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# Structure and composition of mangrove vegetation in the coastal area of Mandalika International Street Circuit, Central Lombok, Indonesia

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**Abstract.** *Jayadi EM, Rahman FA, Ihsan MS, Fitriah L, Agustini D. 2024. Structure and composition of mangrove vegetation in the coastal area of Mandalika International Street Circuit, Central Lombok, Indonesia. Biodiversitas 25: 2719-2728.* Mangrove is one of the coastal vegetation that has an ecological role as a buffer for essential areas such as the Mandalika International Street Circuit Special Economic Zone located around the coastal area of Central Lombok District, West Nusa Tenggara, Indonesia. This research, conducted with a rigorous methodology, aims to determine the current condition of the diversity of mangrove vegetation and their vegetation structure as a buffer ecosystem in the Mandalika International Street Circuit area, West Nusa Tenggara. The study utilized the quadrant transect method, a widely accepted approach, with plots measuring 2×2 $m^2$ (seedling strata), 5×5 $m^2$ (sapling strata), 10×10 $m^2$ (pole strata), and 20×20 $m^2$ (tree strata). The total number of observation plots was 49 measuring plots in a total area of the mangrove ecosystem of 38.68 ha. The research results showed that four families and five genera were found consisting of 11 species of mangroves: *Avicennia alba* Blume, *Avicennia lanata* Ridl., *Avicennia marina* (Forssk.) Vierh., *Ceriops tagal* (Perr.) C.B.Rob., *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam., *Rhizophora stylosa* Griffith, *Scyphiphora hydrophyllacea* C.F.Gaertn., *Sonneratia alba* Sm., *Sonneratia caseolaris* (L.) Engl., and *Sonneratia ovata* Backer. *Rhizophora apiculata* is the species with the highest density in the strata of seedlings (261 individuals/ha), saplings (312 individuals/ha), poles (444 individuals/ha), and trees (160 individuals/ha); this condition is in line with the importance value index *R. apiculata* with the highest values in seedlings (105.21%), saplings (89.14%), poles (129.61%), and trees (119.60%). Shannon-Wiener diversity index in the mangrove ecosystem in the Mandalika International Street Circuit is in the quite good category with an even diversity value with an H' value of no less than 1 (1.425).

**Keywords:** Composition, density, Mandalika International Street Circuit, mangroves, structure, vegetation

## INTRODUCTION

Mangrove forests are tropical forests that grow along coastal-intertidal zones, which are still influenced by sea tides (Zhang et al. 2007; Koh et al. 2018; Toorman et al. 2018; Friess et al. 2020). Mangrove ecosystems have unique characteristics and shapes as well as various functions and benefits for living creatures and the environment, such as supporting ecological processes (Lee et al. 2014; Primavera et al. 2019; Mitra 2020; Wang and Gu 2021), hydrological (Pérez-Ceballos et al. 2020; Zhao et al. 2020; Adame et al. 2021), habitat for a diversity of flora and fauna (Wahyuni et al. 2021; Badave et al. 2023; Bindiya et al. 2023), food source (Medina Contreras et al. 2018; Muro-Torres et al. 2020; Then et al. 2021), disaster mitigation area (Asari et al. 2021; Akram et al. 2023; Sunkur et al. 2023), and has the potential to become an ecotourism area (Azis et al. 2018; Abdillah et al. 2020; Winata et al. 2020).

The mangrove ecosystem of Lombok Island is spread around the coast with a total area of 3304.64 ha (Rahman et al. 2019; Kementerian LHK 2024). One of the areas that have an important role as a buffer zone for the special economic zone ecosystem is the existence of mangrove vegetation around the Mandalika International Circuit area, Central Lombok District, based on the results of field observations which confirmed through Google Earth mapping and data on the mangrove area of Lombok Island, Watershed Management Center of Dodokan Moyosari Land Rehabilitation and Conservation Center, West Nusa Tenggara (2018), that currently remains 38.68 ha out of a total of 62.53 ha due to degradation and conversion to other land use such as the construction of the Mandalika international circuit.

Apart from development activities that have an impact on the decreasing area of mangrove ecosystems in the Mandalika International Circuit area, other conditions can be caused by illegal logging (Sharma et al. 2020; Cahyaningsih et al. 2022), conversion of land into ponds (Arifanti et al. 2019; Tinh et al. 2022), waves, and abrasion (Kusumaningtyas et al. 2019; Biswas and Biswas 2020; Onyena and Sam 2020; Sadono et al. 2020). These various problems have caused the condition of the mangrove ecosystem in the Mandalika international circuit buffer area to be in the heavily damaged category (>80%) since 2006 based on data from the Dodokan Moyosari River Basin Center, West Nusa Tenggara, especially from the impact of the construction of the Mandalika international circuit in 2018-2019 which does not prioritize buffer zone factors as a disaster mitigation function for the sustainability of special economic zones in organizing international events.

The urgency of mangrove ecosystem research on the Mandalika International Circuit is based on the lack of updated mangrove ecosystem ecology related to the status of diversity and structure of mangrove vegetation after the construction of the Mandalika International Circuit. Those studies have never been carried out, especially to support the environmental health status of the mangrove ecosystem area to develop and manage the mangrove ecotourism area as part of world-class tourism activities (Abdus Salam et al. 2000; Sadono et al. 2020; Abdillah et al. 2021). Meanwhile, various previous studies still focused on the fauna diversity in the mangrove ecosystem, such as gastropods (Al Idrus et al. 2021; Hasanah et al. 2023), mollusks (Candri et al. 2020; Al Idrus et al. 2021; Dasilva et al. 2023), birds (Syukur et al. 2023), lobster (Hilyana et al. 2021; Amin et al. 2022), and crabs (Sari et al. 2023).

On the other hand, the destruction of mangrove forests greatly influences the ecological pressure of coastal ecosystems, so efforts to manage mangrove ecosystems to ensure mangrove sustainability, especially in Central Lombok District, conducted in an integrated, planned, and careful manner (Dencer-Brown et al. 2020; Golebie et al. 2022; Shah and Ramesh 2022; Bakri et al. 2023). Efforts to conserve and rehabilitate mangrove areas should begin with data collection on ecosystem conditions, which includes inventory and identification of existing biophysical conditions of mangroves (Ellison et al. 2020; Rahadian et al. 2022; Hilyana and Rahman 2022). Accurate data is needed on the actual condition of mangroves within the Mandalika International Street Circuit special economic area to support sustainable conservation (Masciotta et al. 2021; Banerjee et al. 2022; Sasmito et al. 2023). This research aims to determine the current condition of the diversity of mangrove vegetation and their ecological structure as a buffer ecosystem in the Mandalika International Street Circuit area, West Nusa Tenggara.

## MATERIALS AND METHODS

### Study area

The research was carried out from November 2023 to February 2024. The research location was carried out in the mangrove ecosystem in the Mandalika International Street Circuit area, Central Lombok District, West Nusa Tenggara, Indonesia, with a mangrove area of 62.53 ha (116'19'40"-116'21'00" S and 9'53'45"-9'55'45" E) (Figure 1).

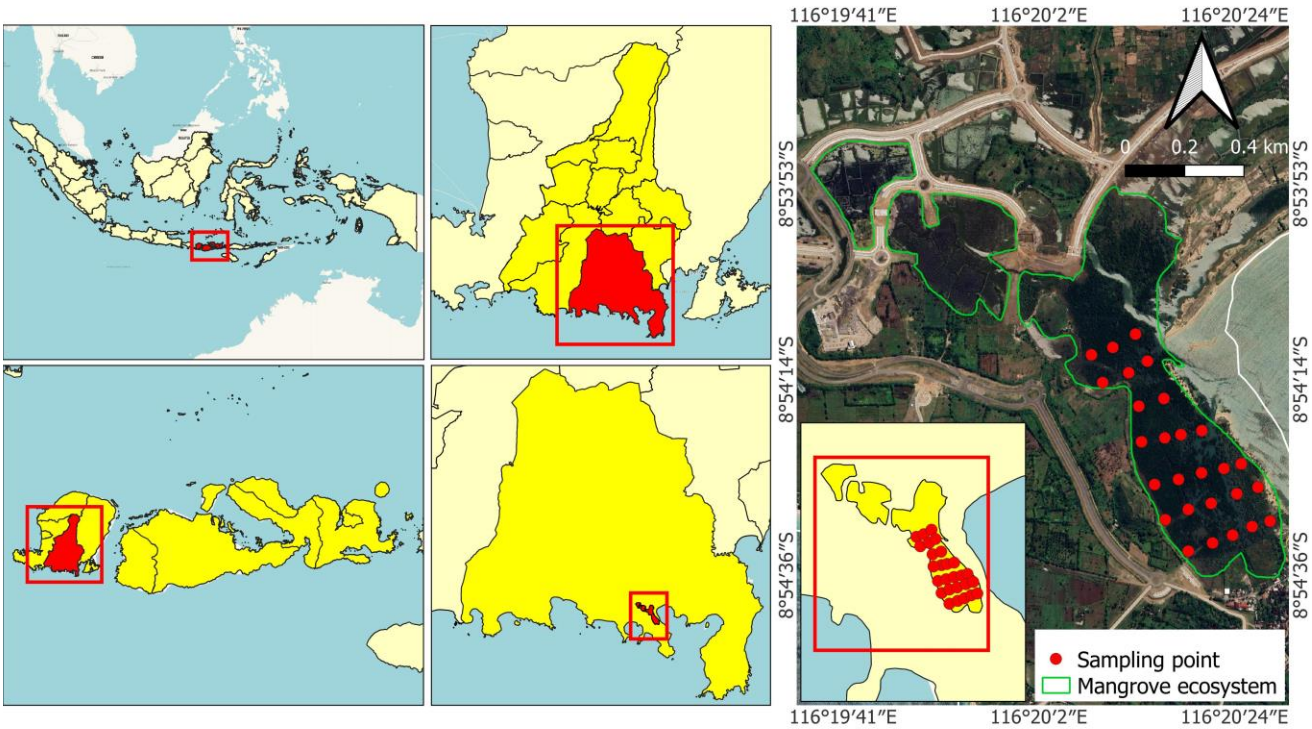


**Figure 1.** Map of the study area and observation plot of mangrove ecosystem Mandalika International Road Circuit, Central Lombok District, Lombok Island, West Nusa Tenggara, Indonesia

## Procedures

The research on the composition and structure of mangrove vegetation in the Mandalika International Street Circuit area was carried out using the transect method with quadrant plots measuring 2×2 $m^2$ for the seedling strata, 5×5 $m^2$ for the sapling strata, 10×10 $m^2$ for the pole strata, and 20×20 $m^2$ for the tree strata (Mueller-Dombois and Ellenberg 1974; Kauffman and Donato 2012; Rosalina et al. 2014; Seftianingrum et al. 2020; Kusmana and Azizah 2022). The total number of observation plots was 49 measuring plots in a total mangrove ecosystem of 38.68 ha. The research mechanism starts with identifying the species in each plot consisting of strata of seedlings, saplings, poles, and trees based on the book Guide Australia's Mangroves: The Authoritative Guide to Australia's Mangrove Plants by Duke (2006), Guide to the Introduction of Mangroves in Indonesia by Noor et al. (2006), Mangrove guidebook for Southeast Asia by Giesen et al. (2007), and Field guide to mangrove identification and community structure analysis by Lebata-Ramos (2013).

Classification of mangrove vegetation strata is carried out based on the mangrove stems height and diameter (Ukpong 2000; Abdillah et al. 2021), as follows:

(i) Seedling stage: From germination until the mangrove is less than 1.5 meters high and the stem diameter is less than 5 cm.
(ii) Sapling level: Mangroves that are more than 1.5 meters high and have a stem diameter of 5-25 cm.
(iii) Pole-level: Mangroves with a trunk diameter between 25-35 cm and a height of more than 1.5 m.
(iv) Tree level: Mangroves with a tree trunk diameter of more than 35 cm.

## Analysis of quality parameters

After identifying the species, the chemical and physical factors of the water were observed in each quadrant plot measuring 20×20 $m^2$ directly in the field using several tools such as water pH, salinity, water temperature, substrate pH, current speed, substrate humidity, and wind speed. The tools used to measure water's physical-chemical factors include digital pH, soil tester, hand refractometer, digital thermometer, Global Positioning System (GPS) receiver, anemometer, and current meter.

## Data analysis

*Importance value index*

The collected vegetation data is then calculated to determine species density, relative density, species dominance, relative dominance, species frequency, relative frequency, and Important Value Index (IVI) as follows Kacholi (2014); Atsbha et al. (2019); Tolangara et al. (2019); Dodo and Hidayat (2020); Yunus et al. (2020); and Ismail et al. (2021).

$$\text{Density} = \frac{\text{The number of species}}{\text{Area of measuring}}$$

$$\text{Relative density} = \frac{\text{Species density}}{\text{Density of all species}} \times 100\%$$

$$\text{Frequency} = \frac{\text{The number of plots containing a species}}{\text{The sum of all plots}}$$

$$\text{Relative frequency} = \frac{\text{Species frequency}}{\text{Frequency of all species}} \times 100\%$$

$$\text{Dominance} = \frac{\text{Species dominance}}{\text{Dominance of all species}}$$

$$\text{Relative dominance} = \frac{\text{Species dominance}}{\text{Dominance of all species}} \times 100\%$$

$$\text{Important value index} = \text{Relative density}\,(\%) + \text{Relative frequency}\,(\%) + \text{Relative dominance}\,(\%)$$

The important value index is the totals of relative density, relative dominance, and relative frequency with the results of the important value index in the interval 1-300% for pole and tree strata, while the important value index for seedling and sapling strata is the totals of relative density and relative frequency with values in the interval 1-200%.

## Density of species

Density is the number of individuals per hectare area or unit volume with the formula:

$$\text{Di} = \frac{ni}{A}$$

Where :
Di : Density of species I (individuals/ha)
ni : Number of individuals of species i
A : Area of sampling plot

Standard criteria for mangrove damage based on the Minister of the Environment in 2004 in Table 1.

## Shannon-Wiener diversity index

The diversity index is calculated based on the Shannon-Wiener equation to obtain information on the distribution of mangrove species diversity in an ecosystem (Krebs 1978) with the formula:

$$H' = -\sum \text{Pi x Ln Pi}$$

$$\text{Pi} = n/N$$

Where:
H' : Shannon-Wiener diversity index
Pi : Proportion of the number of individuals of species i to total individuals
n : Specific density
N : Density of all species

Shannon-Wiener diversity assessment criteria: H'<1 = Low diversity, poor ecosystem stability, and low productivity; 1.0<H'<3.322 = Moderate diversity, sufficient productivity, fairly balanced ecosystem conditions, and moderate ecological pressure; H'>3.322 = High diversity, excellent ecosystem stability, high productivity, and resistance to ecological pressure.

**Table 1.** Standard criteria for mangrove-damaged

| Category | | Density (individuals/ha) |
|---|---|---|
| Good | Very solid | >1500 |
| | Currently | 1000<1500 |
| Damaged | Seldom | <1000 |

## RESULTS AND DISCUSSION

### Species composition

Based on the results of species identification carried out in each observation plot starting from the strata of seedlings, saplings, poles, and trees, it was found that there are four families, five genera consisting of 11 species of mangroves that grow in the Coastal Area of Mandalika International Street Circuit (Table 2). The highest species composition was found in *Avicennia*, *Rhizophora*, and *Sonneratia* genera, with three species. *Ceriops* and *Schyphipora* were found with one species, namely *C. tagal* and *S. hydrophyllacea*.

### Water chemistry and physics

The chemical and physical conditions of the waters within the mangrove ecosystem area of the Mandalika International Street Circuit are still following the minimum threshold to support the growth and development of mangrove vegetation. Following the water health quality standards for coastal and marine flora and fauna habitats based on the Decree of the State Minister for the Environment Republic of Indonesia Number 51 of 2004 as follows in Table 3.

The regular measurements of water chemistry show that the pH of the waters of the mangrove ecosystem of the Mandalika International Street Circuit was an average value of 8.04±0.148, salinity was an average of 31.00±12.728 ppt, and water temperature was an average of 29.25±1.061°C. Meanwhile, the water physics of the mangrove ecosystem shows that the average current speed in all observation plots is 6.50±0.361 meters/second, and the wind speed is 4.00±0.424 meters/second.

### Density of mangrove species

The highest mangrove density was found in the *Rhizophoraceae* family, with the highest species being *R. apiculata* in seedlings strata (261 individuals/ha), saplings (312 individuals/ha), poles (444 individuals/ha), and trees (160 individuals/ha) (Table 4). Apart from that, the highest species density in the *Avicenniaceae* family was *A. lanata* in the sapling stratum (19 individuals/ha), while in the *Sonneratiaceae* family was *S. alba* in the tree stratum (54 individuals/ha). Meanwhile, only one species was found in the *Rubiaceae* family, namely *S. hydrophyllacea* with the highest density in the pole strata (39 individuals/ha).

### Importance Value Index

The importance value index for vegetation is an analysis of the control of a species in its growing habitat, starting from the density, frequency, and dominance of a species. The highest important value index for the mangrove vegetation of the Mandalika International Street Circuit was obtained for the *R. apiculata* species at the seedling (105.21%), sapling (89.14%), pole (129.61%), and tree (119.60%) strata (Table 5). Apart from that, there are several species of mangroves with an important value index equal to 0 at each strata level, namely: seedling strata (*S. casolaris* and *S. ovata*), sapling strata (*A. alba* and *S. ovata*), pole strata (*S. hydrophyllacea*), and tree strata (*A. marina*, *C. tagal*, and *S. hydrophyllacea*).

**Table 2.** Results of mangrove identification in the Coastal Area of Mandalika International Street Circuit, Central Lombok District, Indonesia

| Family | Genus | Species |
|---|---|---|
| Avicenniaceae | *Avicennia* | *A. alba* Blume |
| | | *A. lanata* Ridl. |
| | | *A. marina* (Forssk.) Vierh. |
| Rhizophoraceae | *Ceriops* | *C. tagal* (Perr.) C.B.Rob. |
| | *Rhizophora* | *R. apiculata* Blume |
| | | *R. mucronata* Lam. |
| | | *R. stylosa* Griffith |
| Rubiaceae | *Scyphiphora* | *S. hydrophyllacea* C.F.Gaertn. |
| Sonneratiaceae | *Sonneratia* | *S. alba* Sm. |
| | | *S. caseolaris* (L.) Engl. |
| | | *S. ovata* Backer |

**Table 3.** Environmental parameters of the mangrove ecosystem in the Coastal Area of Mandalika International Street Circuit, Central Lombok District, Indonesia

| Environmental parameters | Average±Standard Deviation | Unit |
|---|---|---|
| pH of waters | 8.04±0.148 | - |
| Temperature | 29.25±1.061 | °C |
| Water flow | 6.50±0.361 | seconds/meter |
| Substrate moisture | 70.00±0.000 | RH |
| Wind velocity | 4.00±0.424 | meters/second |
| Salinity | 31.00±12.728 | ppt |

Note: RH: Relative Humidity; ppt: Part-per-thousand

**Table 4.** The density of mangrove vegetation in the Coastal Area of Mandalika International Street Circuit, Central Lombok District, Indonesia

| Family | Genus | Species | Density (individuals/ha) | | | |
|---|---|---|---|---|---|---|
| | | | Seedling | Sapling | Pole | Trees |
| Avicenniaceae | *Avicennia* | *Avicennia alba* | 1 | 0 | 5 | 1 |
| | | *Avicennia lanata* | 3 | 19 | 14 | 5 |
| | | *Avicennia marina* | 1 | 4 | 1 | 0 |
| Rhizophoraceae | *Ceriops* | *Ceriops tagal* | 74 | 94 | 29 | 0 |
| | *Rhizophora* | *Rhizophora apiculata* | 261 | 312 | 444 | 160 |
| | | *Rhizophora mucronata* | 59 | 105 | 14 | 3 |
| | | *Rhizopora stylosa* | 64 | 86 | 55 | 3 |
| Rubiaceae | *Scyphiphora* | *Scyphiphora hydrophyllacea* | 23 | 1 | 39 | 0 |
| Sonneratiaceae | *Sonneratia* | *Sonneratia alba* | 4 | 28 | 0 | 54 |
| | | *Sonneratia caseolaris* | 0 | 1 | 16 | 12 |
| | | *Sonneratia ovata* | 0 | 0 | 2 | 4 |
| Total | | | 490 | 650 | 619 | 242 |

**Table 5**. Importance Value Index of mangrove vegetation in the Coastal Area of Mandalika International Street Circuit, Central Lombok District, Indonesia

| Species | Importance Value Index (%) | | | |
|---|---|---|---|---|
| | Stratum | | | |
| | Seedling | Sapling | Pole | Trees |
| *Avicennia alba* | 1.75 | 0 | 19.15 | 5.51 |
| *Avicennia lanata* | 2.16 | 10.84 | 24.15 | 17.07 |
| *Avicennia marina* | 1.75 | 3.19 | 6.11 | 0 |
| *Ceriops tagal* | 29.05 | 27.27 | 21.68 | 0 |
| *Rhizophora apiculata* | 105.21 | 89.14 | 129.61 | 119.60 |
| *Rhizophora mucronata* | 22.89 | 28.79 | 15.06 | 3.73 |
| *Rhizopora stylosa* | 25.46 | 24.62 | 25.89 | 9.37 |
| *Scyphiphora hydrophyllacea* | 6.24 | 1.44 | 0 | 0 |
| *Sonneratia alba* | 5.47 | 13.27 | 37.85 | 108.38 |
| *Sonneratia caseolaris* | 0 | 1.44 | 13.04 | 19.99 |
| *Sonneratia ovata* | 0 | 0 | 7.44 | 16.39 |
| Total | 200 | 200 | 300 | 300 |

**Table 6.** Shannon-Wiener Diversity Index in the mangrove ecosystem in the Mandalika International Street Circuit, Central Lombok District, Indonesia

| Species | Density (ind. /ha) | Pi | H'' |
|---|---|---|---|
| *Avicennia alba* | 0.300 | 0.0019 | 0.0120 |
| *Avicennia lanata* | 2.060 | 0.0132 | 0.0572 |
| *Avicennia marina* | 0.420 | 0.0027 | 0.0160 |
| *Ceriops tagal* | 22.590 | 0.1451 | 0.2801 |
| *Rhizophora apiculata* | 82.570 | 0.5302 | 0.3364 |
| *Rhizophora mucronata* | 19.090 | 0.1226 | 0.2573 |
| *Rhizopora stylosa* | 20.000 | 0.1284 | 0.2636 |
| *Scyphiphora hydrophyllacea* | 5.790 | 0.0372 | 0.1224 |
| *Sonneratia alba* | 2.650 | 0.0170 | 0.0693 |
| *Sonneratia caseolaris* | 0.230 | 0.0015 | 0.0096 |
| *Sonneratia ovata* | 0.030 | 0.0002 | 0.0016 |
| Totals | | | 1.425 |

**Shannon-Wiener diversity index**

Shannon-Wiener diversity index in the Mandalika International Street Circuit mangrove ecosystem is included in the quite good category with even diversity values because the H' value is not less than 1 (1.425) (Table 6).

**Discussion**

The condition of the Mandalika International Street Circuit mangrove vegetation is a 62.53 ha rehabilitation of mangroves since 2004. This can be seen from the growth characteristics of the species in the back zone adjacent to the mainland, *R. mucronata* species grows homogeneously with parallel growth characteristics. Apart from that, mangrove stands with the characteristics of trees with quite large diameters still exist with very small stands (15 individuals/ha) in the middle zone of the ecosystem.

Mangrove composition is the number of identification results for each species of vegetation habitat found. The presence of mangrove composition in a habitat can reflect the ability of this species to grow and adapt to environmental conditions. The Mandalika International Street Circuit mangrove identification results of the Mandalika International Street Circuit mangrove identification found four families: Avicenniaceae, Rhizophoraceae, Rubiaceae, Sonneratiaceae. The Rhizophoraceae family has the greatest species diversity, including: *R. apiculata, R. mucronata, R. stylosa*, and *C. tagal*. Meanwhile, three other families were found with 1-3 species of mangroves, namely in the Avicenniaceae and Sonneratiaceae families, three species of mangroves, while in the Rubiaceae only have one species, *S. hydrophyllacea*.

Temperature significantly influences the physiology and respiration in mangrove vegetation (Hopper et al. 1973; Gillis et al. 2019; Rodrigues et al. 2021). This is related to balancing salt levels in cells (Rahimi et al. 2020; Qu et al. 2021). A temperature increase of 10°C can double the speed of physiological reactions, requiring mangroves to adapt to environmental conditions (Kumari and Rathore 2021; Wang and Gu 2021), while the average temperature that is suitable for mangrove growth and development is a maximum of 32°C during the day and a minimum of 23°C at night.

The optimum temperature for the growth and development of each species of mangrove is different (Su et al. 2020; Kaullysing et al. 2023), as is the case with physiological processes (photosynthesis and respiration) for the production of young leaves of *A. marina*, which function well at 18-20°C (Jacotot et al. 2021), while the *R. stylosa*, *Ceriops*, *Excocaria*, and *Lumnitzera* grow optimally at temperatures of 26-28°C (Chen et al. 2022). *Bruguiera* grows optimally at 27°C (Rendana et al. 2023), and *Xylocarpus* grows optimally at 21-26°C (Robertson et al. 2020).

Good salinity conditions support the growth and development of mangrove vegetation at intervals of 10-30 ppt (Noor et al. 2015), while salinity conditions that are too high (hypersalinity) and too low can cause osmotic pressure in cells, resulting in dry plants wither and die (Kodikara et al. 2017; Raganas and Magcale-Macandog 2020). The adaptation mechanism for each mangrove in overcoming salinity levels that do not support its growth and development is carried out in different ways (Peters et al. 2021; Sudhir et al. 2022), one of which is that the *Avicennia* adapts by excreting excess salt through glands found beneath its leaves (Naskar et al. 2021; Wei et al. 2022), *Rhizophora* develops a root system that is almost impenetrable to saltwater (Wang et al. 2022; Ankure et al. 2023). Salt entering the mangrove organs will accumulate in old leaves and be wasted as the leaves fall (Kodikara et al. 2020; Grigore and Toma 2021).

The pH value of a body of water is related to the acid and base content or hydrogen ion content of a solution (Pye et al. 2020). Water pH conditions that are too high can affect the activity of aquatic biota in the decomposition process, which can affect ecosystem fertility (Shivanna and Nagendrappa 2014). The degree of acidity (pH) in the range of pH<5.0 or pH>9.0 is unfavorable for the growth and clustering of mangroves (Raganas and Magcale-Macandog 2020; Wintah et al. 2021), while the pH conditions of the waters of the Mandalika International Street Circuit mangrove ecosystem still support growth and development, with an average of 8.04±0.148.

The highest density in the seedling strata in the mangrove vegetation of Mandalika International Street Circuit is *R. apiculata*, with a total of 261 individuals/ha. The high number of *R. apiculata* can be caused by propagule productivity (Asaeda and Kalibbala 2009; Amaliyah et al. 2018; Wong et al. 2020; Zhang et al. 2021; Mohandas and Abraham 2023). This is following field conditions that *R. apiculata* can produce propagules from the age of mangrove plants in pole and tree strata. The high density of mangrove seedling strata in the Mandalika International Street Circuit indicates good regeneration as a sustainable ecosystem conservation effort, even based on the report of Aluri (2013), that *R. apiculata* takes less than 61 days for the growth of flower buds to become propagules. An interesting condition was found in the density of *C. tagal*, which is the second species with a high level of density (74 individuals/ha) in the seedling strata when compared with the other nine species (*A. alba*, *A. lanata*, *A. marina, R. mucronata, R. stylosa, S. hydrophyllacea, S. alba, S. caseolaris*, *S. ovata*, and *R. apiculata*). This condition occurs due to the ability of *C. tagal* to produce propagules from the sapling strata with good growth ability as part of regeneration (Das et al. 2019; Zhang et al. 2021; Zainol et al. 2022).

Apart from that, other factors that can determine the level of density of mangrove vegetation are topography (Pérez-Ceballos et al. 2020) and the substrate fraction of the mangrove ecosystem (Castán et al. 2016; Soinne et al. 2021). These two factors influence the ability to grow seeds (propagules and fruit) that fall on the substrate around bay habitats with calm waters (Amaliyah et al. 2018; Rahman et al. 2023). This is different from mangroves that grow offshore or in coastal areas, which are always influenced by sea tides, such as the Gili Sulat mangrove ecosystem, East Lombok, the Sekotong mangrove ecosystem, West Lombok, the Tuwas-was mangrove ecosystem, East Lombok, and the Selamat Bay mangrove ecosystem, that the propagules or fruit that falls onto the substrate is very likely to be carried by currents towards the sea, potentially rotting and dying (DeYoe et al. 2020; Friess et al. 2020; Arceo-Carranza et al. 2021).

The mangrove with the highest density in the sapling, pole, and tree strata on the Mandalika International Road Circuit is *R. apiculata,* with respective numbers of 312 individuals/ha, 444 individuals/ha, and 160 individuals/ha; this condition shows that *R. apiculata* is a species with the ability to grow and adapt well to the Mandalika International Street Circuit. Apart from that, the role and benefits of *R. apiculata* from an ecological perspective as disaster mitigation to protect the eastern Mandalika International Road Circuit area. This role refers to the growth zone of *R. apiculata* in the leading zone area, which acts as a wave breaker to minimize the occurrence of abrasion. Furthermore, *R. apiculata* is a species that has the physiological ability to prevent salt through filters in the roots and has good adaptability to mud, clay, and sand substrates (Irawan et al. 2021). This indicates that mangrove regeneration in several species, such as: *R. apiculata, R. mucronata, R. stylosa*, and *S. alba,* will grow well.

This differs from the mangrove species of *A. alba, A. marina,* and *S. ovata,* which are found in small numbers, especially in seedlings, saplings, and tree strata. Therefore, it is feared that some species regeneration will quickly become extinct, especially if many mangrove trees are cut down under the pretext of conversion land functions in the mangrove ecosystem areas. The condition of the density of mangrove vegetation at the Mandalika International Street Circuit refers to the criteria for density of trees in the number of individuals/ha according to the decree of the Minister of Environment (2004) in the rarely damaged status category. This is because the density found in each stratum is less than 1000 individuals/ha, namely in the seedling stratum with a total of 490 individuals/ha, sapling stratum with 650 individuals/ha, pole stratum with 619 individuals/ha, and tree stratum with 242 individuals/ha.

The important value index of seedling and sapling strata is controlled by the *R. apiculata* at 105.21% (seedling stratum) and 89.14% (pole stratum) with relative density and relative frequency that are evenly distributed and greater than the other 10 species. Different conditions of *A. marina* with the lowest important value index in the seedling strata caused by the mismatch of growing habitat on sandy substrates in the Mandalika International Street Circuit mangrove ecosystem, while *A. marina* grows and develops better on muddy substrates (Abubakar et al. 2020; Jalil et al. 2020; Irawan et al. 2021).

Moreover, the important value index of pole and tree strata in the mangrove vegetation of the Mandalika International Street Circuit is dominated by *R. apiculata*. One of the factors for the highly important value index of *R. apiculata* species is supported by the values of relative density (71.73%), relative frequency (42.68%), and relative dominance (15.20%), which are the largest and evenly distributed in 49 observation quadrants; this condition correlates positively for good growth and development productivity in the seedling and sapling strata.

The Shannon-Wiener diversity index can describe the condition of mangrove vegetation based on its species diversity. The mangrove diversity of the Mandalika International Street Circuit is composed of an even diversity of mangrove species, as evidenced by an H value of more than 1 (1.425). The mangrove diversity of the Mandalika International Street Circuit is higher than the mangrove ecosystems on the Pacitan Coast, East Java, Indonesia, with H' between 0.23-0.78 (Sholiqin et al. 2021) and lower than the H' value of the Sundarbans Mangrove Forest, Bangladesh (H': 1.520-2.708) (Siddiqui et al. 2021). Several factors influence the species diversity value of a mangrove ecosystem due to geological systems, anthropocentrism, weather, and sustainable conservation (Sannigrahi et al. 2020).

The existence of a mangrove ecosystem that grows around the Mandalika International Street Circuit has an important role and function ecologically. For example, mangroves follow their growth zoning, which can be a buffer and mitigation area for disasters such as: tsunamis, wind and wave breakers, carbon absorbers, etc. As is the case with mangrove species that grow in the leading zone, such as *Rizhopora*, which can act as wave breakers with the function of their root morphology structure. The *R. apiculata* aligns with this condition in the leading zone facing the sea in the Mandalika International Street Circuit area.

In conclusion, the highest density value and importance index in the Mandalika International Street Circuit mangrove vegetation was found for the *R. apiculata* species in the seedling, sapling, pole, and tree strata. The dominance of *R. apiculata* is good as a disaster mitigation function which ecologically acts as buffer vegetation for the Mandalika International Street Circuit special economic area. Apart from that, the value of H' proves that the distribution of mangroves in the Mandalika International Street Circuit area grows evenly.

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