

Conceptual Design of an Integrated Recreational Park and Mangrove Research Centre in Pasar Rawa Village, Langkat: Towards a Sustainable Mangrove Ecosystem

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ABSTRACT. Mangrove forests are essential for environmental protection, biodiversity conservation, and climate regulation. However, integrated mangrove ecotourism with research centres has not yet been moulded in Indonesia. Therefore, this study aims to propose a conceptual design for an Integrated Mangrove Recreation Park and Research Centre in Pasar Rawa Village, Langkat Regency, using a sustainable architectural and landscape approach. A mixed-method was applied through structured observations, in-depth interviews with tourism officials, tourism managers, and local communities, as well as SWOT analysis using EFAS and IFAS. Literature reviews and comparative studies preceded the research to determine design preferences. The design concept emphasises the integration of sustainability principles, including resource conservation, the utilisation of local materials, renewable energy sources, waste reduction, community empowerment, and multi-stakeholder collaboration. The findings indicate that facilities integrating mangrove conservation, environmental education, and sustainable recreation are highly needed. The design emphasises ecological harmony, community and stakeholder engagement, educational impact, and sustainable accessibility and operations to support mangrove ecosystems while ensuring the long-term success of tourism. This recreation park is expected not only to become a new tourist destination but also to serve as a model of integrated, inclusive, and sustainable edutourism and ecotourism with positive ecological, social, and economic impacts.

Keywords: mangrove ecotourism, edu-tourism, eco-friendly design, mangrove ecosystem, sustainable landscape

ABSTRAK. Hutan mangrove berperan penting dalam perlindungan lingkungan, konservasi keanekaragaman hayati, dan pengaturan iklim. Hingga saat ini ekowisata mangrove yang terintegrasi dengan pusat penelitian di Indonesia masih belum ada. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan desain konseptual untuk Taman Rekreasi dan Pusat Penelitian Mangrove terpadu di Desa Pasar Rawa, Kabupaten Langkat dengan menggunakan pendekatan arsitektur dan lanskap berkelanjutan. Penelitian ini menggunakan metode campuran dengan melakukan observasi terstruktur, wawancara mendalam dengan pejabat di dinas pariwisata, pengelola wisata, dan masyarakat lokal, dan analisis SWOT melalui EFAS dan IFAS. Penelitian didahului dengan studi literatur dan studi komparasi untuk mendapatkan preferensi desain. Konsep desain difokuskan kepada integrasi prinsip keberlanjutan seperti konservasi sumber daya, penggunaan material lokal, energi terbarukan, pengurangan limbah, pemberdayaan masyarakat, dan kolaborasi multipihak. Hasil penelitian menunjukkan bahwa fasilitas yang mengintegrasikan konservasi mangrove, edukasi lingkungan, dan rekreasi yang berkelanjutan terpadu ini sangat penting. Desain menekankan harmoni ekologis, keterlibatan masyarakat dan pemangku kepentingan, pengaruh pendidikan, serta aksesibilitas dan operasional berkelanjutan untuk mendukung ekosistem mangrove sekaligus menjamin keberhasilan jangka panjang wisata ini. Taman rekreasi ini diharapkan tidak hanya menjadi destinasi wisata baru, tetapi juga menjadi model eduwisata dan ekowisata yang terpadu dan inklusif serta berkelanjutan dengan dampak positif secara ekologi, sosial, dan ekonomi.

Kata kunci: ekowisata mangrove, eduwisata, desain ramah lingkungan, ekosistem mangrove, lansekap berkelanjutan

INTRODUCTION

Geographically, Indonesia holds approximately 25% of the world's total mangrove area, as per the

National Mangrove Map (Ministry of Environment and Forestry, 2021). However, the current state is concerning, with 39% of this area experiencing degradation, and mangrove management showing a significant decline since 2020 (Inland Waters and Mangrove Rehabilitation, 2021). Only 30.7% of the total mangrove area is in good condition, while 27.4% is moderately damaged, and 41.9% is severely damaged. The situation is particularly severe in North Sumatra, where a study by the North Sumatra Environmental Agency in 2013 found that around 90% of mangrove forests were severely damaged.

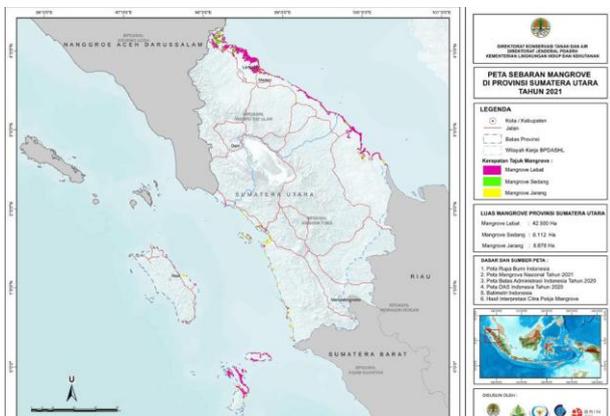


Figure 1. Distribution Map of Mangroves in North Sumatra
Source: *Peta Mangrove Nasional, 2021*

In Langkat Regency, mangrove forests are a vital component that supports the social, economic, and ecological life of coastal communities. However, in recent years, there has been a significant decline in mangrove forest area due to land conversion for aquaculture, plantations, and infrastructure development (Giri, C., et al., 2011). This phenomenon has accelerated coastal abrasion and threatens the sustainability of coastal ecosystems as well as the well-being of local communities. Pasar Rawa Village, located in Gebang District, is one of the areas in Langkat that has been affected by the diminishing presence of mangrove forests. This study will focus on that location, specifically at the Forest Farmers Group (KTH) *Penghijauan Maju Bersama, Dusun X Paluh Baru, Pasar Rawa Village*, Gebang District, Langkat Regency.

This also highlights why Langkat, with its long coastline and rich mangrove ecosystems, holds

great potential to be developed as an environmentally conscious tourism destination. The development of mangrove tourism in this area not only serves as a means of education and recreation for visitors but also as a tool to raise awareness and promote environmental conservation efforts.

On the other hand, through a sustainable architectural and landscape approach, the design of tourism facilities can minimise adverse environmental impacts and support long-term sustainability. Sustainable architecture and landscape design in mangrove tourism include the use of environmentally friendly materials, climate-adaptive design, and the implementation of renewable energy sources. These measures will ensure that the tourism area not only contributes positively to tourism development but also supports the restoration of degraded mangrove ecosystems. Moreover, by involving local communities in tourism management, this initiative is expected to become a sustainable alternative source of income, thereby reducing pressure on the exploitation of coastal natural resources.

In recent years, nature-based tourism that focuses on environmental conservation has gained increasing interest among both local and international tourists, particularly for recreational, educational, and research purposes. As reported by Detiksumut, during the Eid holiday, enthusiastic visitors flocked to the Mangrove Edu-tourism site in Batubara (Detiksumut, 2024). Similarly, another article from Suarasurabaya.net noted that thousands of people visited the Surabaya Mangrove Botanical Garden during the 2024 Eid holiday (Suarasurabaya.net, 2024).

Although there has been much research discussing the development of mangrove ecotourism and the preservation of coastal areas, most of the focus is still limited to ecology-based conservation without integrating educational or recreational spaces; mass ecotourism without in-depth analysis of architectural and landscape sustainability; spatial studies of coastal areas that have not actively considered community involvement in the design of facilities; closed mangrove research centers that are not integrated with public spaces and sustainable tourism.

Until now, there is still minimal research that combines architectural and sustainable landscape-based conceptual design with a mixed method (quantitative and qualitative) approach aimed at creating multifunctional spaces: recreation, education, conservation, and research in real locations such as Pasar Rawa Village, Langkat Regency, which has potential but has not been strategically developed. Additionally, there is a lack of prior research that simultaneously examines the responses of local communities and local governments to this integrated facility concept and applies SWOT analysis as a strategic foundation for determining the site and zoning of sustainability-based facilities. Therefore, it is necessary to develop a conceptual design model that is not only responsive to ecological challenges and climate change but also emphasises the crucial role of local communities in the sustainable preservation of mangrove ecosystems. Base on this problem statement, the following are the research objectives emphasize on four, those are: firstly, to identify the strengths, weaknesses, opportunities, and threats (SWOT) in the selection and development of the site area; secondly, to develop a community-based integrated mangrove facility involving local communities and government through questionnaire and interview results; thirdly, to identify the principles of sustainable architecture and landscape that can be applied to the design of mangrove coastal areas in Langkat; the last is to formulate the conceptual design of the integrated recreation park and mangrove research center in Pasar Rawa Village that integrates education, conservation, and recreation functions.

From the problem formulation above, the following are the research questions in the design of the Recreation Park and Mangrove Research using a Sustainable Architecture approach in the coastal area of Langkat:

- a. What are the strengths, weaknesses, opportunities, and threats (SWOT) in the selection and development of the site area?
- b. How do local communities and stakeholders perceive the plan to develop a community-based integrated mangrove facility? (based on questionnaire and interview results)
- c. What are the principles of sustainable architecture and landscape that can be applied to the design of mangrove coastal areas in Langkat?

- d. What is the conceptual design of the integrated recreation park and mangrove research centre in Pasar Rawa Village that integrates education, conservation, and recreation functions?

The objectives of this study are as follows:

- a. To identify the issues and potential of mangrove tourism development in Langkat
- b. To formulate sustainable architectural and landscape principles applicable to the design of the coastal mangrove area in Langkat.
- c. To develop a conceptual design for an integrated Mangrove Recreation and Research Park in Langkat that meets tourism and environmental conservation needs.

LITERATURE REVIEW

The Concept of Mangrove Ecosystems and Their Role in Climate Change Mitigation

Mangroves are a group of high-level plants that consist of trees, shrubs, palms, herbs, or ferns that primarily grow in tidal coastal areas in tropical and subtropical regions. These plants exhibit a high tolerance to saline conditions and oxygen-poor soils (Saenger, 2002). Mangrove ecosystems play a crucial role in supporting environmental resilience, particularly in addressing the impacts of climate change. Mangrove vegetation can absorb significant amounts of carbon dioxide and store it in the form of biomass and sediments, thus serving as a natural carbon sink (Hilmi et al., 2019). In addition, mangrove roots help prevent coastal erosion, mitigate the impact of tidal waves, and enhance the coastline's resilience (Alongi, 2008). In the context of architecture, a design approach that prioritises the conservation of mangrove ecosystems is crucial for maintaining the area's ecological functions while supporting sustainable tourism activities. The mangrove species found in Pasar Rawa Village include *Rhizophora apiculata*, *Bruguiera gymnorrhiza*, *Sonneratia alba*, *Excoecaria agallocha*, *Acrostichum speciosum*, *Acrostichum aureum*, *Scyphiphora hydrophyllacea*, and *Acanthus ilicifolius*. The diversity of flora and fauna found in the area provides opportunities for the development of nature-based tourism, particularly mangrove ecotourism (Syahrin & NP, 2020).

Table 1. IGT Mangrove Classification

Header Density Class	Wide (Ha)	Percent (%)
Dense Mangrove	3.121.240	92,78
Medium Mangrove	188.366	5,60
Rare Mangrove	54.474	1,62

Source: Ministry of Environment and Forestry, 2021

Sustainable Architecture in Coastal Areas Pesisir

Sustainable architecture is an approach to designing buildings and the built environment that not only aims to minimise negative impacts on the natural environment but also prioritises the health and comfort of occupants (Brenda & Robert Vale, 1996). To achieve a balance between development and environmental sustainability, sustainable architecture implements energy-efficient technologies, utilises environmentally friendly building materials, and supports the sustainability of local ecosystems (UNEP). This focus on occupant well-being ensures that sustainable buildings are not just environmentally friendly but also provide a comfortable and healthy living or working environment.

Greenship, a comprehensive green building assessment system developed by GBCI, covers six main categories. Each category is designed to provide a thorough evaluation of a project's sustainability. First, Appropriate Site Development (ASD) assesses the suitability of the project's location with sustainable principles. Second, Energy Efficiency and Conservation (EEC) focuses on reducing energy consumption. Third, Water Conservation (WAC) assesses strategies for water savings and management.

Next, Material Resource and Cycle (MRC) evaluates the use of environmentally friendly materials. Then, Indoor Air Health and Comfort (IHC) ensures air quality and thermal comfort. Lastly, Building and Environmental Management (BEM) encompasses building maintenance and environmental management. These six aspects serve as a reference in designing environmentally friendly and sustainable buildings.

Sustainable Landscape Design

Integrating ecological, social, and aesthetic elements to create open spaces that are environmentally friendly, efficient, and resilient to climate change. Its main principles include the preservation of local ecosystems, the use of native vegetation, efficient water management, and the enhancement of human quality of life through connections with nature.

According to Mang and Reed (2012), regenerative landscape planning is not just about preservation, but also about revitalising ecosystems. In mangrove areas, sustainable landscapes integrate buffer zones, natural drainage, and native vegetation to ensure resilience. These principles are crucial in designing landscapes in flood-prone and ecologically sensitive zones such as the Rawa Market. The concept is reinforced by Musacchio (2009), who states that sustainable landscapes not only focus on maintaining natural beauty but also on ecological and regenerative functions, especially in sensitive areas such as mangrove forests. This approach emphasises the importance of system-based design that encompasses biodiversity, soil structure, water cycles, and social engagement in spatial usage.

Thompson and Sorvig (2018) in Sustainable Landscape Construction emphasise that landscapes designed with sustainability principles must consider minimising disturbances to the soil and native vegetation, promoting natural water circulation and ecological drainage systems, utilising local and recycled materials, and incorporating educational and social functions into green spaces.

In the context of mangrove areas, landscape design integration must consider tidal height, soil substrate types, and the potential for ecological education that can be utilised in interpretive trails, observation decks, and natural nurseries.

The Concept of Eco-Tourism, Edu-Tourism, and Local-Based Culinary Tourism

The utilisation of mangrove ecosystems as an ecotourism destination reflects a paradigm shift in

tourism from the concept of old tourism, which focuses solely on recreation, to new tourism that integrates elements of education and conservation into its activities (Widiatmaka, Dewi, & Handayani, 2023).

Ecotourism is defined as a form of tourism that is environmentally responsible and empowers local communities. It involves hands-on experiences in nature, environmental education, and conservation efforts (Martha Honey, 2008). On the other hand, edu-tourism refers to tourism activities that integrate educational values through observation, interaction, and learning from natural or cultural attractions (Rodger, 1998). According to Verawati and Idrus (2023), mangrove ecotourism areas designed with an educational approach have the potential to become a strategic environmental learning centre for students and the community. Meanwhile, locally based culinary tourism highlights regional cuisine as a means to introduce cultural identity while promoting local creative economic growth. These three concepts can be integrated into the design of mangrove tourism areas to create an informative and sustainable tourism experience that also supports the local economy.

Comparative Study: Other Mangrove Research Parks

Several mangrove research parks in Indonesia have been developed using diverse approaches tailored to the region's characteristics and their specific purposes. One of them is the Mangrove Ecotourism Area at Pantai Indah Kapuk (PIK), Jakarta, which combines conservation functions with education-based tourism activities. This area not only serves as a conservation zone for mangroves but is also open to the public, allowing visitors to enjoy the beauty of the mangrove forest while gaining knowledge about the important role this ecosystem plays in the environment.

In addition, the Mangrove Centre in Tuban serves as an example of a research park that is more integrated with community empowerment activities. Here, mangrove conservation is combined with skills training and the processing of mangrove-based products, such as snacks and

handicrafts, which provide economic benefits for the surrounding community.

In the mangrove ecotourism of Lembung Village, Galis District, Pamekasan Regency, established since 2019, visitors can learn about mangroves, how to conduct research, how to recognise mangrove ecosystems, how to measure mangrove density, how to determine the DO (Dissolved Oxygen) contained in the space around the mangroves, and how to determine the wave velocity. (Amalia et al., 2023).

Likewise, in Wonorejo, the Wonorejo Mangrove Ecotourism frequently becomes a destination for activities and research for students, including participants of student exchange programs from outside Java and overseas. This place is also often visited by international tourists and educational institutions from various countries such as Japan, the United States, and Africa. (Ramadhanty et al., 2024).

Meanwhile, the MECoK Ecopark in Jepara stands out as a centre for research and a mangrove arboretum based on an educational approach and community participation. Here, conservation aspects are combined with research and education activities, creating an interactive learning space between visitors, researchers, and local residents. These three examples demonstrate how mangrove research parks can be developed with a sustainable approach that focuses not only on ecological aspects but also on social and economic aspects. This aligns with the concept of ecotourism, allowing visitors to enjoy the beauty of mangrove forests while learning about the importance of mangrove ecosystems for the environment.

From this comparative study, it can be concluded that the success of the mangrove tourism area is not only based on its architectural design but also on community-based empowerment, educational programs, and conservation strategies.

METHOD

This research uses a mixed-methods approach, combining qualitative and quantitative methods in data collection and analysis to explore and propose

a conceptual design that integrates recreation, conservation, and scientific research sustainably. This approach was chosen to provide a more comprehensive understanding of the design of Mangrove Recreational Parks in Lalat Beach, as each method offers complementary advantages.

Data Collection Techniques

This study employed both qualitative and quantitative approaches to obtain comprehensive information for the design process. Data were collected through a literature study encompassing books, scientific journals, regulations, and previous research related to mangrove ecosystems, sustainable architecture, and ecotourism, providing theoretical foundations and design references. In addition, structured field observations were conducted on the project site to document physical conditions, natural potentials, accessibility, circulation, vegetation, and surrounding environmental characteristics that influence the design concept.

Furthermore, data were also obtained through in-depth interviews with stakeholders, including tourism office officials, tourism managers, and local communities, to explore perspectives, needs, and expectations regarding the development of mangrove ecotourism. Comparative studies of similar facilities, both nationally and internationally, were conducted to identify best practices, design strategies, and innovative concepts relevant and adaptable to the local context.

Data Analysis Techniques

The data analysis techniques in this study combine qualitative and quantitative approaches to strengthen the formulation of design concepts. Qualitative data from interviews with tourism officials, tourism managers, and local communities were analysed through content analysis to identify key themes related to sustainability, community engagement, and functional needs. Furthermore, a SWOT analysis, combined with EFAS (External Factor Analysis Summary) and IFAS (Internal Factor Analysis Summary), is used to evaluate both internal and external factors that influence development strategies. A comparative study

analysis was also conducted on similar facilities to gather design preferences. The results of all analyses are then synthesised to formulate a design strategy as the basis for the conceptual design of the Integrated Recreational Park and Mangrove Research Centre.

The logical flow of the research starts from data input and the analysis process, leading to the output of the design and its impact on the sustainability of the mangrove ecosystem in Pasar Rawa Village. Conceptually, the logical flow of this research can be seen in the following image.

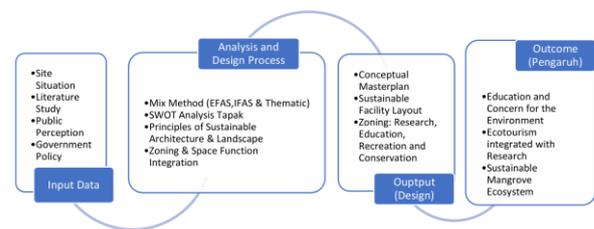


Figure 2. Research Conceptual Framework
Source: Author, 2025

Location Description

The management of the mangrove area is carried out by Kelompok Tani Hutan (KTH) Penghijauan Maju Bersama, a local group of forest farmers that is located in Pasar Rawa Village, Gebang Sub-district, Langkat Regency, North Sumatra. The group consists of local community members who are actively involved in mangrove conservation. This site is situated in a coastal area that still contains natural mangrove ecosystems with strong potential to be developed as an ecotourism destination. Access to this location is relatively poor; however, this area offers enough land for the development of environmentally-based recreational and educational facilities.



Figure 3. The Facilities at the Existing Study Area
Source: Author, 2025

The facilities at the existing location are limited and basic. There is a wooden hut used as a gathering place for group members, a wooden path providing access to the mangrove area, and some information boards displaying information about mangrove species. Additionally, there is an open area that is frequently used for reforestation and environmental education activities. Basic infrastructure, such as electricity, clean water, and sanitation, is not yet fully adequate, thus requiring further development to support sustainable tourism and educational activities.



Figure 4. Natural Elements at the Location
Source: Author, 2025

Pasar Rawa Village features natural elements that are highly supportive of development as a recreational park and mangrove research center. The presence of a still quite extensive and natural mangrove forest becomes the main potential of this area. The diverse types of mangroves and the high density of vegetation create an ideal ecosystem for conservation, research, and environmental education activities. Additionally, the location's proximity to coastal waters enhances biodiversity

and offers a stunning natural backdrop for visitors. The combination of the natural landscape's beauty, the diversity of flora and fauna typical of mangroves, and the calm environmental atmosphere makes Pasar Rawa Village a potential site to unite recreational and research functions in a sustainable area.

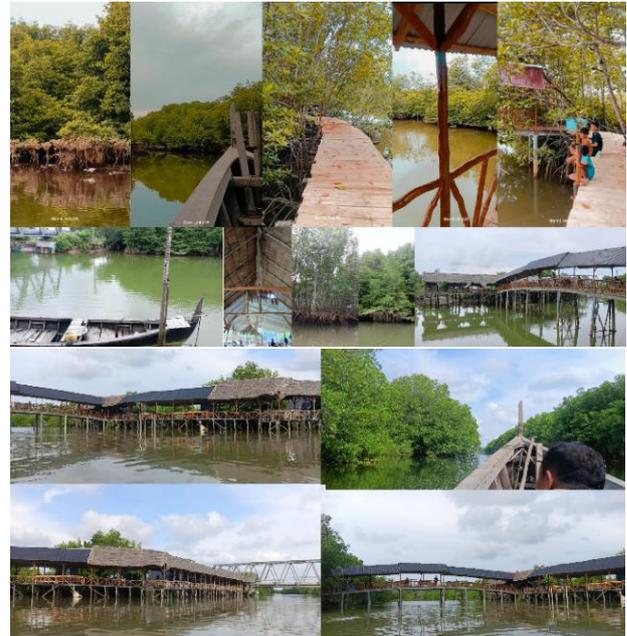


Figure 5. The Situation of The Study Area
Source: Author, 2025

RESULTS AND DISCUSSION

Interview Analysis

In a study of the Silau Laut mangrove area, Nasution et al. (2025) emphasised the importance of cooperation among the government, community, and private sector in developing sustainable ecotourism. Therefore, interviews were conducted directly with various parties involved in the management of mangrove areas and tourism development in Langkat, serving as the primary data source.

According to the Langkat Tourism Office, the management and development of mangrove tourism in Langkat Regency faces complex challenges, starting from the need for cross-agency collaboration, such as with the Environmental Office, the provincial Forestry Office, and parties

that assess the Environmental Impact Analysis (AMDAL). Land ownership issues, which are partially held by the community or the Langkat government, also hinder the development of tourism facilities. Low community awareness of the potential of mangrove tourism, minimal appeal of facilities, poor road access, and budget limitations are also major obstacles. Despite this, the role of the local community remains crucial in the preservation and management of this area, from economic, infrastructure, to environmental aspects. Until now, the development of mangrove tourism in Langkat is still considered stagnant, which necessitates new, more integrative innovations.

In response to these various challenges, the design of an integrated recreational park and mangrove research centre on the coast of Langkat will become a strategic solution. This concept combines education, conservation, and recreation functions within a single area, while also actively engaging the community in management and a creative economy based on mangrove resources. The presence of the research centre also supports continuous monitoring of the ecosystem. With its attractive design, good accessibility, and educational programs, this area has the potential to become a new tourist destination that addresses the stagnation in mangrove tourism development in Langkat.

According to the manager of KTH Penghijauan Maju Bersama in Pasar Rawa Village, Gebang District, visitor activities are currently limited to activities such as fishing, mangrove planting, and forest excursions by boat. However, environmental education has begun to be conducted, for example, through student visits from SMAN 1 Gebang. This area has been visited by foreign tourists from Japan, Malaysia, Australia, and even France, indicating international potential. Community participation is also seen in the initiative of local mothers who process baronang fish into chips as souvenirs. However, the number of visits remains low, primarily due to damaged access roads, limited facilities, and a lack of development budget. This area has a high biodiversity of mangroves.

Table 2. Interview Results

Source	Challenges & Potential
Langkat Tourism Office	<p>Complex challenges: requiring collaboration between institutions (Environmental Agency, Forestry Department, Environmental Impact Assessment team)</p> <p>Land ownership issues (owned by local communities or district government)</p> <p>Low public awareness</p> <p>Unattractive facilities, poor accessibility, and a limited budget</p> <p>Mangrove tourism remains stagnant.</p>
Management of the Forest Farmers Group (KTH) Penghijauan Maju Bersama	<p>Tourism activities are limited: fishing, mangrove planting, and forest exploration.</p> <p>Environmental education has begun (student visits, such as from SMAN 1 Gebang)</p> <p>Potential for international tourists (Japan, Malaysia, Australia, France)</p> <p>Women's participation: production of <i>baronang</i> fish chips</p> <p>Challenges: damaged road access, limited facilities, minimal budget</p> <p>High mangrove biodiversity</p>
Local Community	<p>Awareness is starting to grow, but participation remains limited.</p> <p>There is hope for training, business facilities, and support for local product marketing.</p> <p>Desire to be actively involved in tourism management</p>

Source: Author, 2025

Based on the results of the interview, the design of the Mangrove Tourism Recreation Centre with a sustainable architecture approach also becomes a suitable solution. In addition to optimising ecological and tourism potential, this design also encourages community empowerment through educational facilities, processed seafood production, and an integrated conservation system, which is expected to revive the Langkat mangrove area as a sustainable, attractive, and socially-ecologically beneficial tourist destination.

SWOT Analysis

In designing the Mangrove Recreation Park with a sustainable architectural approach in Langkat, a deep understanding of the site's internal and external conditions is crucial. A SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) is used as a tool to identify the potential and challenges that may affect the design and

development of the area. Through this analysis, the resulting design is expected to be not only responsive to the environment but also capable of meeting the community's needs and supporting the sustainable preservation of the mangrove ecosystem.

a. Strengths (Advantages)

The uniqueness of the mangrove ecosystem in Pasar Rawa Village makes it a rare nature tourism attraction with high educational value. The diversity of mangrove species and the presence of distinctive coastal fauna further strengthen its potential as a nature-based tourist destination. Its strategic location, close to marine waters and relatively pristine ecosystems, enhances its capacity to develop as a sustainable recreation area. Additionally, the availability of extensive land supports plans for developing an integrated and comprehensive recreation zone. Support from the local community—especially from groups of fishermen and artisanal seafood producers—is a key strength in the preservation of mangroves. The potential for utilising renewable energy sources, such as solar power and organic waste processing, also aligns with the sustainable architecture approach intended for the area.

b. Weaknesses

Accessibility to the location remains a significant challenge, particularly due to limited road infrastructure and inadequate public transportation. This situation is exacerbated by the absence of essential facilities in the area, including unstable electricity supply, limited access to clean water, and suboptimal sanitation systems. Additionally, the area's potential as a tourist destination has not yet fully materialised due to minimal promotional efforts and the absence of a strong branding strategy to attract tourists and investors.

c. Opportunity

The increasing trend of eco-friendly tourism and the growing interest in ecotourism present significant opportunities to develop mangrove areas as sustainable tourist destinations. This Opportunity is

strengthened by support from the government and non-governmental organisations (NGOs) in environmental conservation efforts and the empowerment of coastal communities, which can serve as a strong foundation for community-based development. Additionally, the potential for collaboration with academics, students, and researchers opens up possibilities for establishing a Mangrove Research Centre. Other opportunities include local economic diversification through the processing of mangrove products, such as fish chips, souvenirs, and merchandise, which directly support community empowerment.

d. Threat

This development faces various threats that must be seriously anticipated. Climate change, which triggers rising sea levels and coastal erosion, can accelerate the degradation of mangrove ecosystems if not accompanied by appropriate mitigation measures. On the other hand, water pollution and the accumulation of waste due to human activities around coastal areas further worsen environmental quality and disrupt ecosystem balance. Lack of oversight and weak regulations also pose a threat.

According to Musliha, Oktarina, and Suryanto (2023), the development of mangrove tourism in Indonesia faces various challenges, one of which is ensuring sustainability through visitors' willingness to pay for facilities and services.

In addition, there is a potential conflict of interest between nature conservation efforts and uncontrolled mass tourism development, which, if not managed wisely, could undermine the long-term goals of sustainable tourism area development.

Table 3: IFAS (Internal Factor Analysis Summary)

No	Internal Factors	Weight	Rating	Weighted Score
Strengths				
1.	Biodiversity of mangroves and distinctive coastal fauna	0.15	4	0.6
2.	Strategic location near the sea	0.1	3	0.3
3.	Relatively natural ecosystems	0.12	4	0.48
4.	Local community support	0.08	3	0.24
5.	Renewable energy potential (solar, processing)	0.05	3	0.15
Weaknesses				
6.	Road access & limited transportation	0.12	2	0.24
7.	Inadequate basic infrastructure (electricity, water, sanitation)	0.15	1	0.15
8.	Lack of promotion and branding of the area	0.13	2	0.26
Total		0.9		2.42

Source: Author Analysis, 2025

Table 4: EFAS (External Factor Analysis Summary)

No.	External Factors	Weight	Rating	Weighted Score
Opportunities				
1.	The ecotourism trend is increasing	0.15	4	0.6
2.	Government & NGO support for conservation	0.12	4	0.48
3.	Potential collaboration with academics & researchers	0.08	3	0.24
4.	Opportunities for the development of local products from mangroves	0.1	3	0.3
Threats				
5.	Climate change & abrasion	0.12	2	0.24
6.	Water pollution and human waste	0.13	1	0.13
7.	Weak coastal management regulations	0.15	2	0.3
8.	Potential conflicts between conservation and mass tourism	0.15	2	0.3
Total		1.0		2.59

Source: Author Analysis, 2025

Provisional Interpretation

- **IFAS Score (2,42).** It shows that strengths are still slightly superior to weaknesses, but some weaknesses, such as infrastructure and road access, need to be addressed quickly.
- **EFAS Score (2,59)** shows a fairly high opportunity, especially with ecotourism trends and government/NGO support, but threats such as climate change, pollution, and weak regulation are quite significant.

SWOT Quadrant Position

- **X-axis (Internal) = Strength Score – Weakness Score**
 $Strength = 0,60 + 0,30 + 0,48 + 0,24 + 0,15 = 1,77$
 $Weakness = 0,24 + 0,15 + 0,26 = 0,65$
 $Difference = +1,12$ (positive → more dominant strength)
- **Y-axis (External) = Opportunity Score – Threat Score**
 $Opportunity = 0,60 + 0,48 + 0,24 + 0,30 = 1,62$
 $Threat = 0,24 + 0,13 + 0,30 + 0,30 = 0,97$
 $Difference = +0,65$ (positive → greater chance)

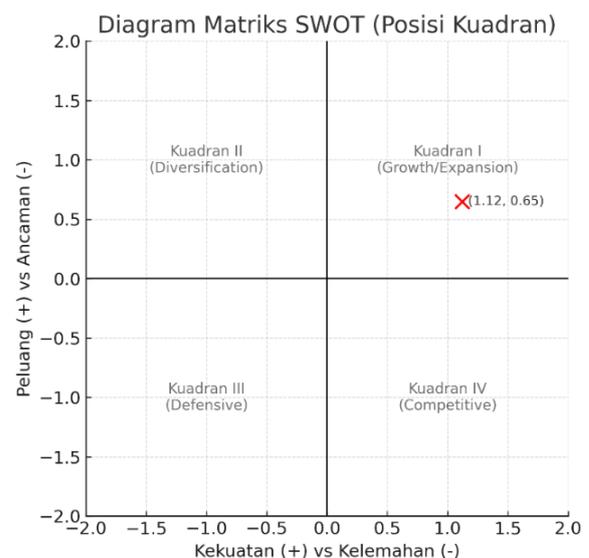


Figure 6. Diagram Matriks SWOT

Source: Author, 2025

Position: Kuadran I (Growth/Expansion) → The suggested strategy is **aggressive**, harnessing power to seize opportunities.

Table 5: Matriks SWOT & Strategi

SO Strategy (Strength-Opportunity)	WO Strategy (Weakness-Opportunity)
1. Developing biodiversity-based mangrove education tour packages. 2. Utilizing strategic locations and renewable energy for promotion. 3. Hold annual festivals/events in the mangrove area.	1. Improving basic infrastructure through government & NGO collaboration. 2. Improve road access & transportation. 3. Develop digital promotion and branding programs.
ST Strategy (Strength-Threat)	WT Strategy (Weakness-Threat)
1. Strengthen conservation regulations to prevent damage. 2. Community-based environmental monitoring system. 3. Academic research for climate change solutions.	1. Develop an ecotourism master plan for ecotourism. 2. Tighten regional regulations and supervision. 3. Training of local human resources to be ready to compete.

Source: Author, 2025

With its position in Quadrant I, the development of mangrove ecotourism in this location has great potential for expansion. The focus of development is directed towards harnessing the power of nature and supporting local communities, as well as optimising ecotourism trends through collaboration with the government and NGOs. In addition, development also needs to fix fundamental weaknesses such as infrastructure and accessibility, while anticipating threats that may arise through regulatory implementation and sustainable management.

General Concept

a. Spatial Planning

Memorable tourist experiences are an important indicator of the success of mangrove ecotourism development. A study by Amirsjafir, Lestari, and Tirtaningtyas (2024) shows that aspects of comfort, accessibility, and interaction with nature influence tourist satisfaction levels. Therefore, the design needs to consider the overall quality of the space to create a satisfying experience. Implications of site planning zoning:

- The highland zone with existing tree canopies and close to waterways is

prioritised for research and educational infrastructure, minimising environmental disruption.

- A buffer zone is planned between building structures and the core mangrove conservation area.
- Accessibility for pedestrians and boats is also considered in the placement of the main reception and observation nodes.
- Areas identified as flood-prone are given platforms on the banks of the river as a barrier to prevent water penetration into the site area and use stilted (or elevated) building structures to minimise impact and provide observation platforms (towers).

b. Integration of Educational, Conservation, and Tourism Functions

The design of the mangrove recreation tourism centre integrates three interrelated main functions: education, conservation, and tourism. The educational function is manifested through the provision of research centres and interactive learning spaces that can be utilised by students, researchers, and the general public. The conservation function is carried out through the preservation of existing mangrove vegetation, rehabilitation of critical areas, and open laboratories for mangrove seedling cultivation. Meanwhile, the tourism function is presented in the form of walking paths, gazebos, fishing areas, observation towers, suspension bridges, production houses for seafood products, and local culinary tourism spaces that offer an authentic beach experience in Langkat.

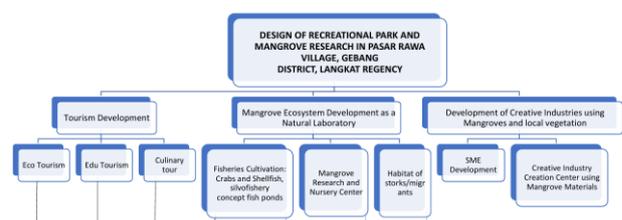


Figure 7. Schematic scope of the Recreational Park Design and Mangrove Research Center in Pasar Rawa Village

Source: Author, 2025

c. Zoning Arrangement

The arrangement in the area design is based on the principle of separating activities according to the intensity and sensitivity of the land. The integrated conceptual plan includes:

- a. Reception zone (information centre, gallery)
- b. Research zone (laboratory, training room)
- c. Recreation zone (cafe, bird observation deck, kayak or boat path)
- d. Nursery and conservation zone (protected mangrove area)
- e. Community creative centre (eco craft workshops and mangrove-based products)

Conceptually, the core conservation zone is placed in areas with the highest mangrove density, where physical intervention is minimised. The education and research zones are located close to the conservation area to support direct observation. Public tourism zones, such as culinary and souvenir areas, are positioned at the edge of the site for easy access from the main road. The circulation system for pedestrians in the forest area is designed as elevated pathways to minimise damage to the mangrove substrate. Furthermore, based on data synthesis, the design should prioritize educational access: open classrooms, interpretive trails, and mangrove nursery gardens. Then, zoning should protect the core conservation area, where building infrastructure is placed in less sensitive zones. Multi-story architecture and passive cooling strategies should be implemented based on the observed climate conditions.

Sustainable Architecture and Landscape Approaches

a. Energy Efficiency and Utilization of Local Resources

Energy efficiency is applied through building orientation that maximises natural lighting and cross ventilation. The use of solar panel systems on the roof area is a renewable energy solution for the electricity needs of the area. On the other hand, utilizing local resources involves bamboo, coconut wood, and nipa roofs available in the coastal region, while supporting the local economy. This design

strategy reduces carbon emissions from material distribution and strengthens local identity in architectural appearance.

b. Adaptation to local climate (Tides, Humidity, Wind)

The tidal conditions in the coastal area of Langkat require a raised or piloted structure design to prevent disturbances caused by changes in water levels. The floor level of the building is set at least 1.5 meters above the highest tide elevation based on local tidal studies. High humidity is anticipated through the selection of materials resistant to decay and mould, as well as the use of cross-ventilation systems and layered walls. The dominant wind direction is utilized for building orientation to achieve thermal comfort without relying on artificial cooling.

c. Use of Environmentally Friendly Materials

The materials used in the design are chosen based on the principles of sustainability and the life cycle of materials. The main materials consist of bamboo and waterproof wood that are legally sourced and FSC certified. The walls of the building utilize natural materials such as woven bamboo or recycled wooden panels. In some parts of the structure, lightweight concrete mixed with rice husk ash is considered an alternative to conventional materials to reduce the carbon footprint. The Trekking Path section uses a PVC-like material to be waterproof and low maintenance, while maintaining a wood-like appearance to keep a natural look.

d. Water and Waste Management

The water management system in this area is designed with a conservative approach. Rainwater is collected through roofs and directed into storage tanks for use as non-potable water, such as for irrigation and toilet needs. Wastewater from public areas is routed to artificial wetlands that use natural filtering plants before being released back into the environment. In addition, integrated composting facilities and waste banks are available, with waste processed into fertilizer for seedling or vegetation needs within the tourism area. This supports public

education on the importance of self-sufficient and sustainable waste management.

Conceptual Design of an Integrated Recreation and Research Park Facility

a. Open Hall / Reception Hall

The open pavilion serves as the main entrance point for visitors, providing information about the area and acting as a meeting point for educational tours. Its design combines traditional structures with local materials such as coconut wood and thatched roofs, as well as a completely open layout. This pavilion also functions as a flexible space for cultural activities, short seminars, or community performances.

b. Research Centre and Workshop

This facility serves as the main centre for research and training activities, consisting of light laboratories, workshop rooms, reading rooms, a library, and archive rooms, as well as storage areas for mangrove samples. It is designed with natural lighting and equipped with environmentally friendly technologies such as solar panels.

c. Guest House for Researchers

The guesthouse serves as accommodation for researchers conducting medium to long-term studies. Each unit is designed in a modular form, using a raised structure to adapt to tidal elevation. Eco-friendly materials such as recycled boards and woven bamboo are used for the exterior walls, creating an atmosphere that is harmonious with nature. Each unit is equipped with basic facilities and connected by walkways leading to the research centre.

d. Creative Houses (Small Industries)

The SWOT study conducted by Nurhayati et al. (2023) shows that one of the main strengths of mangrove ecotourism in Pangandaran is the presence of the local community that supports conservation and educational activities. The Creative House serves as a platform for production and training to process marine and mangrove forest products, such as fish chips, mangrove syrup, and

herbal soap, to empower the local community, especially coastal women.

e. Restaurants and Cafes

Restaurants and cafes serve as centers of social interaction and spaces for consuming local products. The building is designed to face the sea, maximising the view of the mangrove landscape. The menu highlights the wealth of the sea and traditional cuisine, such as grilled mangrove fish, fresh coconut water, and local snacks. This area also integrates a waste management and rainwater system.

f. Mangrove Seedling Park

This facility serves as an open laboratory for mangrove conservation and education. Located near the conservation transition zone, the nursery is equipped with natural irrigation channels, observation paths, and an open seedling house. Visitors can actively participate in planting and caring for seedlings as part of environmental education and coastal rehabilitation programs.

g. Fishing Area and Relaxation Pavilion

This area is designed for passive recreation, offering a relaxing experience immersed in a coastal environment. Several huts with thatched roofs are built on stilts above shallow waters. Designated fishing spots are equipped with wooden platforms that do not disturb the seabed habitat, and information signs are provided to inform visitors about local fish species and environmentally friendly fishing guidelines.

h. Migratory Bird Conservation Area

This area is a low-disturbance zone, designated explicitly for the observation and conservation of waterbirds and migratory birds that rest in the mangrove ecosystem. Boardwalks and birdwatching towers are constructed using lightweight, non-permanent materials to minimise disturbance to the natural environment. Information about bird species and migration patterns is provided through interpretive signs as part of the park's educational program.

CONCLUSION

This study proposes a conceptual design for an Integrated Recreational Park and Mangrove Research Centre in Pasar Rawa Village with a sustainable architectural and landscape approach. By integrating ecotourism, scientific research, education, and community involvement into a single spatial framework, this design aims to enhance environmental awareness, cultural relevance, and ecological resilience. The conceptual design of this facility is a strategic effort to address the challenges of coastal ecosystem degradation, low environmental literacy among the community, and the need for sustainable local economic development. The concept of this area integrates the complementary functions of education, conservation, and tourism, utilising a design approach that is responsive to the local climate, efficiently utilises natural resources, and employs environmentally friendly materials. The research results indicate that this area has excellent potential to provide positive impacts both ecologically and socio-economically. The rehabilitated mangrove ecosystem can serve as a natural barrier against climate change and as a habitat for biodiversity.

The recommendation from this research is to develop the technical design of the building (structure, materials, and MEP), including an Effectiveness Design Study for the Mangrove Ecosystem. This study assesses the design's impact on the surrounding ecosystem through a landscape ecology approach and scientific studies for measuring the Socio-Economic Impact Assessment.

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