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Study of Mangrove Forest Change towards the Diversity and Carbon Stock of Mangroves in Segara Anakan, Cilacap

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Abstract. Segara Anakan Cilacap, being the largest mangrove area in Java Island, is one example of a degraded area which is mostly caused by land conversion to farming lands, ponds, housing, and industrial properties affecting the mangrove community in various ways. The objective of this research is to know the diversity and carbon stock of mangroves in different types of environmental change in Segara Anakan, Cilacap, as well as to know the correlation between environmental factors in various types of environmental change with diversity and carbon stock of mangroves in Segara Anakan, Cilacap. This research was conducted using clustered sampling from 8 stations located at the ex rice field, ex shrimp pond, illegal cutting area, and forest. The highest diversity and carbon stock value belong to stations with forest habitats with a total of 34 tons/ha of carbon stock and the highest diversity of saplings in station F1 (1.80). Correlation values between diversity and environmental factors ranged from 0.172–0.449, whereas results between carbon stock and environmental factors range from 0.065–0.724.

1. Introduction

According to Keputusan Presiden Indonesia Nomor 121 Tahun 2012, the mangrove ecosystem is one ecosystem that is characterized by mangrove forests, which are a group of coastal vegetation that has distinctive morphology with root systems and can adapt to tidal areas with mud or sandy substrates in the tropical and sub-tropical regions. They are among the most productive and biologically relevant ecosystems of the world because they provide an essential and unique ecosystem [1]. Despite their importance, mangroves are still facing a global problem, which has caused their numbers to decline rapidly. Climate changes (sea-level rise and altered rainfall) and human activities (urban development, aquaculture, mining, and overexploitation of timber, fish, crustaceans, and shellfish) represent major threats for mangrove habitats [2]. Segara Anakan Cilacap is the largest mangrove area in Java Island, is one example of an area that still faces these problems today. Segara Anakan Lagoon, Cilacap, was created through the protection of Nusakambangan Island from sea waves and freshwater input of the Citanduy River. In 1978, the mangrove area in Segara Anakan Cilacap consisted of 17,090 ha, whereas in 2004, it was only left with 9,271.6 ha. Each year the mangrove area in Segara Anakan Cilacap faces as much as 192,96 ha of degradation caused by illegal logging as much as 14 m³/day, conversion into agriculture as much as 5.4%, conversion into shrimp ponds as much as 2.5%, urbanization as much as 1.1%, industrial properties as much as 0.4% and conversion into other categories as much as 1.7% [3].



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In 2016, the distribution of mangroves in this area can be grouped into the sparse area as much as 571.95 ha, medium area as much as 762.21 ha, and dense area as much as 4,792.11 ha [3]. According to the previous research conducted by [4], the diversity index of mangrove vegetation in Segara Anakan Cilacap is low to moderate, ranging from 0.562–1.748. Destruction of mangrove ecosystems also impacts its function as the ecosystems' carbon sink. However, previous studies conducted by [5] revealed that from 2003–2012, the capacity of mangroves in Segara Anakan Cilacap to store carbon has decreased due to continuous land conversion. The objective of this research is to know the diversity and carbon stock of mangroves in different types of environmental change in Segara Anakan, Cilacap, as well as to know the correlation between environmental factors in various types of environmental change with diversity and carbon stock of mangroves in Segara Anakan, Cilacap.

2. Methods

This research was done by survey method at eight stations in Segara Anakan Cilacap with three replications. Each station had a distance of approximately 50 m between each other. Three plots were created based on a cluster of each environmental condition with the use of a rolling meter for measuring 1 x 1 m (1 m²) for seedlings, 5 x 5 m (25 m²) for saplings, and 10 x 10 m (100 m²) trees plot. The characteristic of each station was based on four different environmental conditions (ex rice field, ex shrimp pond, illegal logging area, and natural forest). Unknown mangrove trees were also identified [6].

2.1. Calculating mangrove vegetation diversity

Diversity was analyzed using Primer 5 software based on the number of individuals and the number of species to obtain the Shannon-Wiener diversity index (H'). Results will then be presented in the form of a table to compare the diversity index of vegetation categories between stations.

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2.2. Calculating carbon stock

In this research, carbon stock was calculated through the above-ground tree weight starting by estimating the biomass of the mangrove vegetation by the use of an allometric formula, which varies depending on the type of vegetation in each environmental type. Species that are not included in the table were calculated using the common formula.

Table 1. The allometric equation of mangrove tree

No	Species	Formula	Reference
1	<i>Rhizophora apiculata</i>	$W_{top} = 0.235DBH^{2.42}$	Ong <i>et al.</i> (2004) in [7]
2	<i>Bruguiera parviflora</i>	$W_{top} = 0.168DBH^{2.42}$	Clough and Scott (1989) in [7]
3	<i>Rhizophora mucronata</i>	$W_{top} = 0.1466DBH^{2.31}$	Dharmawan (2013) in [8]
4	<i>Avicennia marina</i>	$W_{top} = 0.308DBH^{2.11}$	Comley and McGuinness (2005) in [7]
5	Common formula	$W = 0.251\rho D^{2.46}$	[7]

Notes:

W_{top} = Above ground tree weight (kg)

ρ = Wood density (g cm⁻³)

DBH = Diameter at breast height (cm)

After each biomass was calculated, it was later used to calculate carbon stock based on the formula and conversion value by Kauffman *et al.* (2011) in [9]. Species that are not enlisted in the vegetation conversion value were calculated using the common equation.

Carbon (C) = Biomass (B) x (VCV)

Notes:

Rhizophora apiculata = 0.45

Sonneratia alba = 0.471

Common equation = 0.46

For understorey species, carbon stock was calculated using the allometric formula proposed by [10] as follows:

Table 2. The allometric equation for understorey

No	Species	Equation
1	<i>Acanthus ebracteatus</i>	$C = 4.856 - 0.105H + 0.001H^2 - 6.278.10^{-7} H^3$
2	<i>Acanthus ilicifolius</i>	$C = -2.247 + 0.18H + 1.909.10^{-5}H^2$
3	<i>Derris trifoliata</i>	$C = -4.261 + 0.296H - 0.003H^2 + 2.101.10^{-5}H^3$
4	<i>Acrostichum speciosum</i>	$C = -5.238 + 0.259 H$

Notes:

C = Carbon Stock

H = Length of Vegetation (cm)

2.3. Measuring temperature

Temperature measurement is done by the use of thermometers that are dipped in water, which will eventually show the temperature value [11]. Air temperature measurement was done by hanging the thermometer at the sampling area, and the value was noted.

2.4. Measuring water salinity

The water salinity was measured using a hand-saline-refractometer. A few drops of water were dropped onto the glass of the hand-saline-refractometer, and the level of salinity in ppt (part per thousand) was observed on the scale [11].

2.5. Measuring soil water content and organic matter

Small portions of soil samples were placed in aluminum foil, and the initial weight was measured using an analytical scale. Samples were then placed in an oven for approximately three days at a temperature of 60°C. After three days, the samples were weighed again for their dry weight. The difference between initial weight and dry weight is the amount of water content. For organic matter, samples from the oven were weighed again for initial weight and then placed into a furnace for four hours at a temperature of 400°C. After four hours, the samples were weighed again for their dried weight. The weight loss of the soil from the furnace process is the amount of organic matter. Measurement of organic matter and water content was calculated using the following formula according to [12]:

$$OC = \frac{B\alpha - B\beta}{B\alpha} \times 100 \%$$

$$WC = \frac{Bo - B\alpha}{Bo} \times 100 \%$$

Notes:

WC = Water Content (%)

OC = Organic Content (%)

Bo = Initial weight (g)

Bα = Dry weight from the oven (g)

Bβ = Dry weight from the furnace (g)

2.6. Measuring soil pH

Soil pH was measured using a soil tester. The measurement was done by implanting it into the soil and pressing the button on the soil tester, which deflected the needle on the meter. A constant value, directed by the stabilizing needle within the pH meter, was recorded [11].

3. Results

3.1. Diversity of Mangrove Vegetation

In this study, a total of 19 species of mangroves were obtained from eight research stations. These species include *Xylocarpus molluccensis*, *Aegiceras corniculatum*, *Ceriops decandra*, *Xylocarpus granatum*, *Rhizophora mucronata*, *Rhizophora apiculata*, *Heritiera littoralis*, *Ceriops tagal*, *Sonneratia alba*, *Bruguiera parviflora*, *Sonneratia caseolaris*, *Hibiscus tiliaceus*, *Scyphiphora hydrophyllacea*, *Merope angulata*, *Nypa fruticans*, *Acanthus ebracteatus*, *Acanthus ilicifolius*, *Derris trifoliata* and *Acrostichum speciosum*. The diversity index value for each category as bellow (Table 3.). The similarity between each station for every category shown in Figure 1 – 5. While the correlation between mangrove diversity and its environmental condition is shown in table 4 – 7.

Table 3. Mangrove diversity value

Station	Category			
	Tree	Sapling	Seedling	Understorey
F1	0	1.807	1.388	-
F2	-	0	1.027	-
RF1	0.6931	0	-	0.6442
RF2	-	-	-	-
SP1	0	0	-	0.6697
SP2	0	0.5004	0	0.6792
IL1	0.6365	0	0.5623	1.162
IL2	-	0.3768	0.8676	0.9759

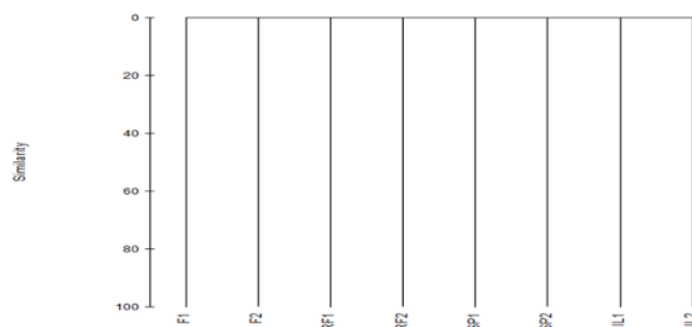


Figure 1. Similarity dendrogram of tree category

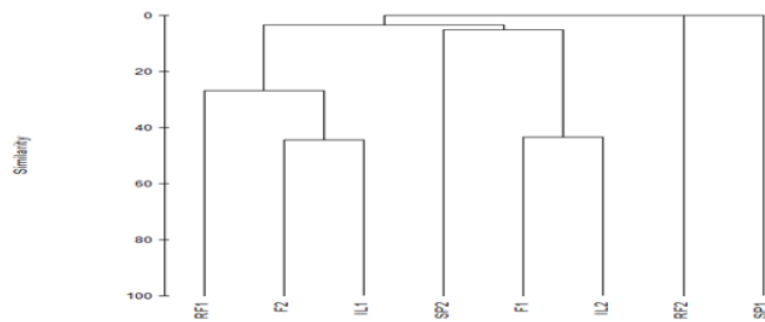


Figure 2. Similarity dendrogram of sapling category

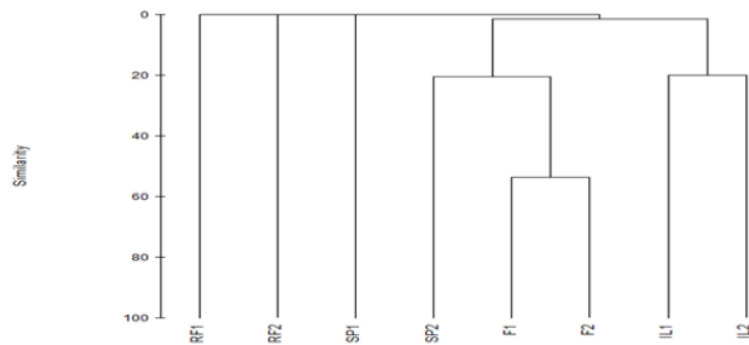


Figure 3. Similarity dendrogram of seedling category

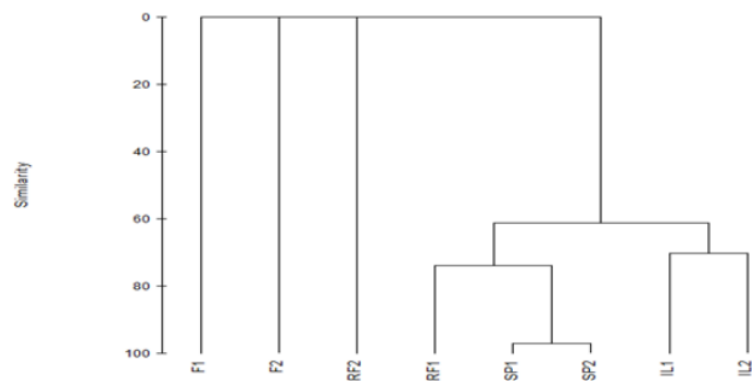


Figure 4. Similarity Dendrogram of Understorey Category

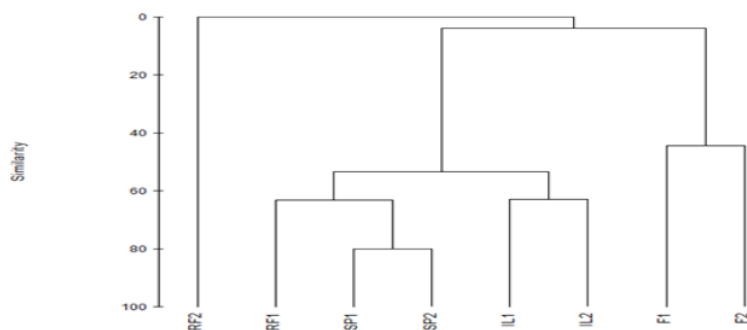


Figure 5. Similarity Dendrogram of All Categories

3.2. Correlation Between Mangrove Diversity and Environmental Factors

Table 4. Correlation between tree diversity and environmental factors

Correlation Value	Variable	Notes:
0,417	6	1. Water salinity (ppt)
0,337	3,6	2. Water pH
0,296	3,6,8	3. Dissolved oxygen
0,269	6,8	4. Air temperature (°C)
0,262	4,6,8	5. Water temperature (°C)
0,224	6,9	6. Soil pH
0,206	1,6,8,9	7. Water content (%)
0,206	6,8,9	8. Organic content (%)
0,201	3,4,6,8	9. Sand (%)
0,199	2,6,8	10. Silt (%)
		11. Clay (%)

Table 5. Correlation of sapling diversity and environmental factors

Correlation Value	Variable	Notes:
0,449	6	1. Water salinity (ppt)
0,284	3,6	2. Water pH
0,266	6,7	3. Dissolved oxygen
0,246	3,6,7	4. Air temperature (°C)
0,195	4,6,7	5. Water temperature (°C)
0,194	5,6,7	6. Soil pH
0,192	2,6,7	7. Water content (%)
0,174	5,6,7,9	8. Organic content (%)
0,173	2,6	9. Sand (%)
0,172	3,6,7,9	10. Silt (%)
		11. Clay (%)

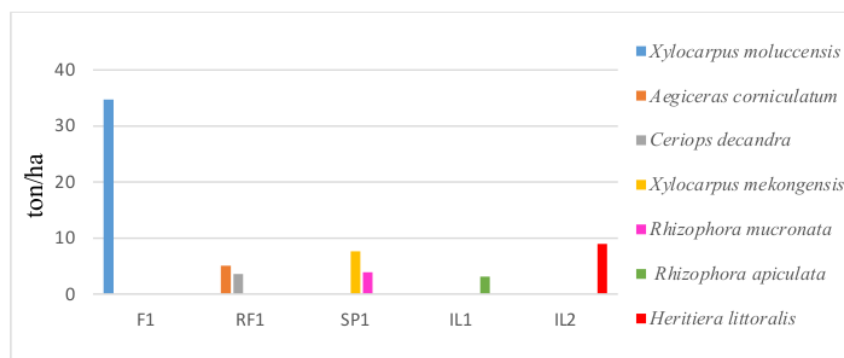
Table 6. Correlation of seedling diversity and environmental factors

Correlation Value	Variables	Notes:
0,408	1,4,6,10	1. Water salinity (ppt)
0,406	1,4,5,6,10	2. Water pH
0,399	1,2,4,10	3. Dissolved oxygen
0,396	1,4,5,10	4. Air temperature (°C)
0,394	1,2,5,10	5. Water temperature (°C)
0,393	1,5,6,10	6. Soil pH
0,393	1,3,4,5,10	7. Water content (%)
0,393	1,2,4,5,10	8. Organic content (%)
0,393	1,3,5,10	9. Sand (%)
0,391	1,2,5,6,10	10. Silt (%)
		11. Clay (%)

Table 7. Correlation of understorey diversity and environmental factors

Correlation Value	Variables	Notes
0,678	4	1. Water salinity (ppt)
0,662	3,4	2. Water pH
0,567	3,4,9	3. Dissolved oxygen (%)
0,539	4,9	4. Air temperature (°C)
0,537	2,3,4,9	5. Water temperature (°C)
0,504	2,4,9	6. Soil pH
0,496	2,4,	7. Water content (%)
0,494	3,4,6,9	8. Organic content (%)
0,480	2,3,4	9. Sand (%)
0,476	3,4,5,9	10. Silt (%)
		11. Clay

3.3. Carbon Stock Value of Mangroves in Segara Anakan Cilacap

**Figure 6.** Tree category carbon stock

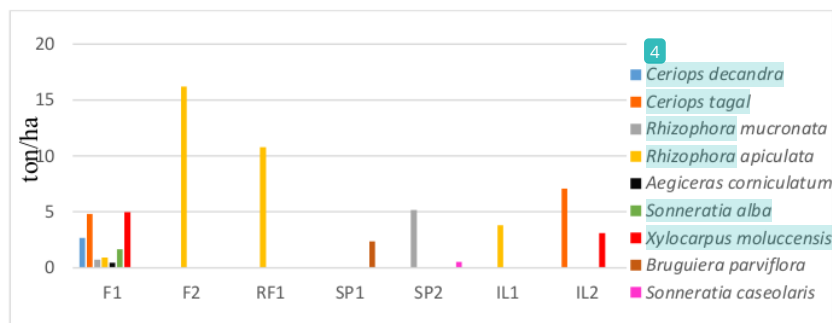


Figure 7. Sapling category carbon stock

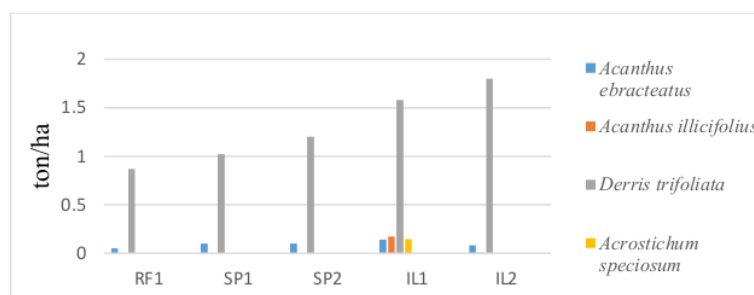


Figure 8. Understorey category carbon stock

4. Discussion

4.1. Diversity of Mangrove Vegetation

The diversity value for mangroves at tree level consists of 0.63 and 0.69, with the highest value that was found at station RF1 (ex rice field 1) and lowest found in IL1 (illegal logging area 1). Whereas for saplings, the value ranges between 0.37–1.80, where the highest value is obtained from station F1 (forest 1) and the lowest from station IL2 (illegal logging area 2). For seedlings, diversity values range between 0.56 obtained from station IL1 (illegal logging area 1) until 1.38 obtained from station F1 (forest 1). Shrubs and herbs included in the understorey level, tend to show the most similarity of vegetation composition between stations. The diversity value ranges between 0.64–1.16, the highest belonging to station IL1 (illegal logging area 1), and the lowest belonging to station RF1 (ex rice field 1).

Low diversity rates are mainly seen in stations that have been altered by human activities. Anthropological changes inflicted on mangrove ecosystems can cause the extinction of various endemic mangrove species within the area [13]. Extensive destruction, such as illegal logging or clearcutting towards the mangrove ecosystem, also causes intensive abrasion along the coast that leads to the failure of sapling and seedling regeneration [14]. To group stations based on the similarity of vegetation composition, cluster analysis was applied. The results of the study were presented in a dendrogram for each vegetation category of each station. A dendrogram was also made for combinations of all vegetation categories.

Results of tree category dendrogram indicate that none of the stations show similarity; hence no clusters are formed. The only stations that possess tree category species are stations F1 inhabited only by *Xylocarpus molluccensis*, RF1 inhabited by *Aegiceras corniculatum* and *Ceriops decandra*, SP1

inhabited by *Xylocarpus granatum*, SP2 inhabited by *Rhizophora mucronata* and IL1 inhabited by *Rhizophora apiculata* and *Heritiera littoralis*. Station IL2 does not contain any tree category species and is likely to be occupied by sapling and understorey species. As for station RF2, no vegetation of any category is found. Stations in the sapling category dendrogram do not show a distinct similarity in species composition. Stations with similarity indices below 60% are still considered different, whereas stations with indices ranging from 60% and above are considered to be similar. The highest percentage within the sapling category is as much as 44.44% between stations F2 and IL1. The species that are present in both stations are *Rhizophora apiculata*, followed by F1 and IL2 as much as 43.48%. Common species found within the two stations are *Ceriops tagal* and *Xylocarpus molluccensis*. Percentage between station RF1, F2 and IL1 are as much as 26.67%. All three stations are linked by the presence of the same species which is *Rhizophora apiculata*. No clusters are formed for station RF2 since no vegetation is present. Whereas station SP1 does not possess any sapling category vegetation.

In seedling dendrogram stations F1 and F2, being the two stations mostly abundant with seedling species, have a percentage as much as 53.66%. However, these two stations are not considered to be similar. Their similarity lies in the presence of three species which are *Rhizophora mucronata*, *Rhizophora apiculata*, and *Aegiceras corniculatum*. Station SP2 also has a slight similarity between the two stations as much as 20.37% due to the presence of *Rhizophora mucronata* which are common in all three stations. A cluster is formed between station IL1 and IL2, with a percentage of 20%. This value is indicated by the presence of *Merope angulata* in both stations.

Cluster analysis of the understorey category shows that no clusters are formed between station F1, F2 and RF2 due to the absence of understorey species. Station F1 and F2 still occupied by various mangrove species due to minimum land use, does not provide any open spaces for understorey species such as *Acanthus*, *Derris*, and *Acrostichum* to grow. Whereas station RF2, has become too damaged that its habitat conditions have become no longer sufficient for any vegetation growth. The highest similarity is between stations SP1 and SP2 as much as 96.97% being only dominated by *Acanthus ebracteatus* and *Derris trifoliata*. Station RF1 also has a high similarity between the two stations as much as 73.91% being also dominated by the same species. Stations IL1 and IL2 show similarity as much as 70.16% composed of *Acanthus ebracteatus*, *Derris trifoliata*, *Acanthus ilicifolius* and being slightly differentiated by the presence of *Acrostichum speciosum* in station IL1. Cluster analysis of all vegetation categories combined shows that the highest similarity of vegetation composition belongs to station SP1 and SP2 as much as 80%. Station RF1 also has a slight similarity between the two stations as much as 63.23. Stations IL1 and IL2 are also formed into a cluster with a similarity percentage of 62.96%.

4.2. Correlation Between Mangrove Diversity and Environmental Factors

Correlation intervals between tree diversity and environmental factors ranged between 0.199–0.417, which is considered to have a very weak to moderate correlation [15]. Based on the best ten combinations analyzed, it was found that the highest correlation value belonged to soil pH as much as 0.417. Whereas correlation intervals between sapling diversity and environmental factors ranged between 0.172–0.449, also indicating very weak to moderate correlation. The highest correlation value also belonged to soil pH as much as 0.449. Measurements of soil pH of each station resulted between 5.3–8.1, with the lowest belonging to station SP1 and SP2 and highest belonging to station IL1. According to [16], the best optimal pH level is neutral, with a value of 6.6–7.5. High pH levels are likely to be caused by the contribution of leaf litter, roots, and stems that fall to the ground and are composed of either weathered by forming layers of organic matter. While slightly, acidic soil pH is caused due to the overhauling of mangrove litter by soil microorganisms that produce organic acids and thus reduces soil pH [17].

Correlation values between the seedling category and environmental factors range between 0.391–0.408, which indicates a moderate correlation. Out of eleven measured ecological factors, the factors that have the most influence are water salinity, air temperature, soil pH, and silt percentage. The

optimum salinity for mangrove growth ranges between 15–25 ppt whereas the tolerance limit ranges between 10–35 ppt [18]. The salinity of the research area ranges between 2–32 ppt with the lowest belonging to station IL1 and the highest belonging to RF1. The optimal range of physiological function and growth of seedlings is approximately from 3 to 27 ppt [19]. Above or below the optimal salinity, gas exchange and growth are reduced. However, the range of salinity varies depending on species. Air temperature measured at the research stations ranged between 28.8–30°C, which is still considered an optimum range for mangrove growth [18], which indicates optimal temperatures for mangrove growth is around 29–30°C and tolerant temperatures range between 21–32°C.

Correlation values between understorey species and environmental factors range between 0.476–0.678, which indicates moderate to strong correlation with the highest influence coming from air temperature. Air temperature and sun exposure is a supporting factor for the growth of all three species. *Acanthus* spp. and *Derris trifoliata* are considered as mangrove associates who are mangroves that do not grow within actual mangrove communities and usually live with land plants [20]. Both species are usually found to be dominating in wide-open areas from a result of an anthropological activity. Besides, *Acanthus* spp. and *Derris trifoliata*, *Acrostichum speciosum* is also found in one of the research stations. *Acrostichum* colonizes different habitats of current vegetation due to its ability to adapt to the disturbed areas devoid of local vegetation [21].

4.3. Carbon Stock Value of Mangroves in Segara Anakan Cilacap

The carbon stock value for tree category indicates that the highest value belongs to *Xylocarpus mollucensis* from station F1 as much as 34.68 ton/ha⁻¹ and the lowest value belonging to *Rhizophora apiculata* (station IL1) as much as 3.14 ton/ha⁻¹. The amount of carbon deposits in vegetation depends on the amount of biomass, soil fertility, and vegetation absorption [22]. For sapling category, the highest carbon stock value belongs to *Rhizophora apiculata* in station F2 as much as 16.21 ton/ha⁻¹ followed by *Rhizophora apiculata* in station RF1 as much as 10.78 ton/ha⁻¹ with the lowest value belonging to *Aegiceras corniculatum* in station F1 as much as 0.46 ton/ha⁻¹. Saplings show a smaller carbon value than trees because biomass will increase along with plant age which is caused by the increase of plant diameter that enables it to store more carbon [23].

Carbon stock calculation for understorey species reveals that *Derris trifoliata* shows the highest carbon value in station IL2 as much as 1.8 ton/ha⁻¹. The lowest carbon value belongs to *Acanthus illicifolius* in station IL2 as much as 0.005 ton/ha⁻¹. *Derris trifoliata* is seen to be quite dense in most stations, which might contribute to its carbon stock value. Areas consisting of trees with higher density values will possess higher biomass compared to areas which possess low-density values [24]. Overall results reveal that the highest value belongs tree category with an average of 8.38 tons/ha. The lowest carbon stock value belongs to the understorey category, with an average of 1 ton/ha⁻¹. It can be observed that forest habitats produce the highest amount of carbon with a total of 34 tons/ha⁻¹ for all categories. The lowest amount belongs to ex rice field habitats as much as 10 tons/ha⁻¹. Changes in the quantity of biomass can occur because of natural succession and by human activities such as silviculture, harvesting, and degradation. This statement is supported by the results obtained during this research, which shows that carbon stock is higher in un-damaged stations.

4.4. Correlation Between Environmental Factors and Carbon Stock

Correlation values between tree carbon stock and environmental factors range between 0.522–0.578, which indicates a strong correlation. Factors that most influence tree carbon stock consist of water salinity, soil pH, organic content, and sand percentage. Influence by factors such as salinity and soil conditions, which the local environmental factors influencing mangrove forests, vegetation cover is closely related to soil composition and salinity [25]. Whereas correlation values between saplings carbon stock and environmental factors range between 0.065–0.359, which is considered as very weak to moderate correlation. The factor that influences saplings the most is soil pH. Accumulation of organic matter also contributes to carbon stock. Mangrove litter, which will later be decomposed, is

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the biggest contributor to the high content of organic carbon [26], which is a contributing factor towards soil fertility. Soils with high organic matter can sustain a higher life capacity for mangroves.

Understorey correlation values range between 0.553–0.724, which indicates a very strong correlation. The carbon stock of understorey species is mainly influenced by dissolved oxygen and air temperature. Since carbon is strictly correlated to biomass, its production depends on factors that sustain the growth of the plant. The better the mangrove growth, the more carbon stock produced along with the increase of biomass [27].

4 Conclusion

This study can be concluded that:

1. The highest mangrove vegetation diversity was found in stations with forest habitats with the highest value as much as 1.80 for the sapling category. Lowest diversity value belongs to illegal logging area stations, with the lowest value as much as 0.37 for the sapling category indicating that mangrove forest change causes a decrease towards vegetation diversity.
2. The highest carbon value was obtained from forest habitat stations with a total of 34 tons/ha. Highest belonging to tree category as much as 17.34 tons/ha. The lowest carbon value was from the ex rice field area, with a total of 10 tons/ha. The lowest value from the understorey category as much as 1.21 tons/ha, indicating that carbon stock values decrease due to mangrove forest change.
3. Correlation between environmental factors with the tree, sapling, and seedling diversity indicates moderate relationships with the highest value as much as 0.417 for tree category, 0.449 for the sapling category, and 0.408 for the seedling category. Both tree and sapling categories are mostly influenced by soil pH, whereas seedlings are influenced mainly by water salinity, air temperature, soil pH, and silt percentage. Correlation between understorey diversity and environmental factors indicate a strong correlation with the highest value as much as 0.678, influenced by the air temperature.
4. Tree carbon stock is influenced by water salinity, soil pH, organic content, and sand percentage indicating a strong correlation as much as 0.578. Sapling carbon stock is affected by soil pH, showing a moderate correlation as much as 0.359. Whereas for understorey carbon stock, factors that mostly influence are dissolved oxygen and air temperature as much as 0.724, indicating a robust correlation.

References

- [1] Srikanth S, Lum S K Y and Chen, Z 2015 Mangrove Root: Adaptations and Ecological Importance *Trees* **30** 451–65
- [2] Ellison J C and Zouh I 2012 Vulnerability to Climate Change of Mangroves: Assessment from Cameroon *Biology* **1** 617–38
- [3] Ardli E R, Widyastuti A and Yani E 2015 Kajian Perubahan Bioekologi pada Restorasi Ekosistem Mangrove di Segara Anakan Cilacap *Biosfera* **32** 19–28
- [4] Ismail, Sulistiono, Haryadi S and Madduppa H 2018 Condition and Mangrove Density in Segara Anakan, Cilacap Regency, Central Java Province, Indonesia *AACL Bioflux* **11** 1055–68
- [5] Ardli E R and Wolff M 2009 Land Use and Land Cover Change Affecting Habitat Distribution in the Segara Anakan Lagoon, Java, Indonesia *Environmental Change* **9** 235–43
- [6] Noor R, Khazali Y M and Suryadiputra I N N 1999 *Panduan Pengenalan Mangrove di Indonesia* (Bogor: PHKA/WI-IP)
- [7] Komiyama A, Ong J E and Pongparn S 2008 Allometry, Biomass, and Productivity of Mangrove Forests: A Review *Aquatic Botany* **89** 128–37
- [8] Suryono, Soenardjo N, Wibowo E, Ario R and Rozy F E 2018 Estimasi Kandungan Biomassa dan Karbon di Hutan Mangrove Perancak Kabupaten Jembrana, Provinsi Bali *Buletin Oseanografi Marina* **7** 1–8
- [9] Azizah M, Ardli E R and Sudiana E 2013 Analisis Stok Karbon Hutan Mangrove pada Berbagai

Tingkat Kerusakan di Segara Anakan Cilacap *Jurnal Sains Natural Universitas Nusa Bangsa* **3** 161–72

- [10] Rosani E S 2013 *Analisis Biomassa dan Karbon Tersimpan pada Tumbuhan Bawah di Kawasan Hutan Mangrove Segara Anakan Cilacap* (Universitas Jenderal Soedirman)
- [11] APHA, AWWA and WEF 1992 *Standard Methods for the Examination of Water and Wastewater* 18th ed. (Washington: American Public Health Association, American Water Work Association and Water Environmental Federation)
- [12] Sudjadi M W, Soleh and Widjik I M 1971 *Penuntun Analisa Tanah* (Bandung: Lembaga Penelitian Tanah)
- [13] Ulfa F, Sarong M A and Abdullah 2016 Dampak Pengalihan Lahan Mangrove terhadap Keanekaragaman Benthos di Kecamatan Jaya Baru Kota Banda Aceh *Jurnal Biotik* **4** 41–6
- [14] Pramudji 2000 Dampak Perilaku Manusia pada Ekosistem Hutan Mangrove di Indonesia *Oseana* **25** 13–20
- [15] Clarke K R and Ainsworth M 1993 A Method of Linking Multivariate Community Structure to Environmental Variables *Marine Ecology Progress Series* **92** 205–19
- [16] Nursin A, Wardah and Yusran 2014 Sifat Kimia Tanah pada Berbagai Zonasi Hutan Mangrove di Desa Tumpapa Kecamatan Balinggi Kabupaten Parigi Moutong *Warta Rimba* **2** 17–23
- [17] Setiawan H 2013 Status Ekologi Hutan Mangrove pada Berbagai Tingkat Ketebalan *Jurnal Penelitian Kehutanan Wallacea* **2** 104–20
- [18] Juwita E, Soewardi K and Yonvitner 2015 Kondisi Habitat dan Ekosistem Mangrove Kecamatan Simpang Pesak, Belitung Timur Untuk Pengembangan Tambak Udang *Jurnal Manusia dan Lingkungan* **22** 59–65
- [19] Krauss K W, Lovelock C E, McKee K L, Lo'pez-Hoffman L, Ewe S M L and Sousa W P 2008 Environmental Drivers in Mangrove Establishment and Early Development: A Review *Aquatic Botany* **89** 105–27
- [20] Purwanto A D, Winarso G and Julzarika A 2018 Identifikasi Mangrove Sejati Menggunakan Metode OBIA Berdasarkan Citra Landsat 8 OLI dan Landsat 7 ETM+ Studi Kasus: Kawasan Mangrove Segara Anakan, Cilacap *Prosiding Seminar Nasional Geomatika 2018 Badan Informasi Geospasial*
- [21] Tomlinson P B 1986 *The Botany of Mangroves* (Cambridge: Cambridge University Press)
- [22] Afiati R N, Rustam A, Kepel T L, Sudirman N, Astrid M, Daulat A, Mangindaan P, Salim H L and Hutahaean A A 2014 Stok Karbon dan Struktur Komunitas Mangrove sebagai Blue Carbon di Tanjung Lesung, Banten *Segara* **2** 119–27
- [23] Rahmah F, Basri H and Sufardi 2015 Potensi Karbon Tersimpan pada Lahan Mangrove dan Tambak di Kawasan Pesisir Kota Banda Aceh *Jurnal Manajemen Sumberdaya Lahan* **4** 527–34
- [24] Rahayu S, Lusiana B and Noordwijk V 2007 *Pendugaan Cadangan Karbon di Atas Permukaan Tanah pada Berbagai Sistem Penggunaan Lahan di Kabupaten Nunukan, Kalimantan Timur* (Bogor: World Agroforestry Centre)
- [25] Estrada G C D, Soares M L G, Chaves F O and Cavalcanti V F 2013 Analysis of the Structural Variability of Mangrove Forests through the Physiography Types Approach *Aquatic Botany* **111** 135–43
- [26] Kaseng E S 2018 Analysis of Nitrogen and Carbon Content on Mangrove Forests in Tongke – Tongke, Sinjai *Journal of Physics: Conference Series* **1028** 12–67
- [27] Chanan M 2010 Pendugaan Cadangan Karbon (C) Tersimpan di Atas Permukaan Tanah pada Vegetasi Hutan Tanaman Jati (*Tectona grandis* Linn. F) (di RPH Sengguruh BKPH Sengguruh KPH Malang Perum Perhutani II Jawa Timur) *Jurnal Gamma* **7** 61–73

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