Mangrove Ecosystem Condition at Three Regency on The East Coast of North Sumatra: A Review

Bambang Hendra Siswoyo(*)[1,3], Siti Mardiana[2], Sabrina Sabrina[2]

[1] Doctoral student of Agricultural Science, Medan Area University,
[2] Graduated School of Agricultural Science, Medan Area University,
Jalan Setia Budi No. 79 B/ Jalan Sei Serayu No. 70A Medan, North Sumatra, Indonesia, Postcode 20121
[3] Faculty of Fisheries, Dharmawangsa University, Jalan. KL. Yos Sudarso No.224, Medan, North Sumatra, Indonesia, Postcode 20115

***Correponding author**: bambang.hs@dharmawangsa.ac.id

Submitted April 05th 2024 and Accepted June 17th 2024

Abstract

This study aims to analyze the condition of mangrove ecosystems in the three districts on the east coast of North Sumatra. Data collection was carried out from June to December 2023 in the Deli Serdang, Serdang Bedagai, and Langkat districts. The sampling location was determined by purposive sampling, and the target location was a mangrove area that had aquaculture activities. There were 9 sampling points, 3 points each in each district. Observations were made using a 10 x 10 m quadratic transect method with 20 replications. Density, relative density, frequency, relative frequency, dominance, and relative dominance were calculated to obtain the importance index value of each species. The calculation results showed that Rhizopohora apiculata with a density of 2359-4208 ind/ha with a relative density between 43.7-48.8%. The highest frequency and relative frequency values are also in R. apiculata, and R. mucronata species between 0.67 - 1 with a relative frequency between 25 - 44.4%. The highest species dominance and relative dominance of R.apiculata was 0.000010272 - 0.00001105, with a relative dominance of 23.07 - 40.25%. Therefore, these two species are the species with the highest importance index >65%.

Keywords: *Importance value index; Mangrove condition; North Sumatra*

https://doi.org/10.36987/jpbn.v10i2.5679

INTRODUCTION

Indonesia has the largest mangrove area in the world, covering approximately 3.1 million hectares. The mangrove forests in Indonesia play a crucial role in carbon absorption and contribute significantly to regulating global climate change (Hamzah et al., 2023). However, these mangrove ecosystems are under threat due to land-use changes and deforestation (Maulana et al., 2023). Sustainable management is needed to maintain and improve the area and quality of mangroves (Aprilina & Hastijanti, 2023). Monitoring efforts using remote sensing technology, such as machine-learning algorithms, have been employed to classify and monitor mangrove forests in Indonesia (Purwanto et al., 2022). The conservation and preservation of mangrove forests are essential for supporting the economy, local societies, and the environment (Pratiwi et al., 2022). One of the mangrove distribution areas in Indonesia is the east coast of North Sumatra.

The mangrove condition in North Sumatra has been the focus of several studies. One study in Medan City found a significant decrease in the mangrove forest area in the Medan Labuhan Sub-district over the past fourteen years. The study used remote sensing, GIS (Geographic Information System), and AHP (Analytical Hierarchy Process) to map and analyze changes in mangrove cover, with the economy identified as the top priority for preventing further changes (Rahmawaty et al., 2023). Another study in Lubuk Kertang Village evaluated mangrove rehabilitation efforts and found that planting propagules and seedlings resulted in the survival of 69.42% and 86.38% of plants, respectively. The carbon stocks stored by the plants ranged from 51.18 Mg ha−1 to 56.79 Mg ha−1 (Amelia et al., 2023). A study in North Sumatra and Aceh compared different mangrove management conditions and found that the macrozoobenthic community could serve as a practical indicator for assessing the functionality of restored mangroves (Basyuni et al., 2022). Additionally, a study in North Aceh assessed water quality and sediment characteristics in mangrove areas and found that heavy metal content was generally below permissible thresholds, except in one area (Harifia et al., 2022). Finally, a study in Pantai Labu Subdistrict identified the physical conditions necessary for mangrove growth and development, including aspects of slope, soil, water, sea tide, and climate (Yuniastuti et al., 2019). Based on this background, this study was conducted to analyze the condition of mangrove ecosystems in three locations on the east coast of North Sumatra.

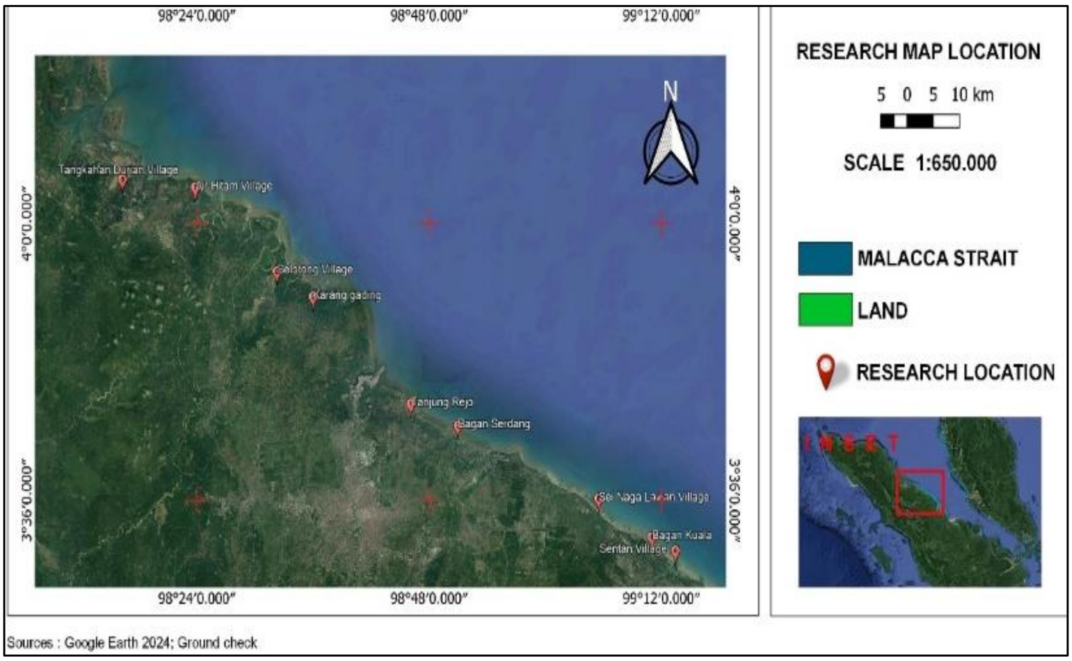

Figure 1. Map of research location

METHOD

This study was conducted in three districts on the east coast of North Sumatra, namely Langkat, Deli Serdang and Serdang Bedagai. Determination of the sampling location is done based on purposive sampling, where the sampling point is set in a location where there are aquaculture activities. Sampling locations are as many as 9 points, with each 3 sampling points in each district (Figure 1). Mangrove observations were carried out with a quadratic transect method with a size of 10 x 10 m with a distance of 20 m between transects (Hasan et al., 2024). Transects were repeated 10 times, starting from the inland area towards the coastline. An illustration of transect laying can be seen in Figure 2.

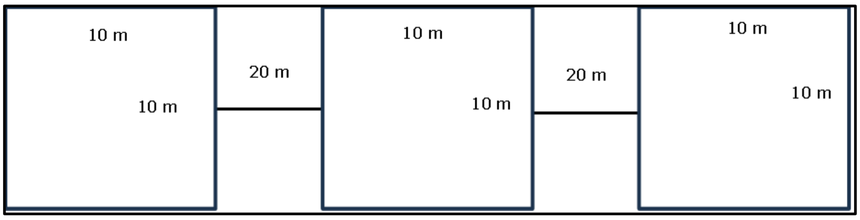

Figure 2. Illustration of mangrove observation transect

Data analysis

Mangrove condition data is analyzed based on the design of observation plots in the field and calculates the density, frequency, dominance and finds the Index of Important Value and Diversity Index (Bengen, 2000) based on the following formula,

Species Density

$$\text{Density (D)} = \frac{\sum \text{species i}}{\text{Sample plot area}} \quad (1)$$

Relative Density Species

$$\text{Relative Density (RD)} = \frac{\text{Density of Species i}}{\text{total density}} \text{ x } 100\% \quad (2)$$

Species Frequency

$$\text{Frequency (F)} = \frac{\text{Number of plots where a species was found}}{\text{Total number of sample plots}} \quad (3)$$

Relative Frequency Species

$$\text{Relative Frequency (FR)} = \frac{\text{Number of plots where a species was found}}{\text{Total number of sample plots}} \text{ x } 100\% \quad (4)$$

Dominance

$$\text{Dominance (C)} = \frac{\text{Basal area of a species}}{\text{Area of sample plots}} \quad (5)$$

Relative Dominance

$$\text{Relative Dominance (RC)} = \frac{\text{Dominance species i}}{\text{Dominance of all species}} \times 100\% \quad (6)$$

Importance Value Index

$$\text{INP} = \text{RD}_\text{i} + \text{RF}_\text{i} + \text{RC}_\text{i} \quad (7)$$

Where :
RDi = Relative Density
RFi = Relative Frequency
RCi = Relative Dominance

RESULTS AND DISCUSSION

Density and Relative Density (RD_i)

Based on the results of the study found 7 species of mangroves that grow in the observation location including *Rhizophora apiculata, Rhizophora mucronata, Avicennia alba, Avicennia marina, Bruguiera gymnorhiza, Bruguiera cylindrica,* and *Sonneratia alba*. *R. apiculata* is a mangrove species with the highest density in all three study sites, the highest density value in Serdang Bedagai 4208 ind/ha with a relative density value of 43.7%, Deli Serdang 2359 ind/ha with a relative density of 44.6%, and then 2442 ind/ha with a relative density value of 48.8% in the district of Langkat (Figure 3). *Rhizophora* tends to favor muddy and soft substrates and boasts a wide distribution (Hariphin et al., 2016; Malahayati et al., 2023). Moreover Gazali et al., (2019), elucidated that the high density of *Rhizophora* species is attributed to its year-round production of flowers and fruits. This ability is closely linked to sunlight intensity.

Mangrove species with the lowest density are different in each research location, *A. marina* being the species with the lowest density in Deli Serdang and Langkat, respectively 467 ind/ha with a relative density of 8.84%, and 867 ind/ha with a density of 17.34% species. Meanwhile, in Serdang Bedagai District, the species with the lowest density was Bruguiera cylindrica 292 ind/ha, and relative density 3.03% (Figure 3). The population density of *A. marina* is influenced by various factors such as seasonal changes in physicochemical parameters of water and soil, including temperature, pH, nutrient content, and pollution levels (Patale & Tank, 2022). Additionally, the distribution of *A. marina* in mangrove forests can be affected by shade intolerance and seed predation, limiting its presence in certain intertidal regions (Elhag et al., 2015). Furthermore, demographic features like phenological phase, tree size, density, cover, and pneumatophore characteristics play a role in the sensitivity and survival of *A. marina* populations in different habitats (Smith, 1987).

p-ISSN: 2442-9481
e-ISSN: 2685-7332

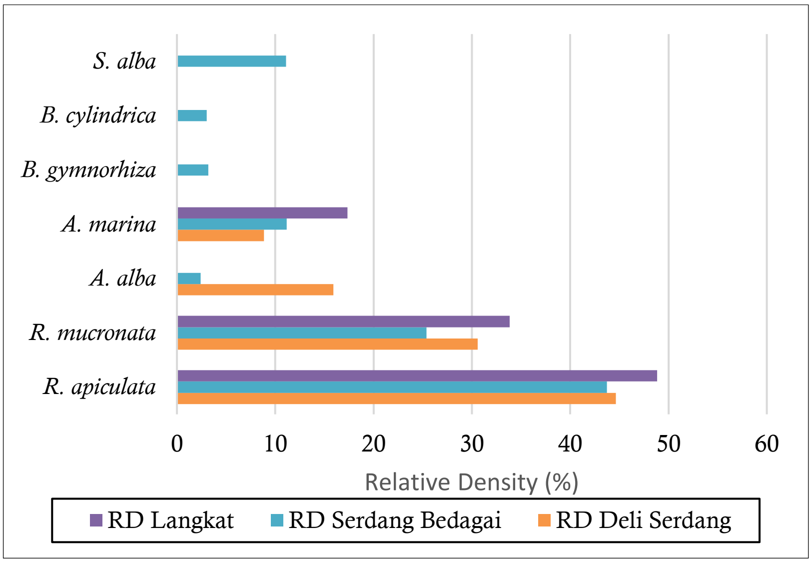

Figure 3. Graph of Relative Density of species at three research location

Frequency and Relative Frequency (RF$_i$)

Based on the analysis results of mangrove species *R. Apiculata*, and *R. mucronata* are the species with the highest frequency and relative frequency throughout the study site. The frequency of these two species is between 0.67 - 1 with a relative frequency between 25 - 44.4% (Figure 4). Various factors influence the relative frequency of mangroves. Physical factors such as temperature, coastal typology, ocean currents, and tidal range play a crucial role in determining the extent of mangrove populations (Ellison, 2021). Additionally, biotic factors like predation, resource availability, and stress intensity impact seedling recruitment and distribution patterns of different mangrove species (Wang et al., 2018). Furthermore, environmental conditions such as salinity can affect the sex ratio in mangrove populations, with lower salinity levels correlating with higher male frequencies in certain species (Silva & Cruz, 2021). The dispersal mechanisms of mangrove propagules, establishment success, growth development rates, and unique tolerance limits of each species also contribute to their distributional ranges (Giri & Long, 2016; Romero-Berny et al., 2019).

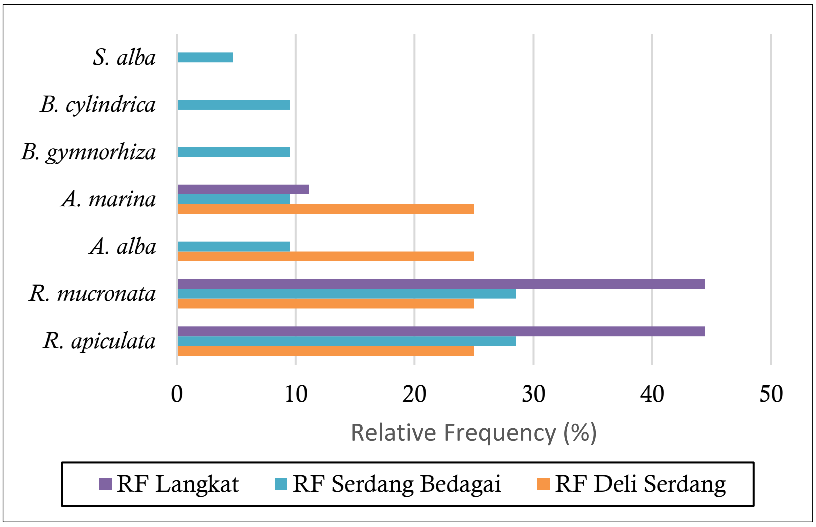

Figure 4. Graph of Relative Frequency of species at three research location

Dominance and Relative Dominance (RCᵢ)

The results explained that the highest species dominance and relative dominance were in *R. Apiculata* and *R. mucronata* species. The closing value of *R. apiculata* species is 0.000010272 - 0.00001105 with relative dominance of 23.07 - 40.25%. Meanwhile, the dominance value of *R. mucronata* species ranged from 0.000005197 - 0.000009802 with a relative dominance value of 11.66 - 35.57%. A dominance index value near 0 suggests the absence of a dominant species (Destiana et al., 2022). Overall, the dominance values for all observations were low, indicating no dominant mangrove species. Mangrove communities typically exhibit uniformity when ecological conditions are stable (Sipahelut et al., 2020).

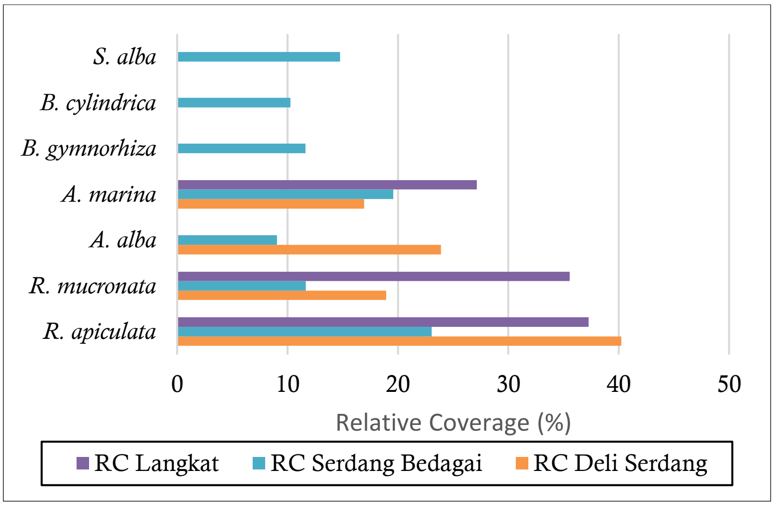

Figure 3. Graph of Relative Coverage of species at three research location

Importance Value Index

The highest importance index in *R. apiculata* species was 95.4% for the Serdang Bedagai district, 109.9% in the Deli Serdang district, while it was 130.6% in the Langkat district. Furthermore, *R. mucronata* has an important index value of 65.6% in Serdang Bedagai Regency, 74.5% in Deli Serdang Regency and 113.8% in Langkat Regency (Table 1). Research by Hasan et al. (2024) also found the highest importance index of Rhizophora spp in the mangrove ecotourism area of Lubuk Kertang Langkat. Various factors influence the index of important values of mangroves. Factors such as inundation frequency, soil sorting coefficient, water salinity, length of residency, awareness of sustainability, population pressure, deforestation, leaf-to-total area ratio, and leaf biochemical properties play significant roles in determining the value orientations and vulnerability of mangrove ecosystems (Afefe et al., 2019; Assaf et al., 2022; Niu et al., 2021; Shih, 2020). Additionally, the biophysical properties of mangroves, including fractional cover and plant area index, are crucial in assessing the canopy reflectance and overall health of mangrove forests (Himes-Cornell et al., 2018).

Table 1. Mangrove importance index in three districts on the east coast of North Sumatra

Species	Deli Serdang				Serdang Bedagai				Langkat			
	RDi (%)	RFi (%)	RCi (%)	IVI (%)	RDi (%)	RFi (%)	RCi (%)	IVI (%)	RDi (%)	RFi (%)	RCi (%)	IVI (%)
R. apiculata	44.6	25.0	40.3	109.9	43.7	28.6	23.1	95.4	48.8	44.4	37.3	130.6
R. mucronata	30.6	25.0	18.9	74.5	25.4	28.6	11.7	65.6	33.8	44.4	35.6	113.8
A. alba	15.9	25.0	23.9	64.8	2.4	9.5	9.1	21.0	0.0	0.0	0.0	0.0
A. marina	8.8	25.0	16.9	50.8	11.2	9.5	19.6	40.3	17.3	11.1	27.1	55.6
B. gymnorhiza	0.0	0.0	0.0	0.0	3.2	9.5	11.6	24.4	0.0	0.0	0.0	0.0
B. cylindrica	0.0	0.0	0.0	0.0	3.0	9.5	10.3	22.8	0.0	0.0	0.0	0.0
S. alba	0.0	0.0	0.0	0.0	11.1	4.8	14.8	30.6	0.0	0.0	0.0	0.0
∑ Total	100	100	100	300	100	100	100	300	100	100	100	300

CONCLUSION

The condition of mangrove ecosystems in three districts on the east coast of North Sumatra is in good condition with a dominance value close to 0, the importance index of *R. apiculata* and *R. mucronata* > 65%. This indicates that the condition of the mangrove ecosystem in the three locations is still in a balanced state.

REFERENCES

Afefe, A., S. Abbas, M., Sh. Soliman, A., A. Khedr, A.-H., & E. Hatab, E.-B. (2019). Physical and chemical characteristics of mangrove soil under marine influence. A case study on the Mangrove Forests at Egyptian-African Red Sea Coast. *Egyptian Journal of Aquatic Biology and Fisheries*, *23*(3), 385–399. https://doi.org/10.21608/ejabf.2019.47451

Amelia, R., Basyuni, M., Alfinsyahri, A., Sulistiyono, N., Slamet, B., Bimantara, Y., Harahap, S. S. H., Harahap, M., Harahap, I. M., Al Mustaniroh, S. S., Sasmito, S. D., & Arifanti, V. B. (2023). Evaluation of Plant Growth and Potential of Carbon Storage in the Restored Mangrove of an Abandoned Pond in Lubuk

Kertang, North Sumatra, Indonesia. *Forests*, *14*(1), 158. https://doi.org/10.3390/f14010158

Aprilina, R., & Hastijanti, R. (2023). Penerapan Konsep Solid Nature pada Penataan Ekowisata Mangrove di Gunung Anyar Surabaya. *Selasar*, *19*(2), 61–70. https://doi.org/10.30996/selasar.v19i2.8535

Assaf, H., Idwan, S., Jallad, A. H., Ammari, M. Z. J., Al Chaar, A., & Kouja, M. (2022). Public Values Regarding An Urban Mangrove Wetland In The United Arab Emirates. *Journal of Environmental Engineering and Landscape Management*, *30*(1), 114–123. https://doi.org/10.3846/jeelm.2022.16333

Basyuni, M., Bimantara, Y., Cuc, N. T. K., Balke, T., & Vovides, A. G. (2022). Macrozoobenthic community assemblage as key indicator for mangrove restoration success in North Sumatra and Aceh, Indonesia. *Restoration Ecology*, *30*(7), e13614. https://doi.org/10.1111/rec.13614

Destiana, D., Lestariningsih, S. P., Darwati, H., & Iswandaru, D. (2022). Biodiversitas Makrobentos Sebagai Indikator Kualitas Habitat Pada Ekosistem Mangrove. *Journal of Tropical Marine Science*, *5*(1), 37–44. https://doi.org/10.33019/jour.trop.mar.sci.v5i1.2940

Elhag, M., Hegazy, A. K., Alatar, A. A., Faisal, M., El-Bana, M., Bahrawi, J. A., & Al-Ghamdi, A. A. M. (2015). Population demography and global sensitivity analysis of *Avicennia marina* on the eastern and western coasts of Saudi Arabia. *Koedoe*, *57*(1), 9 pages. https://doi.org/10.4102/koedoe.v57i1.1317

Ellison, J. C. (2021). Factors influencing mangrove ecosystems. In *Mangroves: Ecology, Biodiversity and Management* (R. P. Rastogi, M. Phulwaria, D. K. Gupta, pp. 97–115). Springer Singapore. https://link.springer.com/chapter/10.1007/978-981-16-2494-0_4

Gazali, S., Rachmawani, D., & Agustianisa, R. (2019). Hubungan Kerapatan Mangrove Dengan Kelimpahan Gastropoda Di Kawasan Konservasi Mangrove Dan Bekantan (Kkmb) Kota Tarakan. *Jurnal Harpodon Borneo*, *12*(1), 9–19. https://doi.org/10.35334/harpodon.v12i1.781

Giri, C., & Long, J. (2016). Is the Geographic Range of Mangrove Forests in the Conterminous United States Really Expanding? *Sensors*, *16*(12), 2010. https://doi.org/10.3390/s16122010

Hamzah, A. H. P., Marzuki, M., Nurhasanah, N., & Nurmawati, S. (2023). Environmental risk analysis in magrove and crab conservation areas in pamusian village due to land use change in tarakan city. *Jurnal ilmiah global education*, *4*(2), 980–995. https://doi.org/10.55681/jige.v4i2.905

Harifia, R., Irham, M., Muhammadar, Faisal, & Rusdi, M. (2022). Chemical analysis of mangrove land in north Aceh. *IOP Conference Series: Earth and Environmental Science*, *1116*(1), 012083. https://doi.org/10.1088/1755-1315/1116/1/012083

Hariphin, Linda, R., & Rusmiyanto, E. (2016). *Analisis Vegetasi Hutan Mangrove Di Kawasan Muara Sungai Serukam Kabupaten Bengkayang*. *5*(3), 66–72.

Hasan, U., Mardiana, S., & Hasibuan, S. (2024). *Ecological review of mangroves in coastal ecotourism areas: A case study of mangroves in Lubuk Kertang, Langkat Regency, Indonesia. 17*(1), 431-439.

Himes-Cornell, A., Grose, S. O., & Pendleton, L. (2018). Mangrove Ecosystem Service Values and Methodological Approaches to Valuation: Where Do We Stand? *Frontiers in Marine Science*, *5*, 376. https://doi.org/10.3389/fmars.2018.00376

Malahayati, M., Arlita, T., & Dewiyanti, I. (2023). Indeks Nilai Penting dan Keanekaragaman Jenis Vegetasi Mangrove di Pesisir Utara Aceh Besar (Importance Value and vegetation Diversity Indeks Mangroves on the North Coasth of Aceh Besar). *Jurnal Ilmiah Mahasiswa Pertanian*, *8*(1), 522–531. https://doi.org/10.17969/jimfp.v8i1.23218

Maulana, A. M., Wiradana, P. A., Yudha, I. K. W., Sutiadipraja, N., Qur'ani, C. G., & Baral, H. (2023, May 15). *Assessing impact of land-use changes on carbon stock dynamics in coastal mangrove ecosystem in Bali Island, Indonesia*. https://doi.org/10.5194/egusphere-egu23-13684

Niu, C., Phinn, S., & Roelfsema, C. (2021). Global Sensitivity Analysis for Canopy Reflectance and Vegetation Indices of Mangroves. *Remote Sensing*, *13*(13), 2617. https://doi.org/10.3390/rs13132617

Patale, V. V., & Tank, J. G. (2022). Evaluation of the edaphic and water properties of Diu coast (Saurashtra, Gujarat, India) in relation to the population density of Avicennia marina. *Applied Water Science*, *12*(4), 78. https://doi.org/10.1007/s13201-022-01602-w

Pratiwi, N. R., Amalia, F. N., Rahmawati, I. F., & Setyoko, S. (2022). Keanekaragaman Flora Mangrove pada Tingkat Pohon di Cagar Alam Pulau Dua Banten. *bionature*, *23*(1). https://doi.org/10.35580/bionature.v23i1.35697

Purwanto, A. D., Wikantika, K., Deliar, A., & Darmawan, S. (2022). Decision Tree and Random Forest Classification Algorithms for Mangrove Forest Mapping in Sembilang National Park, Indonesia. *Remote Sensing*, *15*(1), 16. https://doi.org/10.3390/rs15010016

Rahmawaty, Siahaan, J., Nuryawan, A., Harahap, M. M., Ismail, M. H., Rauf, A., Kurniawan, H., Gandaseca, S., & Karuniasa, M. (2023). Mangrove cover change (2005–2019) in the Northern of Medan City, North Sumatra, Indonesia. *Geocarto International*, *38*(1), 2228742. https://doi.org/10.1080/10106049.2023.2228742

Romero-Berny, E. I., Tovilla-Hernández, C., Torrescano-Valle, N., & Schmook, B. (2019). Heterogeneidad Estructural Del Manglar Como Respuesta A Factores Ambientales Y Antrópicos En El Soconusco, Chiapas, México. *Polibotánica*, *0*(46). https://doi.org/10.18387/polibotanica.47.4

Shih, S.-S. (2020). Spatial Habitat Suitability Models of Mangroves with Kandelia obovata. *Forests*, *11*(4), 477. https://doi.org/10.3390/f11040477

Silva, M. F. D., & Cruz, M. V. (2021). Geographical and environmental contributions to genomic divergence in mangrove forests. *Biological Journal of the Linnean Society*.

Sipahelut, P., Wakano, D., & Sahertian, D. E. (2020). Keanekaragaman Jenis Dan Dominansi Mangrove Di Pesisir Pantai Desa Sehati Kecamatan Amahai, Kabupaten Maluku Tengah. *Biosel: Biology Science and Education*, *8*(2), 160. https://doi.org/10.33477/bs.v8i2.1145

Smith, T. J. (1987). Effects of seed predators and light level on the distribution of Avicennia marina (Forsk.) Vierh. In tropical, tidal forests. *Estuarine, Coastal and Shelf Science*, *25*(1), 43–51. https://doi.org/10.1016/0272-7714(87)90024-2

Wang, X., Zhou, L., & Lu, C. (2018). Do environmental factors affect the male frequency of exotic mangrove species Laguncularia racemosa (Combretaceae) along the southeast coast of China? *Aquatic Ecology*, *52*(2–3), 235–244. https://doi.org/10.1007/s10452-018-9658-3

Yuniastuti, E., Astuti, A. J. D., & Simanungkalit, N. (2019). Identification of the Physical Characteristics of Mangrove Ecosystems in the Coastal Area of Pantai Labu Subdistrict, Deli Serdang Regency, North Sumatra. *Proceedings of the 1st International Conference on Social Sciences and Interdisciplinary Studies (ICSSIS 2018).* Proceedings of the 1st International Conference on Social Sciences and Interdisciplinary Studies (ICSSIS 2018), Medan, Indonesia. https://doi.org/10.2991/icssis-18.2019.79

How To Cite This Article, with *APA style* :
Siswoyo, B.H., Mardiana, S., & Sabrina, S. (2024). Mangrove Ecosystem Condition at Three Regency on The East Coast of North Sumatera: A Review. *Jurnal Pembelajaran dan Biologi Nukleus*, 10(2), 523-532. https://doi.org/10.36987/jpbn.v10i2.5679

Conflict of interest : The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions : All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [Bambang Hendra Siswoyo]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.