Genetic Resources Institute & University of Malaya.