World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Ecological Analysis Of Vegetation In The Tangkas Lake Nature Tourism Area, Muaro Jambi

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World Journal of Advanced Research and Reviews, 2026, 30(02), 1930-1940

Publication history: Received on 07 April 2026; revised on 16 May 2026; accepted on 19 May 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.30.2.1348

Abstract

This study examines the ecological structure and vegetation composition in the freshwater swamp forest ecotourism area of Tangkas Lake, Muaro Jambi, which is still limited and generally dominated by *Barringtonia acutangula*, as a reference in supporting ecosystem management and conservation efforts. The sampling method was the transect and plot method with purposive sampling technique in the freshwater swamp forest ecosystem conducted from August to October 2025. The analysis included vegetation composition, Importance Value Index (IVI), Shannon-Wiener diversity index (H'), and Principal Component Analysis (PCA). The results showed that 13 species from 8 families (229 individuals) were recorded at the tree level, dominated by the Lecythidaceae family (70%) and co-dominant Ebenaceae (15%). Meanwhile, at the sapling level, 9 species from 7 families (155 individuals) were found, with a strong dominance of Lecythidaceae (86%). The highest IVI value at both levels was obtained by *Barringtonia acutangula* (164.064% in trees and 216.577% in saplings). The species diversity index is classified as moderate, namely 1.647 at the tree level and 1.08 at the sapling level. PCA shows that water temperature and pH are the main factors influencing habitat conditions, while salinity is the environmental differentiating factor. These findings indicate that the freshwater swamp forest ecosystem of Tangkas Lake has moderate diversity with the dominance of certain species. This condition also emphasizes the importance of conservation efforts and sustainable management to maintain the stability and ecological function of the area.

Keywords: *Barringtonia acutangula*; Ecology; Freshwater swamp forest; Tangkas Lake; Plant diversity

1. Introduction

Indonesia is a mega-biodiversity country with abundant natural resources. Indonesia's forests harbor a high level of biodiversity, containing approximately 10% of the world's plant species [1], and an estimated 40,000 plant species are found in Indonesia. Plant diversity is an important indicator in assessing the level of biodiversity in a region, reflecting variations at the ecosystem, species, and genetic levels, as demonstrated by the number and frequency of organisms present [2] [3]. This high species diversity underscores the strategic position of Indonesia's forests as a primary supporter of flora conservation and a foundation for sustainable ecosystem management.

Plant diversity also makes an important contribution to maintaining air quality through carbon absorption and maintaining the overall balance of the ecosystem [4] [5]. Therefore, as a first step to understand the composition of plant species that inhabit an area, identification and inventory activities are necessary [6]. Identification is a process of determining the identity, scientific name, and classification of plants, while inventory is the activity of collecting detailed and specific data related to the type, number, and status of populations in their natural habitats and in environments

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outside those habitats [7]. Information obtained from the inventory is used as an important reference in supporting management and sustainable use to maintain the sustainability of biodiversity.

In the context of vegetation analysis, data on the type, diameter, and height of plants are needed to calculate the importance value (IVI) and understand the condition of vegetation in a forest area. Through this analysis, quantitative information can be obtained that supports the planning and management of plant areas [8]. Vegetation structure is a form of vegetation that is one aspect of qualitative character analysis [9]. Vegetation structure needs to be known to find a number of vegetation characteristics including density, frequency, dominance and importance value. The importance of vegetation analysis lies in its ability to describe the condition of the plant community, describe its characteristics, and assess the state of the ecosystem being studied [10].

Tangkas lake is an ecotourism area located in Tanjung Lanjut Village, Muaro Jambi Regency, Jambi Province with a total area of 403.11 ha. This natural tourism area holds the potential for plant diversity. The unique topography of Tangkas lake is dominated by putat plant species. However, so far, information about vegetation is still limited using non-destructive methods in the area. Previous studies focused more on the ecotourism aspect, especially in improving the quality of human resources in the local area related to understanding the importance of educational value in tourism activities [11]. This study aims to determine the ecological structure and composition of forests in the Tangkas lake area. The results obtained are expected to provide data information related to the ecological structure in Tangkas Lake Nature Tourism and contribute to ecosystem-based tourism conservation efforts as well as provide baseline data on biodiversity.

2. Method

The research location is located at the coordinates 1°28'42"S 103°24'33"E in the Tangkas Lake area, Sekernan District, Muaro Jambi Regency. This research has been conducted for ±3 months (August - October 2025) and continued with sample identification at the ANDA Herbarium, Andalas University. Data analysis was conducted at the Plant Ecology Laboratory, Faculty of Mathematics and Natural Sciences, Andalas University, Padang.

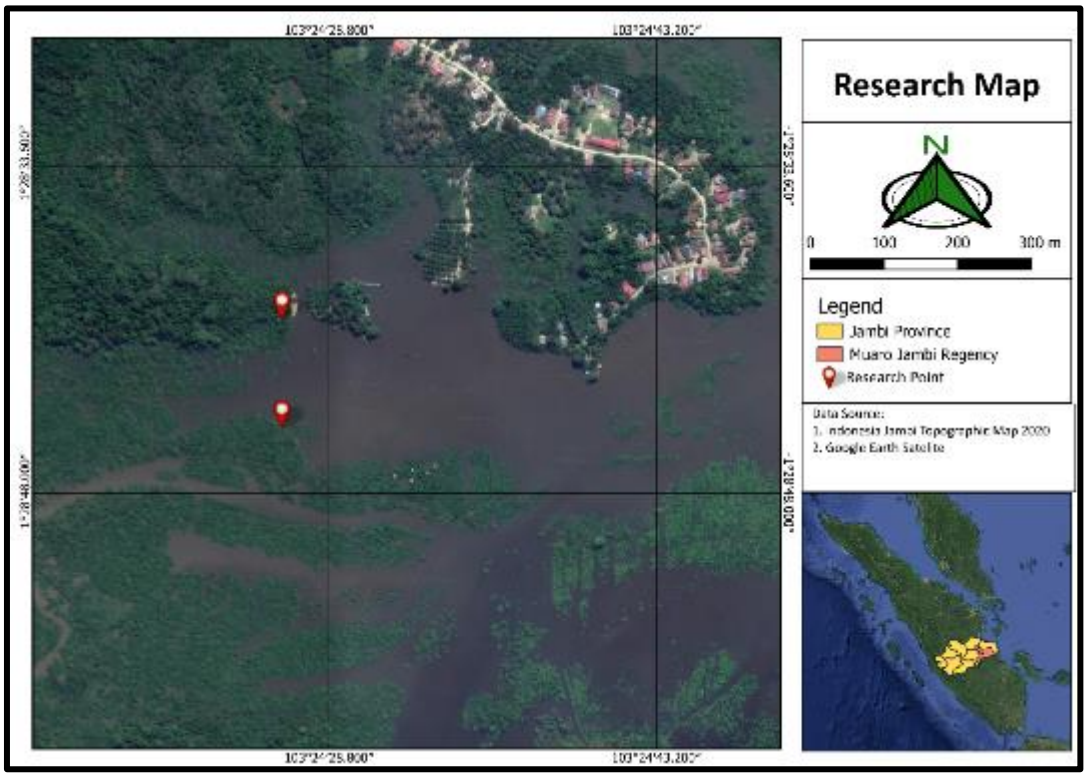

Figure 1 Research Location

The study began with a survey of observation sites to determine field conditions. The transect method was used to collect field survey data [12]. Transect placement was determined using purposive sampling, with plots placed

systematically. Plots measuring 10 m x 10 m were used for tree-level observations, and subplots measuring 5 m x 5 m were used for sapling-level observations [13] [14].

This study used a non-destructive transect method. Observations were conducted on two transect lines, the distance between transects 1 and 2 was 150 meters. The first transect was placed at coordinates 1°28'39"S 103°24'27"E with a length of 100 m, while the second transect was placed at coordinates 1°28'45"S 103°24'26"E with a transect length of 100 m. Each transect was arranged vertically, that is, perpendicular from the edge of the lake towards the area that was still covered with vegetation. On each transect, a 10 x 10 m plot was made for tree level observations with a diameter of >10 cm and a 5x5 m subplot for sapling or sapling level observations with a diameter of 2-10 cm [13] [15].

Data collection includes identification of species names (scientific and local), number of species, number of individuals, and tree diameter using DBH meter (Diameter Breast Height = 1.3 meters from the ground surface). In addition, the characteristics of freshwater swamp forest vegetation at the research location were recorded. Species that have not been identified in the field are collected as specimens for further identification purposes.

2.1. Data Analysis

2.1.1. Vegetation Composition

Composition includes the families and number of individual plants that make up a vegetation. The composition of dominant families is analyzed using the following formula:

$$\textbf{Dominant and CoDominant Families} = \frac{\textbf{Number of individuals in a family}}{\textbf{Number of individuals in the entire family}} \textbf{x 100}\%$$

A family is said to be dominant if it has a percentage value of >20%, whereas if it only has a percentage value of 10-20%, the family is said to be Co-Dominant [16].

2.1.2. Importance Value Index (IVI)

The Importance Value Index is a number that describes the importance of a vegetation type and indicates the level of species dominance in a plant community by adding the percentages of relative density, relative frequency, and relative dominance using the following equation [17]:

$$\text{Density (D)} = \frac{\text{Number of individuals of a species}}{\text{Plot area (m}^2\text{)}}$$

$$\text{Relative Density (KR)} = \frac{\text{Density of a species}}{\text{Density of all species}} \text{x } 100\%$$

$$\text{Frequency} = \frac{\text{Number of plots occupied by a species}}{\text{Total number of plots}}$$

$$\text{Relative Frequency (FR)} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} \text{x } 100\%$$

$$\text{Dominance} = \frac{\text{Total basal area of a species}}{\text{Sampling plot area}}$$

$$\text{Relative Dominance (DR)} = \frac{\text{Dominance of a species}}{\text{Dominance of all species}} \text{x } 100\%$$

$$\text{Importance value index} = \text{Relative Density} + \text{Relative Frequency} + \text{Relative Dominance}$$

2.1.3. Species Diversity Index

The species diversity index of an area is analyzed using the Shannon-Wienner Index (H') with the following formula [18]:

$$H' = -\sum pi \ln pi$$

$$pi = \frac{\text{IVI of a species}}{\text{IVI of all spesies}}$$

Description:

H' = Diversity index; and

pi = The ratio of the sum of the important values of a species to the sum of the important values of all species.

The greater the H' value indicates a high value of species diversity. The value of a species' diversity is defined as follows: 1) if the H' value > 3 indicates high species diversity; 2) if the value of 1 ≤ H' ≤ 3 indicates moderate species diversity; and 3) if the H' value ≤ 1 indicates low species diversity [15].

2.1.4. Environmental Physico-Chemical Parameter Data Collection

Physico-chemical parameter data collection was conducted at each observation plot twice daily. The observed physico-chemical environmental conditions included substrate, water temperature, water pH, and salinity in Tangkas Lake. Substrate samples were taken at each transect using a hoe. The sediment was filtered to determine its composition, according to the following criteria: 1) gravelly sand, 2) sandy, 3) sandy mud, 4) muddy, 5) littered sand. Temperature testing was conducted at each observation plot using a Water Quality Meter. pH testing was performed using a pH meter at each plot by inserting the device into the soil until the display stopped and the measurement results were displayed. To determine the relationship between physico-chemical environmental factors, a PCA test was conducted using the Past program.

3. Result and Discussion

3.1. Composition of Vegetation of Tree-Level Plants

Tangkas lake freshwater swamp ecosystem has an area of ± 403 ha which is dominated by putat trees (*Barringtonia acutangula*), also known as pendant trees, this area has an alluvial soil type. The tree-level plant vegetation found in the area is 8 families, consisting of 11 genera, 13 species, and 229 individuals. The Lecythidaceae family was found with two species with 161 individuals in the entire transect. Then, the Ebenaceae family was found with one species with 35 individuals in the entire transect.

Table 1 Composition of tree-level plants in the Lake Tangkas area

No	Family	Genus	Species	ΣIndividual	Composition (%)
1	Lecythidaceae	1	2	161	70.306
2	Ebenaceae	1	1	35	15.284
3	Melastomataceae	1	2	10	4.367
4	Myrtaceae	3	3	9	3.930
5	Combretaceae	1	1	6	2.620
6	Fabaceae	2	2	4	1.747
7	Clusiaceae	1	1	2	0.873
8	Gentianaceae	1	1	2	0.873
		11	13	229	100,00

The results of the study showed the diversity of tree-level plants in Tangkas Lake with 13 species from 8 families. The Lecythidaceae family dominates, followed by Ebenaceae as a co-dominant family (Table 1). A previous study in the Lake Tangkas Freshwater Swamp Forest, Muaro Jambi, found 31 species from 20 families, with Myrtaceae and Elaeocarpaceae as the dominant families, the findings showed differences in the types that dominate an area [19].

The vegetation composition at the research location showed that there was one dominant family, namely Lecythidaceae with a proportion of 70%, accompanied by the co-dominant family Ebenaceae at 15%. A family is said to be dominant if it has a percentage of >20%, while the co-dominant family is in the range of 10–20% [16].

The dominance of a single family in an area generally indicates low species evenness and may reflect selective environmental conditions, allowing only certain groups to adapt well. This condition also has the potential to reduce the structural and functional diversity of an ecosystem, as ecological contributions are largely supported by a single major taxon group.

High levels of dominance are often associated with low community stability and resilience, although certain plant groups can exhibit strong resilience, such as in shrub communities [20]. Conversely, when a family's dominance is low, it generally reflects high species diversity, which in turn can support more stable ecosystem functions and services.

The presence of the Ebenaceae family as a co-dominant family in the study area indicates that, although not as dominant as the main family, this group possesses ecological adaptations that allow it to grow in tropical wetland habitats. Several Ebenaceae species are known to grow in freshwater swamp forests and tropical swamps, demonstrating tolerance to water-saturated soil conditions and the hydrological fluctuations typical of peat swamp and swamp forest ecosystems.

Physiological and morphological adaptations, such as resistance to anaerobiosis in roots and tolerance to high soil water levels, allow Ebenaceae to maintain populations despite high competitive pressure from dominant major taxa. Furthermore, records from peat swamp forests in other conservation areas indicate that the Ebenaceae family can also have high ecological importance in swamp forest communities [21]. Thus, the presence of Ebenaceae as a co-dominant indicates that environmental factors such as soil moisture, water table regulation, and substrate characteristics provide a suitable ecological niche for its survival.

3.2. Sapling-Level Vegetation Composition

The sapling-level vegetation in the forest comprises 7 families, consisting of 8 genera, 9 species, and 155 individuals. Unlike tree vegetation, which has dominant and co-dominant species, the sapling vegetation has only one highly dominant family, the Lecythidaceae, with a high dominance index of 85.806%.

Table 2 Composition of plants at the sapling level in the Lake Tangkas area

No	Family	Genus	Species	ΣIndividual	Composition (%)
1	Lecythidaceae	1	2	133	85.806
2	Ebenaceae	1	1	13	8.387
3	Myrtaceae	2	2	4	2.581
4	Gentianaceae	1	1	2	1.290
5	Fabaceae	1	1	1	0.645
6	Clusiaceae	1	1	1	0.645
7	Melastomataceae	1	1	1	0.645
		8	9	155	100,00

The presence of a dominant family found in the sapling-level vegetation indicates that the composition of species and individuals across all families found is uneven. This means that the Lecythidaceae family is the family with the largest number of species and individuals found in the sapling-level vegetation.

The Lecythidaceae family is generally found in tropical wetland habitats such as riverbanks, freshwater swamps, and riparian areas in lowland forests. This is also supported by research, that Lechythidaceae, especially the *Barringtonia acutangula* species, is able to grow in soil that is often flooded or saturated with water, with tolerance to hydrological fluctuations and freshwater conditions [22].

Ecosystems like Lake Tangkas are ideal locations for this species to establish large, uniform populations because its floating fruit facilitates (hydrochorous dispersal) and its ability to withstand prolonged flooding. This successful

adaptation to swampy conditions, high humidity, and periods of inundation also explains the Lecythidaceae family's dominance of sapling-level vegetation in the Tangkas Lake area.

3.3. Vegetation Structure

3.3.1. Tree Strata Importance Value Index

Based on research conducted in Tangkas Lake, Muaro Jambi Regency, the importance value index (IVI) of tree-level vegetation ranges from 1.904% - 164.064%. The lowest importance value index was found in the *Syzygium* sp. species, while the highest importance value index was obtained by the *Barringtonia acutangula* and *Diospyros* sp. species as seen in Table 3.

Table 3 IVI of Tree-Level Plants in the Lake Tangkas Area

No	Species Name	Family	KR%	FR%	DR%	IVI
1	*Barringtonia acutangula*	Lecythidaceae	62,44	27,03	74,58	164,06
2	*Diospyros* sp.	Ebenaceae	15,28	20,27	7,87	43,43
3	*Barringtonia racemosa*	Lecythidaceae	7,86	12,16	4,10	24,12
4	*Memecylon edule*	Melastomataceae	3,06	8,11	2,32	13,49
5	*Combretum* sp.	Combretaceae	2,62	6,76	1,51	10,89
6	*Rhodamnia cinerea*	Myrtaceae	2,18	5,40	1,71	9,30
7	*Tristaniopsis* sp.	Myrtaceae	1,31	4,05	2,43	7,80
8	*Memecylon* sp.	Melastomataceae	1,31	4,05	1,23	6,60
9	*Cyrtophyllum fragrans*	Gentianaceae	0,87	2,70	1,54	5,12
10	*Archidendron microcarpum*	Fabaceae	0,87	2,70	1,19	4,76
11	*Milletia* sp.	Fabaceae	0,87	2,70	0,76	4,34
12	*Garcinia* sp.	Clusiaceae	0,87	2,70	0,62	4,19
13	*Syzygium* sp.	Myrtaceae	0,44	1,35	0,12	1,90
			100	100	100	300

Vegetation structure needs to know a number of vegetation characteristics including relative density, relative frequency, relative dominance, and importance value index of each species [23]. The highest relative density of tree-level plants was found in the Lecythidaceae family with the species *Barringtonia acutangula* as much as 62.445%, this indicates that the species *Barringtonia acutangula* is able to adapt well to riparian areas and compete with other species for survival.

The highest relative frequency values for tree-level plants were found in the Lecythidaceae family with the species *Barringtonia acutangula* at 27.027% and the Ebenaceae family with the species *Diospyros* sp. at 20.270%. The high relative frequencies are due to these species having high tolerance to environmental factors and nutrient availability in an area. This indicates that *Barringtonia acutangula* and *Diospyros* sp. are species that have high tolerance to environmental factors and nutrient availability in the area.

The highest relative dominance among all species was found in the Lecythidaceae family with the species *Barringtonia acutangula* at 74.592%. The dominance value of each vegetation type was calculated based on the size of the stem diameter measured at breast height or what is commonly called DBH (Diameter at Breast Height), so that the magnitude of the dominance value of a species is also influenced by the density of the species and the average size of the stem diameter in each vegetation of the same type. Furthermore, the species with the highest IVI was *Barringtonia acutangula* with a value of 164.064.

Barringtonia acutangula is the species with the highest relative density, relative frequency, relative dominance, and importance value index among other species found at the study site. This indicates that *Barringtonia acutangula* is a

species that plays an important role in tree-level vegetation in this area. This species is from the genus Barringtonia of the family Lecythidaceae. This species distributed in tropical regions such as Southeast Asia, East Asia, India, Sri Lanka, East Africa, and Australia [24]. According to the IUCN redlist (2025), this species has a conservation status of Least Concern (LC) and its population tends to be relatively stable, or abundant in nature.

3.3.2. Strata Sapling Importance Value Index

Based on research conducted in Lake Tangkas, Muaro Jambi Regency, the importance value index of plant vegetation at the sapling level ranged from 3.686% to 216.577%. The lowest importance value index was found in *Millettia* sp. and *Garcinia* sp. species, while the highest importance value index was obtained by *B. acutangula* species, as shown in Table 4.

Table 4 IVI of Plants at the Sapling Level in the Lake Tangkas Area

No	Species Name	Family	KR%	FR%	DR%	IVI
1	*Barringtonia acutangula*	Lecythidaceae	80,64	50,00	85,93	216,58
2	*Diospyros* sp.	Ebenaceae	8,39	17,50	4,79	30,67
3	*Barringtonia racemosa*	Lecythidaceae	5,16	10,00	3,14	18,31
4	*Cyrtophyllum fragrans*.	Gentianaceae	1,29	5,00	1,84	8,12
5	*Rhodamnia cinerea*	Myrtaceae	1,29	5,00	1,21	7,50
6	*Tristaniopsis* sp.	Myrtaceae	1,29	5,00	1,07	7,36
7	*Memecylon edule*	Melastomaceae	0,64	2,50	0,79	3,94
8	*Garcinia* sp.	Clusiaceae	0,64	2,50	0,67	3,82
9	*Millettia* sp.	Fabaceae	0,64	2,50	0,54	3,69
			100	100	100	300

The IVI value from the calculation results of KR, FR, and DR. The highest relative density of sapling level plants was found in the Lecythidaceae family with the species *B. acutangula* as much as 80.6452%. Then, the highest relative frequency of sapling level was found in the Lecythidaceae family with the species *B. acutangula* at 50.00% and the Myrtaceae family with the species *Rhodamnia cinerea* at 17.50%. Meanwhile, the highest relative dominance was found in the Lecythidaceae family with the species *Barringtonia acutangula* at 85.9322%. The highest IVI value in sapling level plants was found in *B. acutangula* in the Lecythidaceae family at 216.577%.

B. acutangula is a species that plays a significant role in the vegetation structure at the sapling level. This is evidenced by its highest IVI and DR values among other species at the sapling level. Furthermore, its KR and FR values are also among the highest. Habitat-wise, this species grows in both swamp and highland forests.

The putat often inhabits swampy areas, wetlands, and seasonally inundated lowlands. This species has a very wide distribution and encompasses many tropical environments, particularly tropical rainforests with high humidity. In Indonesia, this species has been recorded on large islands such as Sumatra, Java, Kalimantan, Sulawesi, and Papua [25]. The highly suitable habitat for *B. acutangula* in the Tangkas Lake area is thought to be the main reason this species thrives there, resulting in its highest IVI value.

3.3.3. Diversity Index (H')

The species diversity index value of the freshwater swamp forest ecosystem in Lake Tangkas for the tree category (H' = 1.647), the sapling category (H' = 1.08). According to [26] if H <1 means low species diversity, if 1 ≤ H' ≤ 3 means moderate species diversity, if H' > 3 means high species diversity. Overall, the value of species diversity in Tangkas Lake is included in the moderate category, both at the tree and sapling levels. Further descriptions of the diversity index for each species can be seen in Table 5.

Table 5 Diversity Index (H') of species in Tangkas Lake

Species	Diversity Index (H')	
	Tree	**Sapling**
Barringtonia acutangula	0.330	0.235
Barringtonia racemosa	0.203	0.170
Tristaniopsis sp.	0.095	0.091
Memecylon edule	0.139	0.056
Combretum sp.	0.120	-
Syzygium sp.	0.032	-
Diospyros sp.	0.280	0.233
Archidendron microcarpum	0.066	-
Garcinia sp.	0.060	0.055
Memecylon sp.	0.084	-
Rhodamnia cinerea	0.108	0.092
Cyrtophyllum fragrans	0.069	0.097
Milletia sp.	0.061	0.054
	1,647	1,0866

The diversity index is determined by its importance value; the higher the importance value of a species, the higher the level of diversity of that species. The diversity value of a community is highly dependent on the number of species and the number of individuals contained within the community. A community's species diversity will be high if the community is composed of many species and no species dominates. Conversely, a community will have a low species diversity value if the community is composed of few species and there is a dominant species [27]. *B. acutangula* is a mangrove-associated species that has the highest diversity index at both the tree and sapling levels, namely 0.330 and 0.235, respectively.

The diversity index of vegetation at the tree and sapling levels at this location is still considered moderate. The diversity index of a plant community depends on the number of species and the number of individuals of each species (species richness). Environmental conditions in the area will also influence sapling growth. According to [18] and [15], diversity and ecosystem stability are synonymous, meaning that high diversity tends to stabilize the ecosystem.

The diversity index is an important parameter that reflects the stability of a forest community. The obtained index value indicates that this forest area still has the potential to increase species diversity while strengthening the stability of its vegetation. This finding aligns with initial observations, which indicated that the vegetation in the area falls into the category of freshwater swamp forest, which are still relatively well-maintained and have not experienced severe ecological pressures.

3.3.4. Environmental Conditions of Lake Tangkas Swamp Forest

Each plant species requires suitable environmental conditions to survive, thus varying its lifestyle. Complex changes in habitat quality can result in shifts in the plant species that make it up. The dominance of a plant community is influenced by environmental factors. Based on observations of the physical and chemical conditions of the freshwater swamp forest environment in Lake Tangkas, data were obtained on salinity, water temperature, water pH, and the substrate of the forest ecosystem. The relationship between environmental factors and the presence of plant species can be seen in Figure 2.

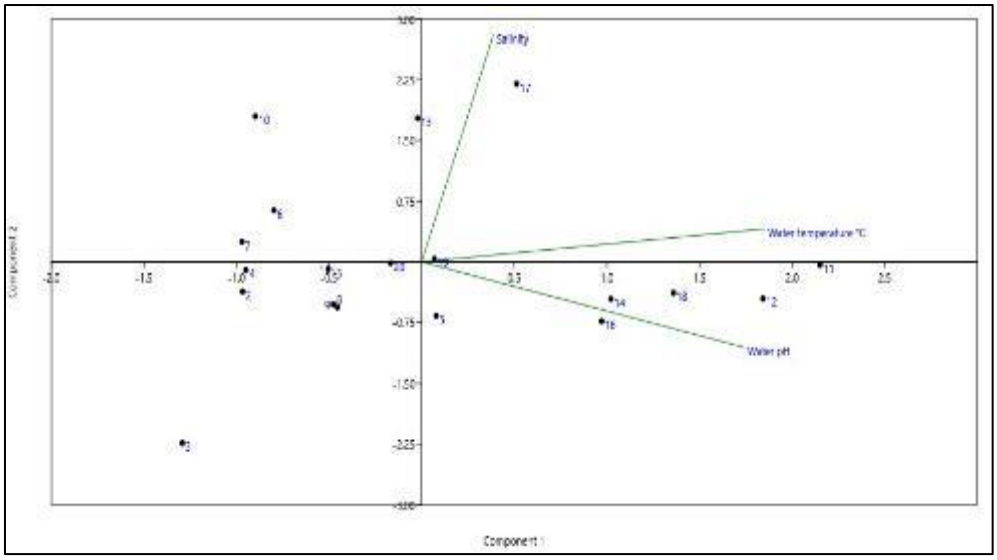

Figure 2 Combined results of PCA measurements from transects 1 and 2 showing the relationship between environmental factors

The results of the Principal Component Analysis (PCA) with several component characteristics that support the growth of plant species at the research location can be explained in the following description. The results of the combined PCA analysis of transects 1 and 2 (Figure 2) show that the main axis (PC1) is influenced by water temperature and pH, which have relatively high loading values and are in the same direction. This indicates that the main variations in *B. acutangula* habitat conditions are related to thermal gradients and water chemistry. The second axis (PC2) is dominated by salinity with very high loading values, thus reflecting differences in salinity levels between observation locations.

Meanwhile, the third axis (PC3) shows an inverse relationship between temperature and pH, indicating additional variation in the dynamics of water conditions. Overall, these results indicate that temperature and pH are the primary factors influencing freshwater swamp forest habitat conditions, while salinity acts as a differentiating environmental factor.

4. Conclusion

The Tangkas Lake Nature Tourism Area has a diversity index (H') value in tree and sapling strata that is still classified as moderate. This forest is dominated by the Lecythidaceae family with a proportion of 70%, accompanied by the co-dominant Ebenaceae family at 15%. This difference is also influenced by physicochemical factors such as salinity, water temperature, water pH, and soil texture. The results of this study emphasize the importance of sustainable conservation efforts in the freshwater swamp forest in Tangkas Lake, which has moderate diversity. In the long term, increasing plant diversity from the moderate to high category requires an integrated approach. Efforts such as enrichment planting, habitat restoration, monitoring and evaluation of local species, and further research on dominant species. Thus, diversity can be maintained through a stable, resilient, and sustainable system.

Compliance with ethical standards

Acknowledgments

The author would like to thank the Department of Biology, Andalas University, to the supervisors, namely Prof. Dr. Chairul and Prof. Dr. Erizal Mukhtar who have provided input for the perfection of this article and all the teams who took part in helping to carry out the research.

Disclosure of conflict of interest

The authors declare no competing interests in relation to this study.

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