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Analysis of Mangrove Suitability for Ecotourism Development Based on Geographic Information System in Kemboja Village North Kayong Regency, West Kalimantan

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Abstract

Mangrove ecotourism has an important role in maintaining the balance of coastal ecosystems. Mangroves have various important benefits, such as in mitigating climate change with their ability to absorb carbon and protect coastal areas from abrasion. To improve tourism development, the Geographic Information System's ecotourism suitability analysis has become an important instrument. The purpose of this study is to explore mangrove types and the value of the Tourism Suitability Index. A Geographic Information System (GIS) and Tourism Suitability Index (TSI) approach was used to analyze parameter data, including mangrove density, species richness, mangrove thickness, tides and association biota. Results show that the dominant mangrove species are *Xylocarpus granatum*, *Rhizopora mucronata, Rhizopora apiculata*, and *Bruguiera parviflora*, with densities varying from 4 m²/ind to 23 m²/ind. Mangrove thickness varied from <50 to >500 meters, and biota association varied from 1 to 4 groups. The average tides vary in height, providing an important hydrological context. The land suitability analysis showed great mangrove ecotourism potential in Kemboja Village, with 2,532.20 hectares classified as highly suitable (46.07%) and 2,961.86 hectares classified as suitable (53.89%) for sustainable tourism development. Unsuitable areas cover 1.61 hectares (<1%).

Keywords: Mangrove Ecotourism, Tourism Suitability Index, Geographic Information System, Kemboja Village

1. Introduction

The mangrove ecosystem is an environment that has a high level of productivity but is very sensitive to changes in surrounding conditions. Given its vulnerability to external disturbances, mangrove ecosystem management requires a holistic approach that combines ecological, economic and socio-cultural aspects of local communities (Tahir et al., 2016). Its uniqueness and natural riches make the mangrove area a valuable asset in developing the environmentally based tourism sector (Agussalim & Hartoni 2014).

Ecotourism, according to Rahim & Baderan (2017), is a tourist activity that allows visitors to enjoy natural beauty without damaging the forest ecosystem. Surjanti et al., (2020) added that ecotourism also functions as a means of ecological learning that can be applied in developing mangrove ecosystems.

The ecotourism approach allows people to appreciate the pristine beauty of nature while maintaining its sustainability. Research by Spalding & Parrett (2019) shows that mangrove ecotourism has the potential to attract millions of visitors every year. Furthermore, Shoo & Songorwa (2013) emphasized that ecotourism can increase income and encourage local community participation in its management.

The potential development of mangrove ecosystems can play a direct role in the state of coastal ecosystems (Saru 2014). Based on Minister of Culture and Tourism Regulation no. KM.67/ UM.001/ MKP/ 2004, explains that the implications of developing tourism activities and providing tourism support on small islands will have an impact on the physical, social, cultural and economic environment of small islands.

The use of mangrove ecosystems for the concept of tourism (ecotourism) is in line with the shift in tourist interest from old tourism, namely tourists who only come to do tourism without any elements of education and conservation to new tourism, namely tourists who come to do tourism that includes elements of education and conservation (Hafizi et al., 2017).

Kemboja Village, Pulau Maya District, North Kayong Regency is not yet known to the general public and has not received special attention in developing existing resource potential by the government or related parties so Kemboja Village has not been optimized as a domestic or foreign tourist destination. Kemboja Village has several ecosystems, one of which is the mangrove ecosystem. The zoning area for mangrove use in Kemboja Village is around 65,148.54 Ha.

This research aims to identify and map the potential of mangroves as a mangrove ecotourism area in Kemboja Village, Pulau Maya District, North Kayong Regency and calculate and map the Tourism Suitability Index (TSI).

2. Method

2.1 Time and Location of Research

This research was conducted in Kemboja Village, Pulau Maya District, North Kayong Regency, on 22-25 June 2023 (Figure 3.1). The data analysis process was carried out at the OSO university mapping and data processing laboratory. Pulau Maya District consists of five villages, namely Dusun Besar, Dusun Kecil, Kemboja, Satai Lestari, and Tanjung Satai. The location of this sub-district is very strategic, located between the Karimata Strait and the South China Sea, making it an important route for inter-island and international shipping.

Fig 1. Research Location

2.2 Tools and Materials of Research

The tools and materials used in the research are Rapia rope used to make station line transects, Global Positioning System to determine stations and sampling points, Sewing meter used to measure tree diameters, Roll meter to measure transect lengths, Mangrove identification guidebooks to identify mangrove species, Biota identification book for observing biota and Digital camera for research documentation.

2.3 Research Procedures

The selection of research station locations was carried out using the purposive sampling method. Sugiyono (2022) explains that purposive sampling is a technique for determining samples based on certain criteria that are relevant to the research objectives. To collect mangrove vegetation data, researchers used a combination of line transect and plot transect methods. This process involves making a transect route using raffia rope, which is pulled perpendicularly from the sea towards the mainland, along the area covered by the mangrove ecosystem.

2.3.1 Mangrove Vegetation Data Collection

Mangrove data collection was carried out on each transect using the quadratic transect method. For the tree category, the sample plot used is 10x10 m^2. The criteria for trees to be recorded are those that have a trunk diameter of at least 10 cm, measured at a height of 1.5 m or more from the ground surface (Dharmawan & Pramudji, 2014). In each of these plots, several observations were made: identification of mangrove varieties, calculating the quantity of each species, and measuring the trunk circumference of mangrove trees at breast height.

Mangrove thickness measurements are carried out using two approaches: directly in the field and through the interpretation of satellite images. This measurement was carried out from the outer boundary of the mangrove on the seaside, perpendicular to the land to the last boundary of the mangrove vegetation, with measurements carried out at each observation station.

2.3.2 Tides Estimation

One of the important environmental factors considered in this research is tidal dynamics. Information regarding tidal patterns in the research area, namely Kemboja Village, was not collected directly in the field. On the other hand, this data was obtained from secondary data, specifically from the Meteorology, Climatology and Geophysics Agency (BMKG in Bahasa). Specifically, the tidal data used in the analysis comes from the records of the Pontianak Maritime Meteorological Station, which is part of the BMKG network. The use of data from official sources allows researchers to obtain accurate and reliable information about tidal conditions at the research location without the need to carry out direct measurements which take time and resources.

2.3.3 Biota Object Collection

Biota observations were carried out in situ at each sampling point. This process involves direct observation of organisms at the research location. For each biota found, visual documentation is carried out in the form of taking pictures or photos. The next step is the species identification process, which is carried out by referring to the identification guide by Compagno (1998). This method allows researchers to accurately record biodiversity in mangrove ecosystems, by combining field observations and visual documentation.

2.3.4 Ecotourism Suitability Analysis

Suitability analysis for mangrove ecotourism is modeled spatially using a Geographic Information System approach. This approach is in line with the views of Kalogirou (2001) and Hossain et al., (2008) who emphasize the advantages of GIS in this context. According to them, GIS has very useful capabilities, namely the ability to process spatial data effectively and present the results of suitability analysis in a visual form that is easy to understand. This allows decision-makers to have a clear picture of the most suitable areas for mangrove ecotourism development based on various relevant environmental and socio-economic parameters.

1. The steps taken include: Delineating sentinel 2A imagery with a spatial resolution of 10 m for land and water boundaries
2. Spatially analyze location points obtained during the survey Inputting in situ data into the map
3. Next, enter the value resulting from the multiplication of the weight and score on the attribute of each feature that has been formed to obtain the appropriate location.

The spatial analysis process in this research utilized ArcGIS software version 10.4.1. The methodology applied is the spatial overlay modeling technique, an approach that integrates various layers of geographic data.

2.4 Data Analysis

This research applies a methodology that combines a Geographic Information System with a Tourism Suitability Index (TSI). This approach is used to examine five main aspects, namely mangrove thickness, mangrove density level, diversity of mangrove types, tidal dynamics, and the presence of biota objects in the area. The assessment of land suitability for mangrove ecotourism can be calculated using the formula developed by Yulianda (2019):

TSI = $\sum_{i=1}^{n}(\mathrm{B}i \ \mathrm{x}\ \mathrm{S}i)$............(1)

Keterangan :
TSI : Tourism Suitability Index (*IKW in Bahasa)
n : The number of suitability parameters
B*i* : Parameter weight in -*i*
S*i* : Parameter score in-*i*

The assessment is carried out based on multiplying the weight and score, which is then combined with several variables to determine the suitability class. The value of the tourist suitability index obtained is then adjusted to the category, IKW 2.25 - 3 = Very suitable; IKW 1.5 – 2.25 = Suitable; IKW = 0.75 – 1.5 = Not suitable; IKW 0 – 0.75 = Very unsuitable. The tourism suitability index can be seen in Table 1.

Table 1. Tourism Suitability Index Matrix

No	Parameter	weight	Category/Score			
			3	2	1	0
1	Mangrove Thickness (m)	0.38	>500	200-500	50-200	<50
2	Mangrove Density (100m^2)	0.25	>15-20	>10-15;>20	5-10	<5
3	Mangrove species	0.15	>5	3-5	1-2	0
4	Tides	0.12	0-1	>1-2	>2-5	>5
5	Biota Object	0.1	Fish. Shrimp. Mollusk Crab. Reptile. Bird	Fish. Shrimp. Crab Molluscs	Fish. Molluscs	One of the aquatic biota

Source: Yulianda (2019) with modifications

3. Results and Discussion

3.1 Thickness of Mangrove

Mangrove thickness consists of 4 categories (<50 meters, 50-200 meters, 200-500 meters, >500 meters). The categories <50 and 50-200 meters are found in the south of the area in Kemboja Village. The most dominant thickness category found in all mangrove areas is the category >500 meters to the north of the mangrove area. The mangrove thickness map can be seen in Figure 2.

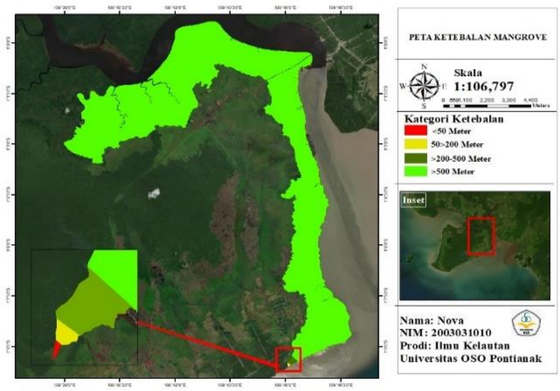

Fig 2. Category of Mangrove Thickness at Location

Research by Maulida et al., (2014) in Malang Rapat Village found that the thickness of the mangrove forest ranged from 96-150 meters. The thickness of the mangrove forest has a crucial role, especially in supporting mangrove exploration activities and determining the capacity of the area to accommodate visitors. Rodiana et al., (2019) emphasized that one of the main functions of mangrove thickness is as a natural barrier against sea waves. Other research also says Setiawan (2013) that mangroves can influence the salinity of surrounding well water which has a thickness of around 200-300 M at the lowest salt content.

3.2 Mangrove Density (100m²)

The mangrove density measured at each station is based on the density of mangroves found at the location consisting of 4 categories (<5, 5-10, 10-15;>20, >15-20). Categories <5, 5-10, and 15-20 are found in the north and east of Cambodia. Categories 10-15 or >20 are found to the east and south of Kemboja Village.

Mangrove density in Kemboja Village varies between 4 ind/100m² to 23 ind/100m² at various observation stations. In assessing the tourism suitability index, the mangrove density parameter was given a weight of 0.250, indicating the importance of this factor in determining the suitability of an area for ecotourism. Based on tree categories at all stations, it shows that *Rhizopora mucronata, Rhizopora apiculata, Bruguiera parviflora* and *Xylocarpus granatum* have the highest density values when compared to other types. The high density of mangrove vegetation indicates that the vegetation community is in an undisturbed condition and reflects the large number of tree stands in the area (Triyadi et al., 2014).

Akbar et al., (2017) said that species density shows the number of individuals of a species per unit area. The high or low density is influenced by the ability of the species to environmental factors, seed dispersal and seedling growth. The type that has the highest density is due to its strong survival in its environmental conditions and has the opportunity to live and reproduce well compared to other types.

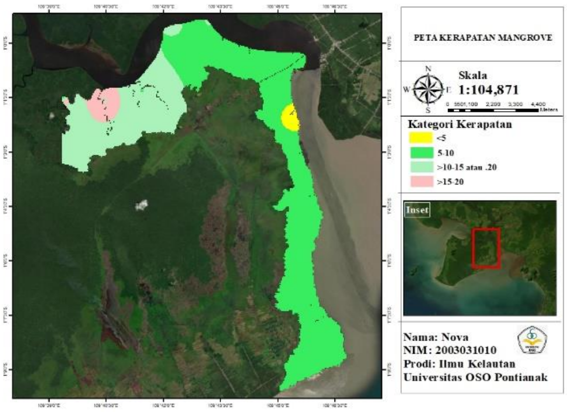

Fig 3. Density Category

3.3 Mangrove Spesies

The types of mangroves identified at each station based on observations at the research location resulted in seven types of mangroves, namely (*Rhizophora mucronata, Bruguiera gymnorhiza, Bruguiera parviflora, Excoceria agallocha, Lumnitzera racemosa, Rhizopora apiculata, Xylocarpus granatum*). The dominant mangrove types found (*Xylocarpus granatum, Rhizopora mucronata, Rhizopora apiculata* and *Brugeria parviflora*) were most often found at stations 3-8 and station 10 which indicated optimal conditions for the growth of mangrove species while the fewest types were (*Brugeria gymnorrhiza, Excoceria agalloca* and *Lumnitzera racemosa*) at station 2 indicates the presence of specific environmental pressure.

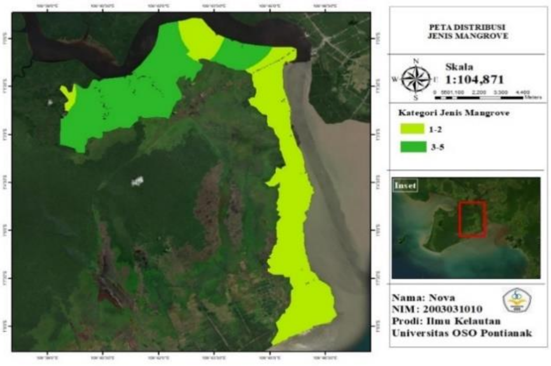

Fig 4. Mangrove Species category

The categories most commonly found in mangrove areas are 3-5 species, generally found in the north of Kemboja Village. The most dominant ones are categorized as 1-2 types of mangroves found in the southern and northern parts of the Kemboja Village mangrove area. Mangrove vegetation data at the research location shows significant species diversity at tree level. Four mangrove species were found to dominate the area, with *Xylocarpus granatum* emerging as the most abundant species, with 87 individuals recorded. Meanwhile, *Rhizopora mucronata* and *Rhizopora apiculata* had the same number, each found with 73 individuals. *Bruguiera parviflora* also has a significant presence with 55 individuals identified. These four species outperform the three other types of mangroves which are also found at the research location but in smaller numbers.

The dominance of these species indicates the existence of environmental conditions suitable for their growth, as well as the possibility of effective adaptation strategies to local conditions. These distribution and dominance patterns can provide important insight into the dynamics of the mangrove ecosystem in the area, including environmental factors that influence the growth and distribution of certain species.

The importance of mangrove types shows that there are variations in each type, this is closely related to the contribution and important role of the population in the mangrove community or ecosystem. Akbar et al., (2018) said that the composition and number of presence of each individual at the research location influenced the important value. According to Indriyanto (2006), the dominant species in a plant community have a high importance value index, so that species.

3.4 Tides

Analysis of 2023 tidal data from the BMKG Pontianak Maritime Meteorological Station for Kemboja Village, Pulau Maya District, North Kayong Regency, shows significant variations. The highest high tide reaches 1.0384 meters, while the lowest low tide is at 0.000 meters. The average tidal height ranges from 0.05 meters for the lowest tide to 0.60 meters for the highest tide.

These characteristics are by the tourism suitability index criteria for mangrove areas, obtaining a score of 3 and are presented in Figure 5. The tidal pattern in Kemboja Village is classified as mixed with a double daily trend. This is characterized by the occurrence of two high tides and two low tides in a day, with relatively similar heights. This significant influence on the mangrove ecosystem in areas with tidal patterns is important for managing coastal areas and planning the activities of communities that depend on the sea.

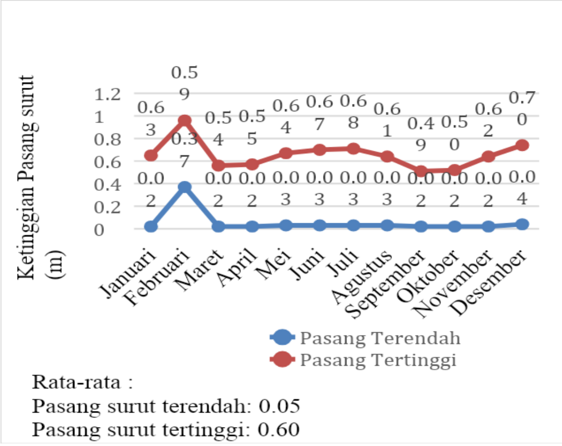

Fig 5. Tides Chart

The results of observations of tides in the mangrove ecosystem of Kemboja Village, located in Teluk Batang District, North Kayong Regency, have been visualized in the form of Figure 5. The number found in the mangrove area is in the 0-1 meter category. The suitability of the mangrove area in Kemboja Village is included in the very suitable category (S1).

Fig 6. Category of Tides

According to Alongi (2015), tidal fluctuations in this range contribute to good nutrient circulation in the mangrove ecosystem. Meanwhile, according to Sasmito et al., (2020), an analytical study found that locations with tidal ranges similar to Kemboja Village (around 1 meter) tend to have more stable levels of carbon absorption compared to areas with more extreme ranges. Meanwhile, Kathiresan and Bingham (2001) said that tidal patterns with an average height of 0.05-0.60 meters allow optimal flooding periods for various mangrove species. Overall, the tidal characteristics in Kemboja Village not only support the survival of the mangrove ecosystem but also enrich its ecotourism potential.

3.5 Biota Object

The results of exploration and field observations of biodiversity in the mangrove area of Kemboja Village, Pulau Maya District, North Kayong Regency have been compiled. An inventory of mangrove ecosystem biota was carried out at several predetermined observation stations. At the research location, the crustacean aquatic biota that is often found is crabs (*Syclla* sp.), the Bivalvia aquatic biota found (*Arctica islandica*), clams (*Anadara* sp.), fish (*Oxudercinae*) and mudskippers (*Periopthalmus* sp.). Meanwhile, in terrestrial areas, the mammalian fauna found are monkeys (*Macaca* sp.) and squirrels (*Callosciurus notatus*).

The terrestrial fauna of bird species that are encountered include pleci (Zosterops), punai (Treron), king prawns (Alcedines), merbah (Pycnonotidae), kucica (*Copsychus malabaricus*), egret (*Egyretta alba*). The category of biota objects in Kemboja Village with a score of 0 is found in the south of the mangrove area, for a score of 1 it is found in the north of the area, while a score of 2 is found in the east to south of the mangrove area. This difference in scores can be influenced by various environmental factors such as soil type, water salinity, and the level of human intervention in each area.

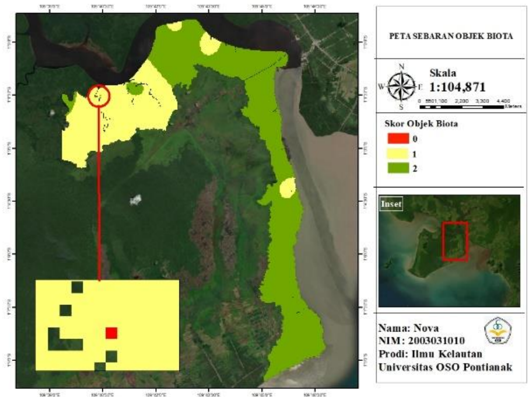

Fig 7. Category of Biota Object

Based on the biota objects Rahmah et al., (2021) in the Awur Bay mangrove area, Jepara uses a similar scoring system to assess the abundance of gastropods, a score of 0 indicates the absence of gastropods, a score of 1 indicates a rare presence, and a score of 2 indicates a dense population. Their findings show a pattern that is more similar to Cambodian Village, in that areas with a score of 2 tend to be spread across several locations within the mangrove area. Meanwhile, research by Santoso et al., (2018) in the mangrove area of Pari Island, Seribu Islands used a similar scoring system to assess bivalve density. They found a distribution pattern similar to Kemboja Village, where areas with a score of 2 tended to be in the eastern and southern parts of the area.

3.6 Analysis of Mangrove Ecosystem Suitability for Ecotourism Development

Geographic Information Systems (GIS) can be used to assess and evaluate the suitability of mangrove ecotourism based on the results of each parameter (mangrove thickness, density, type, tides and biota objects). Based on the calculation of the Tourism Suitability Index (IKW), there is one analysis that is categorized as inappropriate (S3) with a weight and total score of 1.44. The appropriate category (S2) is found in the north and east of the mangrove area with a total weight and score of 1.95-2.25. Meanwhile, the very suitable category (S1) was found north of the mangrove area with a weight and total score of 2.25-2.75.

Based on the results of a geospatial study of the suitability of areas for mangrove ecotourism in Kemboja Village, most areas show promising potential for developing mangrove ecotourism. In detail, an area of 2,532.20 hectares is classified as very suitable (S1), while 2,961.86 hectares is included in the suitable criteria (S2). Only a small portion, namely 1.61 hectares, was deemed unsuitable (S3) for ecotourism development. Based on the overlay of all parameters, the results for the suitability of mangrove ecotourism are obtained in Figure 7.

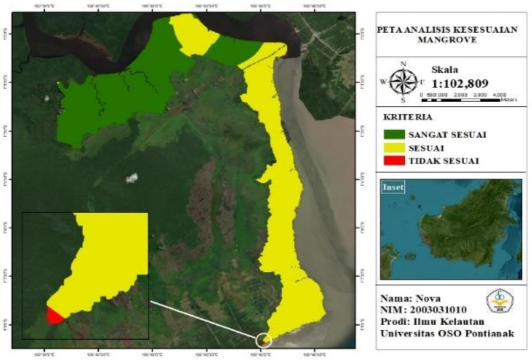

Fig 8. Ecotourism Mangrove Suitability Criteria

Research analyzing the suitability of mangrove ecotourism with the lowest ecotourism suitability index score (1.44) was categorized as not suitable for ecotourism development. According to Fitriana et al., (2019) stated that areas with low scores like this may be more suitable for focusing on conservation and rehabilitation rather than ecotourism development. Although categorized as unsuitable for ecotourism, these areas still have important ecological value. Safitri & Hidayat (2020) emphasize that even mangrove areas with low scores still play a role in coastal protection, habitat for various species, and carbon sequestration. Based on Yulianda's research (2019), it is stated that mangrove areas in the appropriate category have ecological characteristics and accessibility that support ecotourism activities, but still have room for improvement in terms of facilities or conservation.

According to Fahrian et al., (2015) areas in this category usually have natural mangrove ecosystem conditions, high vegetation density, and an interesting diversity of species. In addition, Hardiman et al., (2021) stated that mangrove areas in the very suitable category generally have good accessibility and adequate supporting infrastructure, which supports the development of various ecotourism activities. Meanwhile, according to Siburian et al., (2022) even though an area is categorized as very suitable, management is needed to maintain a balance between the use of ecotourism and the preservation of the mangrove ecosystem.

For the development of ecotourism, according to Suryanto & Wibowo (2022), this S3 area may have significant limitations that hinder the potential for effective development of mangrove ecotourism. According to Pratiwi et al., (2023), the S1 and S2 categories indicate that the area has ecological characteristics and accessibility that support mangrove ecotourism activities according to Pratiwi et al., (2023).

4. Conclusions

Mangroves in Kemboja Village show significant ecotourism potential, with varying thickness and dominance >500 m in the north, and a density suitable for tourism. This ecosystem has seven types of mangroves with the dominance of certain species and diverse distribution. Mixed tidal patterns and high biota diversity add to its ecological value. Ecotourism suitability analysis revealed that most of the area (5,494.06 hectares) is very suitable or suitable for the development of mangrove ecotourism, with the varied spatial distribution and only a small portion (1.61 hectares) is unsuitable, indicating great potential for sustainable ecotourism development in this area.

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References

Agussalim, A dan Hartoni. (2014). Potensi Kesesuaian Mangrove Sebagai Daerah Ekowisata di Pesisir Muara Sungai Musi Kabupaten Banyuasin. *Jurnal Maspari*, Vol. 6, No. 2.

Akbar N, A. Ibrahim, I. Haji, I. Tahir, F. Ismail, M. Ahmad, R. Kotta. (2018). Struktur Komunitas Mangrove Di Desa Tewe, Kecamatan Jailolo Selatan, 12 Kabupaten Halmahera Barat Provinsi Maluku Utara. Jurnal Enggano

Akbar, A. A., Sartohadi, J., Djohan, T. S., Ritohardoyo, S. (2017). Erosi Pantai, Ekosistem Hutan Bakau dan Adaptasi Masyarakat Terhadap Bencana Kerusakan Pantai Di Negara Tropis. *Jurnal Ilmu Lingkungan*

Alongi, D. M. (2015). The impact of climate change on mangrove forests. *Current Climate Change Reports*, *1*, 30-39.

Compagno, L. J. V. (1998). Fao Species Identification Guide For Fishery Purposes Western Central edited by Norwegian Agency for International Development. In Fao (Vol. 3).

Dharmawan, I. W. E. & Pramudji, S. (2014). Panduan Monitoring Status Ekosistem Mangrove di Indonesia. PT. Sarana Komunikasi Utama: Jakarta.

Fahrian, H. H., Putro, S. P., Muhammad, F. (2015). Potensi ekowisata di kawasan mangrove, Desa Mororejo, Kabupaten Kendal. Biosaintifika: *Journal of Biology & Biology Education*, 7(2), 104-111.

Fitriana, D., Yulianda, F., Lukman, M. (2019). Perencanaan Lanskap Ekowisata Pesisir di Kecamatan Koto XI Tarusan, Kabupaten Pesisir Selatan, Provinsi Sumatera Barat. *Journal of Natural Resources and Environmental Management*, 9(2), 483-497.

Hafizi, R., Irma., D., Chitra, O. (2017). Produksi Serasah Hutan Mangrove di Kuala Langsa, Provinsi Aceh. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah*.

Hardiman, G., Pramono, R. W. D., Fajriyanto, F. (2021). Pengembangan Ekowisata Mangrove Berbasis Masyarakat di Desa Bedono, Kabupaten Demak. *Jurnal Wilayah dan Lingkungan*, 9(1), 1-15.

Indriyanto. (2006). Ekologi Hutan. Jakarta (ID):Penerbit Bumi Aksara.

Kementerian Kebudayaan dan Pariwisata Republik Indonesia. (2004). Peraturan Menteri Kebudayaan dan Pariwisata Nomor KM.67/UM.001/MKP/2004. Jakarta: Kementerian Kebudayaan dan Pariwisata RI.

Maulida, S. Dony A. Andi Z. (2014). Kesesuaian Pengembangan Ekowisata Mangrove Berbasis Masyarakat di Desa Malang Rapat. Univ. Raja Ali Haji. Press.

Pratiwi, R., Widyastuti, A., & Zahrudin, D. A. (2023). Karakteristik Ekosistem Mangrove dan Potensinya untuk Pengembangan Ekowisata di Desa Kemboja. Biodiversitas Journal of Biological Diversity, 24(4), 1876-1885.

Rahim, S., D., W., K., Baderan. (2017). Hutan Mangrove dan Pemanfaatannya. Yogyakarta: Budi Utama. Yogyakarta.

Rahmah, W., Nandini, E., & Siregar, K. A. A. K. (2021). Potensi Tanaman Mangrove Sebagai Agen Antikanker: Literature Review. *Jurnal Penelitian Farmasi Indonesia*, *10*(1), 12-16.

Safitri, R., & Hidayat, J. W. (2020). Penilaian Jasa Ekosistem Mangrove dalam Penyerapan Karbon di Desa Timbulsloko, Demak. *Jurnal Ilmu Lingkungan*, 18(1), 109-115.

Kalogirou S. 2001. Expert system and GIS: an application of land suitability evaluation. computers. *Environment and Urban Systems*

Hossain, M.S., R.C. Sayedur, G.D. Nani, S.M. Sharifuzzaman, & S. Abida. (2008). Integration of GIS and multicriteria decision analysis for urban aquaculture development in Bangladesh. *Landscape and Urban Planning*

Santoso, A. B. (2018). *Tutorial & Solusi Pengolahan Data Regresi*. Agung Budi Santoso.

Saru, A. (2014). Potensi ekologis dan pengelolaan ekosistem mangrove di wilayah pesisir. *Institut Pertanian Bogor Press. Bogor*.

Setiawan, H. (2013). Status Ekologi Hutan Mangrove Pada Berbagai Tingkat Ketebalan. *Jurnal Penelitian Kehutanan Wallacea*

Shoo, R.A A.N. Songorwa. (2013). Contribution of eco-tourism to nature conservation and improvement of livelihoods around Amani nature reserve, Tanzania. *J. Ecotourism*

Siburian, R., Simatupang, E. J., & Ginting, P. A. (2022). Analisis Kesesuaian dan Daya Dukung Kawasan Wisata Mangrove di Kampung Nipah Kabupaten Serdang Bedagai Provinsi Sumatera Utara. Jurnal Geografi, 14(1), 92-101.

Spalding, M. C.L. Parrett. (2019). Global patterns in mangrove recreation and tourism. Marine Policy

Sugiyono. 2022. Metode penelitian kualitatif dan R&D. Bandung. Alfabet. Hlm 85.

Surjanti, J., A. Soejoto, D.N. Seno, Waspodo. (2020). Mangrove forest ecotourism: Participatory ecological learning and sustainability of students' behavior through self-efficacy and self-concept. *Social Sciences & Humanities Open*

Suryanto, A., Wibowo, E. (2022). Analisis Daya Dukung Kawasan untuk Pengembangan Ekowisata Mangrove di Desa Kemboja. *Jurnal Pengelolaan Wilayah Pesisir dan Laut Indonesia*

Tahir I., Rustam E. P., dan Nebuchadnezzar A. (2016). *Analisis Kesesuaian Ekowisata Hutan Mangrove di Kawasan Teluk Jailolo Kabupaten Halmahera Barat. Prosiding Seminar Nasional Kemaritiman dan Sumberdaya Pulau-Pulau Kecil*.

Triyadi, D., Adler, J. (2014). Sistem Otomatisasi Gerbang Dengan Pengolahan Citra Membaca Nomor Plat Kendaraan. *Skripsi, Universitas Komputer Indonesia*.

Yulianda, F. (2019). Ekowisata Perairan Suatu Konsep Kesesuain dan Daya Dukung Wisata Bahari dan Wisata Air Tawar. IPB Press. Bogor. 84 p.