

SPATIAL ANALYSIS OF SUSTAINABLE MANGROVE TOURISM IN THE SERAMBI DELI COASTAL AREA, PANTAI LABU DISTRICT, NORTH SUMATRA

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Abstract

Mangrove ecotourism is largely unknown to the general public due to limited development and insufficient assessment of its suitability, especially in North Sumatra. Spatial analysis in determining the suitability of coastal areas is rarely conducted. This spatial analysis uses Geographic Information System (GIS) applications in determining the management model for mangrove forest areas. The purpose of this study is to determine how to manage and develop mangrove ecotourism through spatial analysis based on ecotourism-related parameters. This study was conducted from September to December 2025. The research methodology included an analysis of the suitability matrix of mangrove forests for ecotourism, a SWOT analysis to identify the strengths, weaknesses, and challenges in the suitability of land for ecotourism, and remote sensing analysis using ArcGIS 10.8 with Band 8 and Band 4 for NDVI. The results obtained were an Ecotourism Suitability Index value of 71.05%, which is classified as conditionally suitable, a SWOT analysis in the form of ecotourism development for promotion through social media and support for accessibility and ecotourism infrastructure, and remote sensing analysis with an average NDVI value of 0.36, which is classified as high density. The conclusion of this study is that the mangrove forest at Serambi Deli Beach is suitable for ecotourism development, but several conditions must be improved, including mangrove species diversity, mangrove density, and infrastructure to support ecotourism activities.

Keywords: Analysis, Ecotourism, Mangroves, Geographic Information System, Spatial

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INTRODUCTION

Mangrove forests are important habitats in coastal ecosystems, located in the transition zone between terrestrial and marine ecosystems, due to their ecological, social, economic, and physical functions. The ecological functions of mangroves include providing habitat for a variety of organisms, including fish, birds, shrimp, crabs, and mammals. Mangrove forests also provide a good place for marine life to reproduce naturally. The economic benefits of mangrove forests include the ability of local communities to utilize them as a source of firewood, and the fruits from mangrove forests can be used as food. Physically, mangrove forests provide protection from waves, strong winds, and sea storms, thereby minimizing damage (Daulay et al., 2023).

Lush mangrove forests and dense canopy cover can serve as natural tourist attractions managed by surrounding communities, such as mangrove ecotourism, enjoyed by both local and international tourists. One way to utilize mangrove forests without damaging the ecosystem is to establish ecotourism areas. Ecotourism activities include enjoying the beauty of the mangrove forest, studying the mangrove ecosystem, and others (Utomo, Budiastuti, and Muryani, 2017). These activities can be opened to local communities to generate economic income and developed for promotion to other countries.

Ecotourism in Indonesia is widely known and growing annually, but the condition of mangrove forest ecotourism is rarely known by the public (Husamah and Hudha, 2018). The main problem in

developing mangrove ecotourism is the lack of public awareness of mangroves' potential as ecotourism destinations. Furthermore, mangrove forest ecotourism development faces challenges, particularly in balancing nature conservation, environmental protection, and the local economy.

Ecotourism is a form of travel to natural environments that aims to protect, conserve, and improve the well-being of local communities. Hartati et al. (2021) state that ecotourism has several key components: a focus on environmental education, nature-based ecotourism products, management that minimizes damage, and activities that contribute to conservation. Ecotourism is widely recognized as an ideal strategy for generating economic benefits while maintaining environmental sustainability, as it balances conservation objectives with local livelihood development.

Mangrove ecotourism is a highly suitable alternative for coastal areas because it provides ecological benefits, including the utilization of environmental services, as well as economic benefits without damaging mangrove forests. The utilization of environmental services in ecotourism management seeks to preserve mangrove forests as buffer zones for conservation areas (Harto et al., 2021). Utilizing mangrove forests for ecotourism will generate income for the region and surrounding communities (Musa, Fozi, and Mohd, 2020). This use of ecotourism is a direct benefit to the community, as clearing mangrove forests for recreation will generate income for the communities that manage the recreational areas.

Serambi Deli Beach, located in Paluh Sibaji Village, covers approximately 206 km² and has a population of approximately 4,525. Most of the residents of Serambi Deli Beach, located on the coast of Paluh Sibaji Village, Pantai Labu District, Deli Serdang Regency, work as traders, teachers, fish/shrimp farmers, and fishermen. The villagers rely entirely on the surrounding mangrove forests for income. The economic situation of this community is classified as lower-middle class, with the majority of the population earning their income from fishing (Kartika et al., 2021). This dependence on fisheries highlights the critical role of mangrove ecosystems in supporting local livelihoods, as mangroves provide essential nursery, feeding, and breeding habitats for many commercially important fish and shrimp species.

Spatial analysis is one of the capabilities of Geographic Information Systems (GIS). GIS is an application for extracting geographic information and framework data, particularly in spatial data management. Spatial analysis is crucial for decision-making when involving geographic aspects such as collecting data on climate change, population growth, or infrastructure development. Therefore, GIS plays a role in the comprehensive analysis of a location's geographic conditions (Rahmawati et al., 2024).

In its application, GIS is used for natural resource management and modeling. GIS is an efficient and effective application for determining the land characteristics of an area and its development potential. The application of GIS in coastal and marine resource management remains rare, particularly in assessing ecotourism suitability, thereby encouraging researchers to address ecotourism suitability analysis in coastal areas. Therefore, GIS is a valuable tool for ecotourism management and planning, as it supports decision-making processes by integrating, analyzing, and visualizing spatial data to identify suitable areas for ecotourism development while ensuring environmental sustainability and resource conservation (Septiana, 2020).

This study aims to evaluate the spatial suitability and management potential of mangrove ecosystems for sustainable tourism development in the Serambi Deli coastal area, Pantai Labu District, North Sumatra.

METHOD

This research was conducted from September to December 2025 in the mangrove forest of Serambi Deli Beach in Pantai Labu District. This research began with an assessment of mangrove forests through direct field observations using several predetermined research plots. The research site was analyzed descriptively, including aspects related to mangrove management and ecotourism development. In the next stage, variables influencing mangrove forest conditions and ecotourism development were analyzed, including water quality and mangrove density data. Primary data were collected through interviews using a structured questionnaire. Participants were selected through purposive sampling

based on predefined inclusion criteria, namely individuals who resided in the study area, depended on mangrove-related resources for their livelihoods, or were directly involved in mangrove management and ecotourism activities. Spatial analysis for ecotourism management and development was conducted using remote sensing techniques, satellite imagery, and ArcGIS 10.8.

a. Ecotourism Suitability Index Analysis

Mangrove ecotourism suitability analysis using a suitability matrix table for mangrove ecotourism based on (Pratiwi and Muhsoni, 2021).

Table 1. Suitability Matrix for Mangrove Ecotourism

No	Parameter	Weight	Category	Score	Category	Score	Category	Score	Category	Score
			S1		S2		S3		N	
1	Mangrove thickness	5	>500	4	>200 – 500	3	50 – 200	2	<50	1
2	Mangrove density	4	>15 – 25	4	>10 – 15	3	5 – 10	2	<5	1
3	Types of mangroves	4	>5	4	3 – 5	3	1 – 2	2	0	1
4	ups and down	3	0 – 1	4	>1 – 2	3	>2 – 5	2	>5	1
5	Biota objects	3	Fish, Shrimp, Crab, Mollusk, Reptile, Bird	4	Fish, Shrimp, Crab, Mollusks	3	Fish, Molluscs	2	One of the aquatic organisms	1

Description:

Maximum Value = 76

S1 = Very appropriate, with a score of 80% - 100%

S2 = Conditionally appropriate, with a score of 60% - <80%

S3 = Appropriate, with a score of 40% - <60%

N = Not suitable, with a score <35%

b. SWOT Analysis

The analysis is based on the development of mangrove forests into ecotourism, informed by interviews with local communities and focus group discussions with tourism activists and managers. This analysis aims to determine the management of mangrove forests for ecotourism by identifying internal strengths and weaknesses, as well as external opportunities and threats. Each factor will be scored from 1 to 4 (1 = weak; 2 = moderate; 3 = good; 4 = excellent) (Heshmati, Gheitury, and Shadfar, 2022).

c. Remote Sensing Analysis

This analysis was conducted to determine the vegetation density index using the Normalized Difference Vegetation Index (NDVI). This analysis used ArcGIS 10.8 software, Sentinel 2 imagery, and color imagery in bands 4 and 8. The NDVI formula is presented below.

$$NDVI = \frac{NIR + Red}{NIR - Red}$$

Information:

NIR = Band 8

RED = Band 4

After obtaining the NDVI value, the next step is to classify the vegetation density at that location. The classification categories applied are those of Agusman and Mataburu (2024).

Table 2. Classification of NDVI Values of Sentinel 2 Images

Density Classification Vegetation	NDVI value
Non-Vegetation	-1.00 – 0.00
Low Vegetation	0.00 – 0.25
Moderate Vegetation	0.25 – 0.5
Tall Vegetation	>0.5

RESULTS AND DISCUSSION

The results included an Ecotourism Suitability Index (IKW) analysis, a SWOT analysis, and a remote sensing analysis.

a. Ecotourism Suitability Index Analysis

The suitability of mangrove forest areas is calculated using weights from mangrove tourism suitability parameters consisting of mangrove density, mangrove thickness, mangrove species, mangrove fauna, and sea tides. The mangrove tourism suitability index (IKW) at the study location is presented in the table below.

Table 3. Mangrove Tourism Suitability Index (IKW) at the Research Location

No	Parameter	Weight	Category				IKW (%)
			S1 (Score 4)	S2 (Score 3)	S3 (Score 2)	N (Score 1)	
1	Mangrove thickness	5	9742				19.74
2	Mangrove density	4		13			15.79
3	Types of mangroves	4		4			15.79
4	ups and down	3			3.41		7.89
5	Biota objects	3		Fish, Shrimp, Crab, Mollusks			11.84
Total							71.05

The results of the study above indicate that the Serambi Deli Coast mangrove forest in Pantai Labu District is classified as conditionally suitable (S2) for mangrove ecotourism development, with an IKW value of 71.05%. The tidal parameter shows a score of 2. The influence of tidal fluctuations on mangrove forests is closely linked to the degradation of the mangrove ecosystem. Damage to mangrove areas will affect high sea levels and coastal abrasion (Tumangger, 2019). The Serambi Deli coastal area in Pantai Labu District has experienced a decline in its mangrove ecosystem due to the surrounding community's lack of protection of the mangrove forest. This affects the tidal range value, which is classified as conditional. With the restoration of the mangrove ecosystem, continued damage to the mangrove forest will lead to higher sea waves, thereby threatening the existence of communities around the mangrove (Akram and Hasnidar, 2022).

The mangrove species parameters in this area indicate that only four species occur: *Rhizophora apiculata*, *Avicennia marina*, *Bruguiera sexangula*, and *Nypa fruticans*. The very small number of mangrove species in relation to the suitability of mangrove forests will impact mangrove density. The level of mangrove species diversity in an area to be developed as a tourist attraction must be high to increase the location's attractiveness to tourists and ultimately increase the income of the surrounding community (Azwar et al., 2025). According to table 3 the mangrove species category is classified as 3 (conditional), so it is necessary to plant various species in the location to increase mangrove density and diversity.

Biota objects at the research site include fish, shrimp, crabs, and mollusks, which have a score of only 3. Biota objects are influenced by the density and type of mangroves at the research site; high biota objects will increase tourist attraction. High mangrove diversity will also attract a variety of aquatic

biota because it provides a natural food source. Mangrove roots are a food source and breeding ground for aquatic biota (Pangestu, Setiadi, and Arifin, 2019). Well-managed mangrove forests for ecotourism will increase local communities' income. The large number of tourists visiting mangrove ecotourism locations will increase the income of the surrounding community (Djafar and Mappiasse, 2019).

b. SWOT Analysis

The ecotourism potential of the Serambi Deli Beach mangrove forest in Pantai Labu District provides valuable insights for the development of ecotourism in the area. This analysis uses a SWOT analysis to assess the development of the mangrove forest as a potential ecotourism location. The resulting strategies are as follows:

- a. Developing ecotourism using a tour package system equipped with facilities and infrastructure
- b. Building accessibility to tourist locations, economic centers, and village governments.
- c. Increase cooperation between local governments, village governments, and non-governmental organizations.
- d. Conduct social media promotions by showcasing tour packages and discounts available to tourists.

Table 4. SWOT Analysis

Internal Factors	Strength (S)	Weakness (W)
	1. Potential land and social configurations for tourism 2. Local government support 3. Access to the location is very supportive of ecotourism activities.	1. Budget limitations in ecotourism management 2. Travel packages are not available yet 3. The quality of human resources in developing ecotourism locations is still lacking
External Factors		
Opportunity (O) 1. Ecotourism is currently increasing significantly, both locally and internationally. 2. Government and non-government support in establishing the location as an ecotourism destination 3. Nowadays, social media is very productive in spreading information about ecotourism.	1. Develop several tour packages that tourists can enjoy 2. Building infrastructure for ecotourism development 3. Building easy road access between research, economic and government centers 4. Conducting continuous promotions to increase tourist attraction	1. Collaborating with various stakeholders in North Sumatra in developing ecotourism 2. The quality of human resources must be improved in developing ecotourism 3. Tourism potential must be increased to increase tourist visits through social media promotion.
Threat (T) 1. District and village government awareness regarding mangrove forest conservation is still very low. 2. Forestry regulations are very weak when it comes to mangrove forest conservation.	1. Conduct training and outreach on the benefits of ecotourism 2. Strengthening institutional laws and regulations 3. Implement strict sanctions and regulations against excessive damage to mangrove forests.	1. Providing training to tourism operators and local communities on village government emphasis

Based on the table above, considering the opportunities for mangrove forest development at Serambi Deli Beach, Pantai Labu District, it is highly feasible to develop mangrove forest ecotourism with support from the government and relevant agencies, as well as improving accessibility to ecotourism locations to facilitate tourist visits (Tumanggor et al., 2023). Social media plays a major role in developing mangrove forests for ecotourism. Communities or tourism service provider can create tour packages and disseminate them through social media, thereby increasing tourist appeal by offering attractive package prices (Wantu et al., 2022). The development of mangrove forests for ecotourism

can be seen from its human resources. Human resource empowerment can be achieved through training and increasing knowledge among communities and managers about ecotourism development. Communities and tourism service provider are also emphasized to sustain mangrove forests (Rumondang et al., 2025).

Support from central government, local governments and non-governmental organizations is crucial to developing the Serambi Deli Beach mangrove forest in Pantai Labu District into an ecotourism destination. These institutions are also authorized to regulate mangrove forest protection to ensure the ecosystem's sustainability. They also play a role in developing facilities and infrastructure to enhance the attractiveness of the mangrove forest ecotourism location to tourists (Fauzi et al., 2022).

Mangrove forest ecotourism can be developed by creating tour packages that tourists can enjoy when visiting ecotourism sites. These packages are designed to provide engaging experiences for visitors while also helping preserve local culture and introduce cultural sustainability to tourists. Of course, all tour packages created will boost the local economy or help managers market their businesses in the tourism area (Rahim and Baderan, 2019).

The development of mangrove forest ecotourism at Serambi Deli Beach, Pantai Labu District, certainly faces several threats that must be addressed by managers, namely the logging of mangrove species by local communities for daily needs or for charcoal production. Changes in land use at ecotourism sites must also be considered, including the conversion of mangrove forests to agricultural land or residential areas. Damage to the mangrove ecosystem will reduce sustainability and the aesthetic value of mangrove forests, which are a tourist attraction. Mangrove forest damage also affects the number of aquatic and terrestrial biota, which are considered supporting tourist attractions (Laksananny et al., 2020).

c. Remote Sensing Analysis

This remote sensing analysis used ArcGIS 10.8 with Sentinel 2 satellite imagery (bands 8 and 4) to obtain NDVI values for the mangrove area of Serambi Deli Beach, Pantai Labu District. The results of the analysis are presented in the table below.

Table 5. Algorithms, Equations, and Average Values of Calculation Results

Algorithm	Equality	Average
NDVI	$NDVI = (NIR - Red) / (NIR + Red)$	0.36

Based on the data in the table above, the average NDVI is 0.36, indicating a high vegetation density, which generally reflects a dense, healthy mangrove forest. The mangrove forest location can be developed into a tourist attraction by empowering the local community to plan ecotourism development. Based on the ecotourism suitability analysis using the obtained NDVI imagery, see the image below.

Figure 1 depicts the condition of mangrove forest vegetation in the Serambi Deli Beach area, Pantai Labu District. This location is very strategic because it is not far from the city center and not far from Medan City, making it easy for tourists to visit this ecotourism location. Digital marketing is an important promotional tool for sharing the condition of the mangroves at this ecotourism location. The image above shows a dense mangrove forest, which will attract tourists to visit the location and provide economic, social, and ecological benefits to the environment and the surrounding community (Nanang et al., 2023). The results of the mangrove forest area mapping in this location should be published through a tourism information system or a geographic information system tailored to tourist needs, including location accessibility, tourist attractions, and adequate facilities and infrastructure for ecotourism development. Tourism information systems and geographic information systems can be integrated to display accurate information for mangrove forest ecotourism (Rachmadiarazaq, 2023).

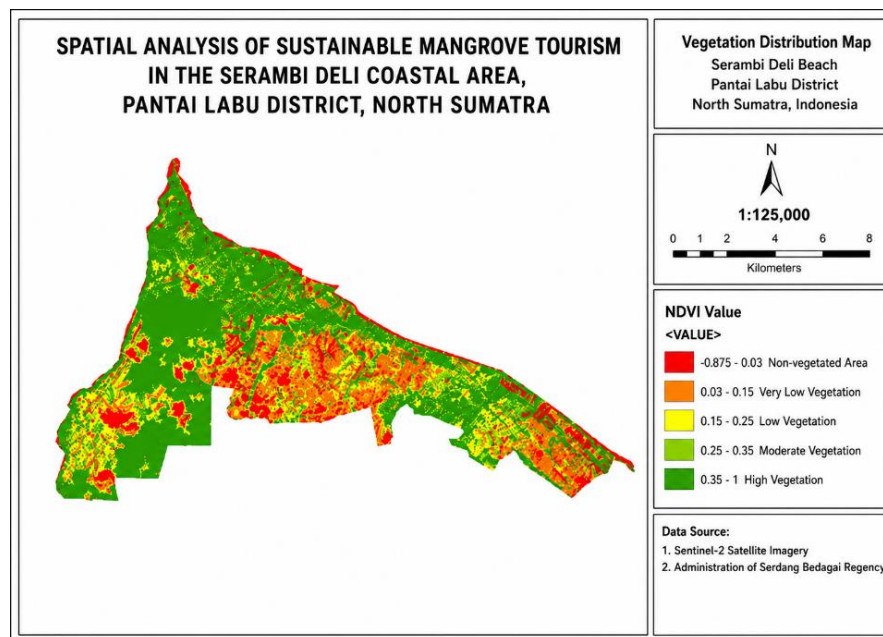


Figure 1. Vegetation Distribution Map of the Research Location

Remote sensing analysis of the Serambi Deli Beach mangrove forest in Pantai Labu District will provide significant benefits for the development of a tourism information system in the district. Using this technology, information on the tourism potential in the mangrove area is processed into accurate data useful for developing mangrove forest ecotourism (Mawardi, Imran, and Djafar, 2020). This remote sensing data is used to identify attractive locations for ecotourism development, assess environmental conditions, and inform decision-making. Furthermore, this technology will monitor the condition of the mangrove forest to ensure its benefits for the surrounding community remain sustainable (Sabir, 2020). Thus, this geographic information system and remote sensing technology demonstrate the importance of implementation in potential mangrove forest areas across various regions, the stages of identifying potential natural resources (SDA) that are managed as regional assets for economic growth, social welfare, and maintaining the sustainability of mangrove forests.

CONCLUSION

The Serambi Deli Beach mangrove forest in Pantai Labu District obtained an Ecotourism Suitability Index score of 71.05%, which is classified as “suitable but with conditions,” thus requiring the addition of mangrove species to increase mangrove diversity in the following locations. The SWOT analysis found that social media plays a significant role in disseminating information regarding the role of government and non-government entities in developing accessibility and infrastructure for ecotourism. The average NDVI value was 0.36, which falls within the moderate vegetation category and could be improved by planting various mangrove species at the study site.

RECOMMENDATION

Mangrove ecotourism development at Serambi Deli Beach should focus on improving ecosystem quality through mangrove rehabilitation and species enrichment, while strengthening tourism infrastructure and empowering local communities. These efforts are crucial for increasing ecotourism suitability, maintaining the area's ecological function, and strengthening the economic benefits derived from the community in a sustainable manner.

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REFERENCE

- Agusman, R. and Mataburu, I.B. (2024) 'Identifikasi Environment Critical Index menggunakan NDVI dan LST di Kota Surabaya', *Jurnal Sains Geografi*, 3(1), pp. 15–20
- Akram, A.M. and Hasnidar, H. (2022) 'Identifikasi kerusakan ekosistem mangrove di Kelurahan Bira Kota Makassar', *Journal of Indonesian Tropical Fisheries*, 5(1), pp. 1–11.
- Azwar, E., Feviani, Y., Haloho, B. and Tarigan, M.R.I.M.A. (2025) 'Vegetation diversity of mangrove forest in Percut Village, Percut Sei Tuan District, North Sumatra', *Jurnal Biolokus*, 8(2), pp. 276–287.
- Daulay, A.P., Sari, R. and Girsang, S.R.M. (2023) 'Pemanfaatan hutan mangrove untuk silvofishery di Desa Pasar Rawa Kecamatan Gebang Kabupaten Langkat, Sumatera Utara', *Jurnal Hutan Lestari*, 11(3), pp. 688–699.
- Djafar, M. and Mappiasse, M.F. (2019) 'Strategi pengembangan ekowisata karst di Dusun Rammang-Rammang Kabupaten Maros', *Gorontalo Journal of Forestry Research*, 2(1), pp. 1–10.
- Fauzi, M.A.R., Pamungkas, R.J., Ahmad, A.L. and Panjaitan, W.S. (2022) 'Analisa kesesuaian kawasan wisata Pantai Sebalang, Desa Tarahan, Lampung Selatan', *Jurnal Kelautan*, 14(3), pp. 223–231.
- Harto, S., Sidiq, R.S.S. and Karneli, O. (2021) 'Development strategy mangrove ecotourism based on local wisdom', *Sosiohumaniora*, 23(1), pp. 115–123.
- Hartati, F., Qurniati, R., Febryano, I.G. and Duryat, D. (2021) 'Nilai ekonomi ekowisata mangrove di Desa Margasari, Kecamatan Labuhan Maringgai, Kabupaten Lampung Timur', *Jurnal Belantara*, 4(1), pp. 1–10.
- Heshmati, M., Gheitury, M. and Shadfar, S. (2022) 'Factors affecting possibility of ecotourism development and sustaining natural resources using SWOT approach in west Iran', *International Journal of Geoheritage and Parks*, 10(2), pp. 173–183.
- Husamah, H. and Hudha, A.M. (2018) 'Evaluasi implementasi prinsip ekowisata berbasis masyarakat dalam pengelolaan Clungup Mangrove Conservation Sumbermanjing Wetan, Malang', *Jurnal Pengelolaan Sumberdaya Alam dan Lingkungan*, 8(1), pp. 86–95.
- Kartika, M., Subakir, S. and Mirsiyanto, E. (2021) 'Faktor-faktor risiko yang berhubungan dengan hipertensi di wilayah kerja Puskesmas Rawang Kota Sungai Penuh Tahun 2020', *Jurnal Kesmas Jambi*, 5(1), pp. 1–9.
- Laksananny, S.A., Poedjirahajoe, E., Purwanto, R.H. and Hermawan, M.T.T. (2020) 'Analisis vegetasi hutan mangrove di Kabupaten Buton Utara', *Jurnal Ilmu Lingkungan*, 18(3), pp. 515–521.
- Mawardi, I., Imran, A.N. and Djafar, M. (2020) 'Strategi pengembangan ekowisata mangrove di Desa Borimasunggu Kecamatan Maros Baru Kabupaten Maros', *Jurnal Eboni*, 4(2), pp. 51–56.
- Musa, F., Fozi, N.M. and Mohd, D.D. (2020) 'Coastal communities' willingness to pay for mangrove ecotourism in Marudu Bay, Sabah, Malaysia', *Journal of Sustainability Science and Management*, 15(4), pp. 130–140.
- Nanang, N. et al. (2023) 'Pendampingan media promosi digital dalam rangka peningkatan perekonomian masyarakat di ekowisata mangrove Medokan Ayu Surabaya', *Jurnal Abadimas Adi Buana*, 6(2), pp. 220–229.
- Pangestu, A., Setiadi, Y. and Susilo Arifin, H. (2019) 'Flora biodiversity at Proboscis Monkey habitat in ecotourism area, Tapin District, South Kalimantan', *Jurnal Ilmu Pertanian Indonesia*, 24(4), pp. 359–365.
- Pratiwi, M.W. and Muhsoni, F.F. (2021) 'Analisis kesesuaian ekowisata mangrove di Desa Taddan Kecamatan Camplong Kabupaten Sampang', *Samakia: Jurnal Ilmu Perikanan*, 12(2), pp. 105–115.
- Rachmadiarazaq (2023) 'Analisis struktur organisasi antarlembaga pada destinasi ekowisata mangrove Wonorejo Kota Surabaya', *Warta Pariwisata*, 20(2), pp. 1–5.

- Rahim, S. and Baderan, D.W.K. (2019) 'Komposisi jenis, struktur komunitas dan keanekaragaman mangrove asosiasi Langge Kabupaten Gorontalo Utara', *Jurnal Ilmu Lingkungan*, 17(1), pp. 181–188.
- Rahmawati, L. et al. (2024) 'Pengembangan sistem informasi geografis (SIG) untuk analisis spasial dalam pengambilan keputusan', *Jurnal Review Pendidikan dan Pengajaran*, 7(2), pp. 4058–4068.
- Rumondang, R. et al. (2025) 'Community perception and participation in Silo Laut regarding mangrove management and conservation in Asahan Regency', *Jurnal Biolokus*, 8(2), pp. 201–213.
- Sabir, M. (2020) 'Strategi pengembangan ekowisata mangrove Tongke-Tongke di Kabupaten Sinjai', *Jurnal Industri Pariwisata*, 3(1), pp. 53–60.
- Septiana, T. (2020) 'Pemanfaatan analisis spasial untuk pemetaan risiko bencana alam tsunami menggunakan pengolahan data spasial sistem informasi geografis', 7(2), pp. 210–218.
- Tumangger, B.S.F. (2019) 'Identifikasi dan karakteristik jenis akar mangrove berdasarkan kondisi tanah dan salinitas air laut di Kuala Langsa', *Biologika Samudra*, 1(1), pp. 9–16.
- Tumanggor, I.I., Hendri, R. and Yulinda, E. (2023) 'Strategi komunikasi pemasaran ekowisata mangrove di Bandar Bakau Kota Dumai Provinsi Riau', *Jurnal Sosial Ekonomi Pesisir*, 4(1), pp. 11–17.
- Utomo, B., Budiastuti, S. and Muryani, C. (2017) 'Strategi pengelolaan hutan mangrove di Desa Tanggul Tlare Kecamatan Kedung Kabupaten Jepara', *Jurnal Ilmu Lingkungan*, 15(2), pp. 117–123.
- Wantu, N. et al. (2022) 'Kesesuaian dan daya dukung ekowisata di kawasan mangrove', 15(3), pp. 248–257.