Structure and dominance of species in mangrove forest in surrounding area of mangrove restoration program REMAJA PHE ONWJ in Bekasi Regency, Indonesia

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Abstract. This study aims to analyze the structure and composition of mangrove vegetation in Pantai Bakti and Pantai Bahagia villages, Bekasi Regency, in West Java, to provide primary data related to mangrove forest diversity. This study was conducted in the surrounding area of Mangrove Restoration Program in the North Coast of Java "*REMAJA"* conducted by PHE ONWJ in Pantai Bakti and Pantai Bahagia villages (Muara Beting and Muara Bendera), Bekasi Regency, West Java in November 2021. Data analysis was conducted to determine the condition and composition of mangrove species at the research site using a transect plot. The analyses include important value index (IVI), species density (K), Shannon-Wiener diversity index (H'), dominance index (C), and evenness index (E). Generally, the results showed that Pantai Bahagia has a high density for all types of growth compared to Pantai Bakti village. Particularly in Muara Beting sample plots which have 16.250 ind ha^{-1} at seedling level. In Pantai Bakti, no species were found at seedling level in the sample plots. Moreover, Pantai Bakti has higher IVI than Pantai Bahagia sample plots. The index results mainly show that mangrove in Pantai Bakti has very low diversity and moderate evenness. While in Muara Beting has low diversity and low to moderate evenness. Muara Bendera has low to moderate diversity and moderate to high evenness index. Comparing the wide areal extent of mangrove covers in Bekasi Regency, it can be improved to moderate to high composition of mangrove by a massive mangrove planting program.
Key Words: Bekasi, IVI, mangrove, PHE ONWJ, REMAJA.

Introduction. Coastal ecosystems play an important role in providing a habitat for various marine communities and humans. Examples of coastal ecosystems include mangroves, estuarine, coral reefs, and seagrass ecosystems that have ecological and economic functions for the sustainability of coastal areas in the future. Unfortunately, coastal ecosystems have often experienced pollution which is mainly caused by human activities, such as land conversion into agricultural land, fisheries or settlements; oil spills; industrial waste pollution, etc. (Hidayatullah et al 2016; Setyonugroho et al 2019; Maulani et al 2021).

Spalding et al (2014) explains that coastal ecosystems are threatened by both direct and ex-situ impacts. The former include habitat loss or fragmentation, notably from the land claim, conversion to aquaculture and mangrove harvest, as well as overfishing and destructive fishing, both of which can lead to significant changes in ecosystem structure and function. Indirect or ex-situ impacts include many land-based activities that affect sediment, nutrient, and pollutant levels in coastal waters. Conversion of natural lands to agriculture and poor agricultural practices frequently leads to freshwater runoff and sediment delivery changes.

Mangroves ecosystem is one that is mainly impacted by these activities. The mangrove ecosystem is susceptible to outside disturbances, especially from pollution

activities, conversion of mangrove forests into non-forest areas, and excessive exploitation of mangrove products. In fact, salt marshes and mangroves contribute to coastal protection by reducing wave energy, increasing sedimentation, and/or reducing erosion and movement of sediments (Gedan et al 2011; Shepard et al 2011).

Due to the development and bad impact of human activities, periodically monitoring over mangroves forest needs to be done. Ecologically, mangrove forest maintains the stability or balance of ecosystems and nutrient sources (Vincentius et al 2018). The enormous potential of the mangrove ecosystem has a very important role in human life, especially for coastal communities (Armitage 2002; Gunarto 2004). It is important to analyze the structure and composition of mangrove vegetation as part of a biodiversity study in that area and also to determine the impact of activities in the surrounding area (Pant et al 2015). Bekasi Regency, especially in Pantai Bakti and Pantai Bahagia villages, has a sufficient area of mangroves that need to be protected. In 2019, mangrove covers in Pantai Bakti and Pantai Bahagia reached 70.72 ha and 245.35 ha, respectively (Maulani et al 2021). Meanwhile, these villages are prone to erosion, coastal floods (Hidayatullah et al 2016), oil spills (Setyonugroho et al 2019), and mangrove product exploitation (Maulani et al 2021).

Therefore, in this study, we aim to analyze the structure and composition of mangrove vegetation in Pantai Bakti and Pantai Bahagia villages, Bekasi Regency, in West Java, to provide primary data related to mangrove forest diversity.

Material and Method

Description of the study site. This study was conducted in the surrounding area of Mangrove Restoration Program in North Coast of Java "REMAJA" conducted by PHE ONWJ in Pantai Bakti and Pantai Bahagia villages (Muara Beting and Muara Bendera), Bekasi Regency, West Java in November 2021 (Figure 1). Generally, mangrove area in Pantai Bahagia village from 2001 to 2010 was dominated by fish and shrimp ponds owned by the community (Figure 2). Then from 2015 to 2019, it showed the development of mangroves, in which mangroves began to be planted both on the edge of the pond and in the pond itself. Mangrove cover in Pantai Bakti village every year has experienced land erosion due to abrasion, especially those adjacent to the shoreline (Maulani et al 2021).

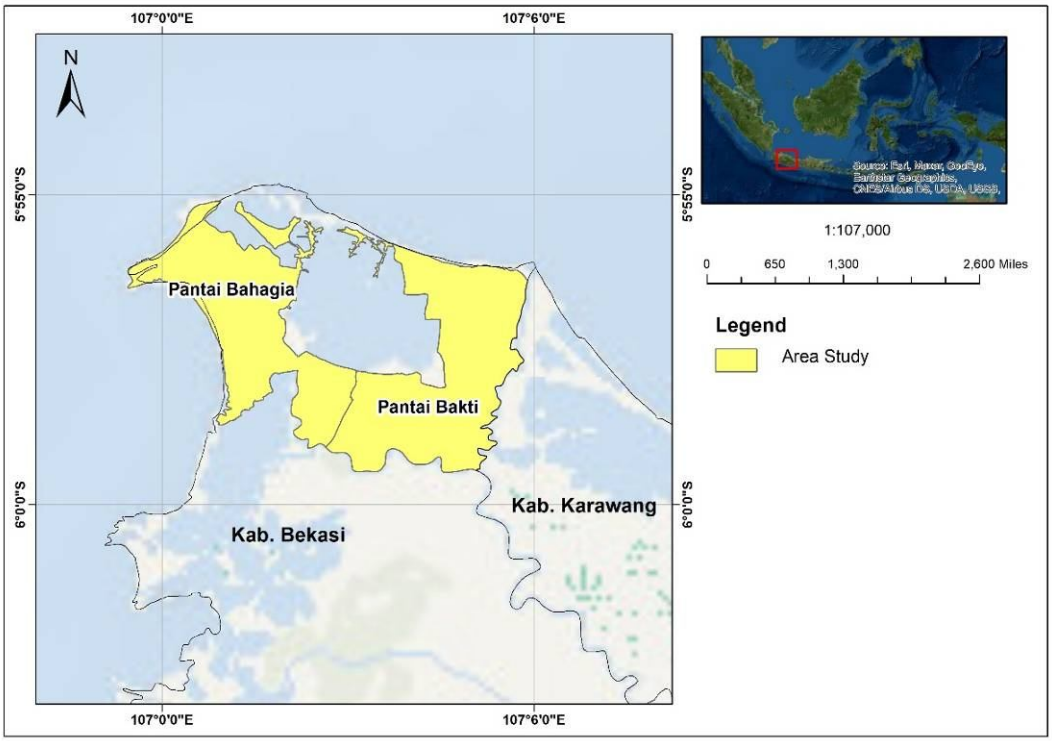

Figure 1. Study area.

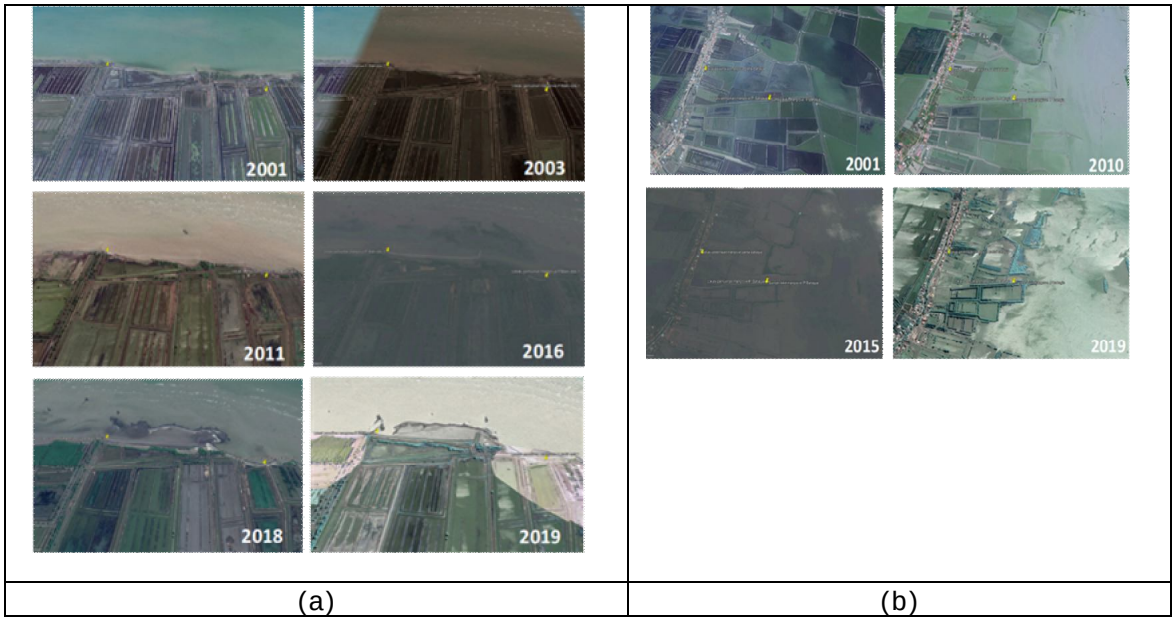

Figure 2. Mangrove forests in Pantai Bakti village (a) and Pantai Bahagia village (b).

The reduced area of mangrove land cover causes abrasion every year because there are no natural or artificial dampers to withstand sea waves. Figure 2 shows the development of mangrove land cover in Pantai Bakti village. Every year, mangrove land cover fluctuated. From 2001 to 2011 mangrove land cover has decreased due to abrasion (Maulani et al 2021). Meanwhile, from 2016 to 2019, there has been an increase of mangrove forest areas due to active replanting programs conducted by PHE ONWJ and many other private companies collaborations with the local community (Sudiarto 2018; Kusuma 2019; Noviyanti 2019; LindungiHutan 2021; Perhutani 2021; Shofa 2022).

Tools and materials. The tools used in this research were GPS, Thallysheet, stationery, field guide, sewing meter, roll meter, rope, and camera. Meanwhile, the tools used for data analysis were Ms. Excel and ArcGIS 10.5. The material used was mangrove at the research site.

Data collection. Data was collected using the transect method, where the location was determined by purposive sampling. Each sampling plot from total 160 m^2 area was made with an area of 10 x 10 meters and divided into 3 plots, namely: 1) 2 x 2 m plots were used to measure seedlings with a height category of < 1.5 m; 2) 5 x 5 m plots are used to measure stakes with categories > 1.5 m high and < 10 cm in diameter; and 3) 10 x 10 m plots were used to measure trees with a height category > 1.5 m and diameter > 10 cm (Figure 3).

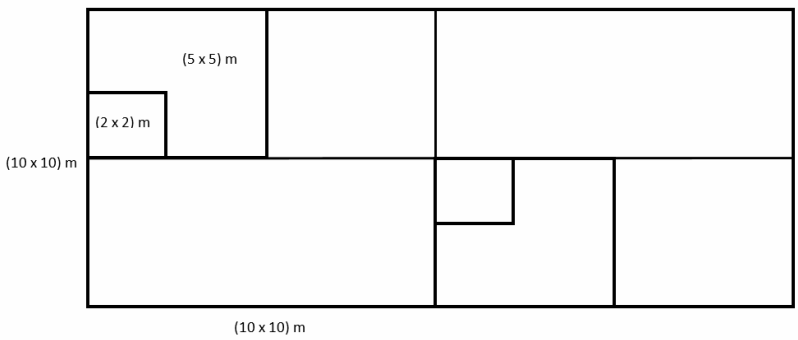

Figure 3. Mangrove method of sampling plot.

Data analysis. Data analysis was conducted to determine the condition and composition of mangrove species at the research site. The results of the analysis of this research data are the important value index (IVI), species density (K), Shannon-Wiener diversity index (H'), dominance index (C), and evenness index (E). IVI can describe the composition of species and the level of species dominance in a community (Indriyanto 2008). IVI at the sapling and seedling level was obtained from the sum of relative density and relative frequency, while for the tree level, IVI was obtained from the number of IVIs for saplings/seedlings and the comparison between the area of the base area of a species and the area of the sample plot.

In addition to the IVI, density which describes the density of individuals per species per hectare, was obtained from the comparison between the number of individuals of a species and the area of the sample plot. While, H' can be used to determine the effect of disturbances on the environment or to determine the stages of succession and stability of the plant community (Hikmah 2017). H' is classified into 3 categories, namely: 1) H' < 2 indicates a low biodiversity; 2) H' = 2-3 indicates a moderate biodiversity; 3) H' > 3 indicates a high biodiversity.

Dominance index (C) describes the dominance of a species in an area. C is obtained by summing the results of the square of the ratio between the density of a species and the total density of all species. The value is $0 \leq C \leq 1$, which means that if the C value is close to 1 then there has been a dominance of a plant species, whereas if the C value is close to 0 then there is no dominance of a plant species, which is then indicated by the presence of several species dominating together. The final analysis result is evenness index (E) which describes the level of individual evenness per species. E is obtained from the comparison between H' and ln(S) where S represents the number of species found. The value of E is classified based on 3 categories, namely: 1) E < 0.3 indicates a low evenness of species; 2) 0.3 < E < 0.6 indicates moderate evenness of species; 3) E > 0.6 indicates a high evenness of species (Magurran 1988).

Results and Discussion

Species composition. Based on the sample plot in study location, mangrove species that were found in Pantai Bahagia village consisted in *Avicennia alba*, *Avicennia marina*, *Bruguiera cylindrica*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa*, and *Sonneratia alba*. While Pantai Bakti village was covered by *Avicennia alba*, *Avicennia marina*, and *Rhizophora mucronata*. According to Indriatmoko et al (2019), mangrove vegetation in the coastal area of Muara Gembong District is mostly overgrown by major mangroves, such as *Avicennia alba*, *Avicennia marina*, *Avicennia officinalis*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Sonneratia alba*, and *Sonneratia caseolaris.* This shows the potential for species regeneration in the coastal area of Muara Gembong (Maulani et al 2021).

Density and importance value index. The results of data analysis showed that the dominant species found in Pantai Bakti was *Avicennia alba* at the tree level, *Rhizophora mucronata* at the sapling level, and no species found in the seedling level. While in Pantai Bahagia, the dominant species at tree level was *Avicennia marina*, and *Rhizophora mucronata* at the sapling and seedling levels. The level of species dominance in a plant community can be determined from the IVI. This can be seen from the similarity of species that appear in the species dominance and IVI analysis (Table 1) in each study location. Species that have a high IVI will be more stable in terms of species resistance and growth (Rahmasari et al 2019). Plants with a high IVI have better adaptability, competitiveness and reproductive capacity compared to other plants in a certain area (Soerianegara & Indrawan 2002).

Based on density level, in Pantai Bakti the highest density was found in *Avicennia alba* at the tree level, *Avicennia marina* at the sapling level and no species found in seedling level. While in Muara Beting, Pantai Bahagia, the highest density was found in *Avicennia marina* at the tree level, and *Rhizophora mucronata* at the sapling and seedling levels. Moreover, the highest density was found in Muara Bendera, Pantai Bahagia, the

highest density was found in *Avicennia marina* at all growth rates (Table 1 and Figure 4). From the results of the vegetation analysis, the potential for mangrove tree in Pantai Bakti, Pantai Bahagia (Muara Beting and Muara Bendera) were 350 ind ha^{-1}, 666.67 ind ha^{-1}, and 990 ind ha^{-1}, respectively.

Table 1

List of important value index (%) and Pantai Bahagia and Pantai Bakti villages that have the highest INP based on growth rate

Class of growth	*Species*	*Importance value index (%)*	*Species density (ind ha^{-1})*
	Pantai Bahagia (Muara Beting)		
Tree	*Avicennia marina*	142.79	316.67
Sapling	*Rhizophora mucronata*	200.00	733.33
Seedling	*Rhizophora mucronata*	127.64	16250.00
	Pantai Bahagia (Muara Bendera)		
Tree	*Avicennia marina*	221.34	810.00
Sapling	*Avicennia marina*	94.66	1720.00
Seedling	*Avicennia marina*	86.64	4500.00
	Pantai Bakti		
Tree	*Avicennia alba*	300.00	350.00
Sapling	*Rhizophora mucronata*	119.78	-
	Avicennia marina	-	680.00
Seedling	-	-	-

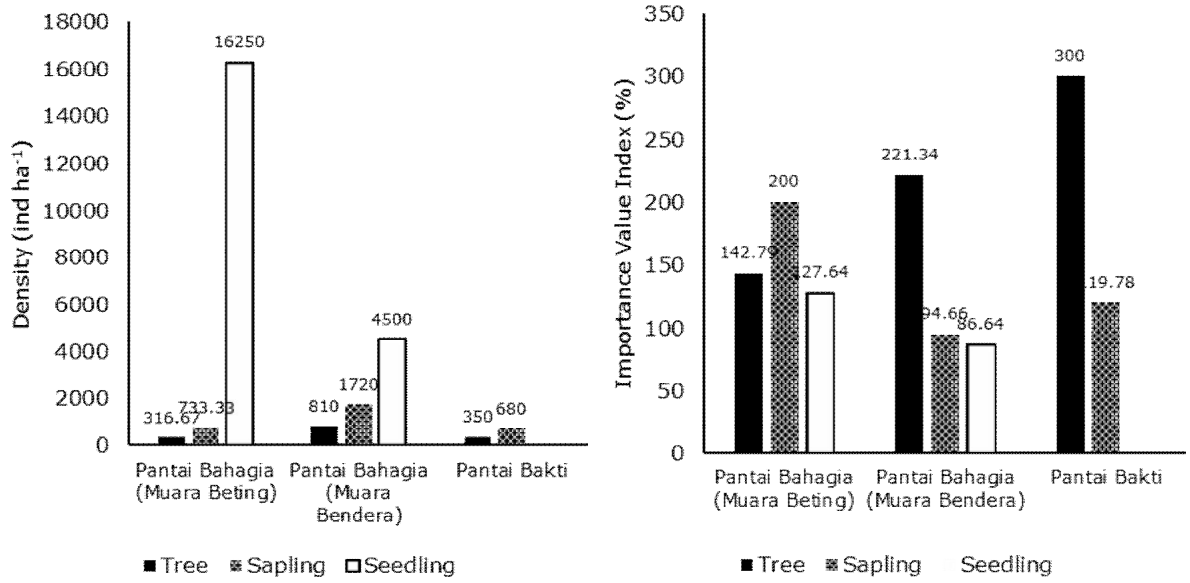

Figure 4. The comparison of density and IVI in Pantai Bahagia (Muara Beting and Muara Bendera sample plot) and Pantai Bakti villages mangrove forests.

Generally, the results showed that Pantai Bahagia has high density for all type of growth compared to Pantai Bakti village. Particularly in Muara Beting sample plots which has 16.250 ind ha^{-1} at seedling level. In Pantai Bakti there were no species found at seedling level in the sample plots. Moreover, Pantai Bakti has higher IVI than Pantai Bahagia sample plots (Figure 4). The IVI shows the range of the index that describes the community structure and distribution pattern of mangroves (Supriharyono 2007). The difference in the IVI of mangrove vegetation is due to competition in each species to get nutrients and sunlight at the research site. Apart from nutrients and the sun, other

factors that cause differences in the density of mangrove vegetation are the type of substrate and the tides (Parmadi et al 2016).

Diversity index, dominance index, and evenness index. The species diversity index (H') in the mangrove location of Pantai Bakti Village ranges from 0.000 to 0.860 (including the low category). The dominance index ranges from 0.488 to 1. Meanwhile, the species evenness index (E) ranged from 0.783 to 0.884. In Pantai Bahagia village, the species diversity index (H') in Muara Beting's sample plots ranges from 0.639 to 0.960 (including the low category). The highest H' index was found at the sapling growth rate and the lowest at the tree growth rate. The dominance index ranges from 0.354 to 0.629. Meanwhile, the species evenness index (E) ranged from 0.397 to 0.873. Lastly, in Muara Bendera's sample plots H' ranges from 0.599 to 1.213 (including low to moderate categories). The highest H' index was found at the sapling growth rate and the lowest at the tree growth rate. The dominance index (D) ranges from 0.349 to 0.686. Meanwhile, the species evenness index (E) ranged from 0.545 to 0.967 (Table 2 and Figure 5).

Table 2

List of species diversity, species dominance, and evenness index of mangrove forest in Pantai Bahagia and Pantai Bakti villages

Class of growth	*Diversity index (H')*	*Dominance index (%)*	*Evenness index (ind ha^{-1})*
	Pantai Bahagia (Muara Beting)		
Tree	0.639 (low)	0.629	0.397 (low)
Sapling	0.960 (low)	0.430	0.873 (moderate)
Seedling	0.895 (low)	0.354	0.460 (low)
	Pantai Bahagia (Muara Bendera)		
Tree	0.599 (low)	0.686	0.545 (moderate)
Sapling	1.213 (moderate)	0.349	0.875 (high)
Seedling	1.011 (moderate)	0.432	0.730 (moderate)
	Pantai Bakti		
Tree	0.000 (low)	1.000	-
Sapling	0.613 (low)	0.578	0.884 (moderate)
Seedling	-	-	-

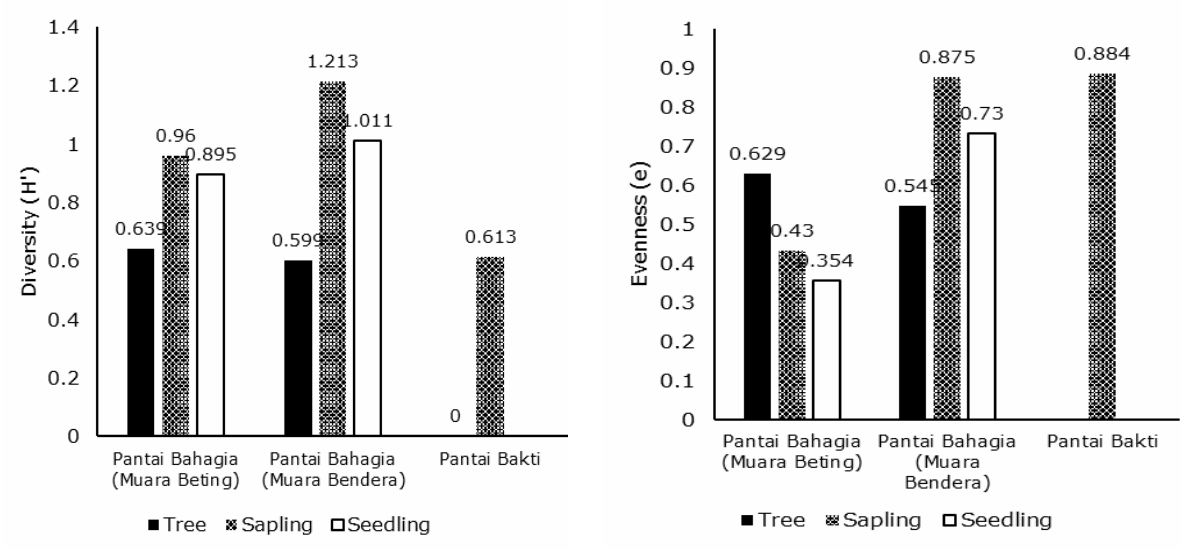

Figure 5. The comparison of diversity index (H') in Pantai Bahagia (Muara Beting and Muara Bendera) and Pantai Bakti villages mangrove forests.

From the results, mainly mangrove in Pantai Bakti has very low diversity and moderate evenness. While in Muara Beting has low diversity and low to moderate evenness. Muara Bendera has low to moderate diversity and moderate to high evenness index. Overall, the mangrove composition in Bekasi Regency was low to moderate. Comparing the wide areal extent of mangrove covers in Bekasi Regency, it can be improved to moderate to high composition of mangrove. Therefore, mangrove restoration indeed is needed to accelerate the mangrove growth in Bekasi. One of the private companies that is currently conducting mangrove restoration in Bekasi is PHE ONWJ. They have been planting a total of 2500 seeds in Pantai Bakti and 8000 seeds in Pantai Bahagia (PHE ONWJ 2021). Dead plants were embroidered in 2022 with 1220 seeds in Pantai Bakti and 1200 in Pantai Bahagia (PHE ONWJ 2022). With this restoration program, it will have an impact on increasing the density and composition of mangrove species, especially the seedling level. This might be the initial encouragement for all stakeholders to participate in the mangrove restoration program as a mitigation to disasters that often occur in coastal areas.

Conclusions. Based on this study, the dominance species of mangrove that found in Pantai Bahagia village at tree level was *A. marina*. Meanwhile, at sapling and seedling levels was *R. mucronata*. While in Pantai Bakti village at tree and sapling levels, were *A. alba* and *R. mucronata* respectively. Meanwhile, no species found in seedling level. Generally, the results showed that Pantai Bahagia has a higher density for all types of growth compared to Pantai Bakti village. Particularly in Muara Beting sample plots which have 16.250 ind ha^{-1} at seedling level. In Pantai Bakti, no species were found at seedling level in the sample plots. Moreover, Pantai Bakti has higher IVI than Pantai Bahagia sample plots. The index results mainly show that mangrove in Pantai Bakti has very low diversity and moderate evenness. While in Muara Beting has low diversity and low to moderate evenness. Muara Bendera has low to moderate diversity and moderate to high evenness index.

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Conflict of interest. The authors declare that there is no conflict of interest.

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