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Study Of Ecological Architecture Concepts in Mangrove Forest Ecotourism Areas

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ABSTRACT

Mangrove forest ecosystems play a crucial role as biodiversity habitats and natural barriers protecting coastal areas from abrasion by ocean waves. However, threats such as human activities, climate change, and the growing interest in developing mangrove areas as tourist destinations call for a more sustainable design approach. Ecological architecture offers a solution by harmonizing built environments with ecological preservation. This study investigates the application of ecological architecture principles in mangrove forest ecotourism, focusing on Angke Kapuk Nature Tourism Park, Mangrove Ecotourism Centre, Pantai Indah Kapuk, and Mangrove Paradise Resort in Brunei. The research explores key principles, including adaptive design, conservation and restoration, energy efficiency, waste management, and the use of local materials, alongside building forms and structures. A descriptive-comparative method with a qualitative approach, through direct observation, documentation, and literature review. The results show that the three locations have applied ecological architecture principles in accordance with local conditions. Angke Kapuk Nature Tourism Park and Pantai Indah Kapuk focus on ecosystem conservation, whereas Mangrove Paradise Resort emphasizes the integration of lodging facilities within the mangrove ecosystem. Common features include stilt-building designs to protect the underlying ecosystem and the use of natural lighting and ventilation for energy efficiency. This study highlights ecological architecture as an effective strategy for developing sustainable ecotourism areas, ensuring a balance between environmental preservation, tourism development, and community engagement.

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1. INTRODUCTION

Mangrove forests, commonly known as tidal forests, can generally be defined as forests that grow in tidal areas, submerged during high tide and exposed during low tide, with ecosystems containing flora and fauna tolerant to brackish water (Utomo et al., 2023). The primary function of mangrove forests is to act as natural barriers that prevent coastal abrasion caused by ocean waves (Manurung et al., 2021).

In DKI Jakarta Province, mangrove forests are found in the Tegal Alur-Angke Kapuk mangrove area and around Kepulauan Seribu. Several mangrove forest areas in Jakarta have been opened to the public as mangrove ecotourism destinations, such as Muara Angke Wildlife Sanctuary, Mangrove Ecotourism Centre, Pantai Indah Kapuk, and Angke Kapuk Mangrove Nature Park. These mangrove forests are among the closest mangrove ecosystems to the residential centers and the capital of Indonesia, offering excellent accessibility and playing a significant role in maintaining coastal ecological balance. In recent years, mangrove forests have shown potential to become attractive destinations for nature and educational tourism (Febriyanto, 2020).

However, these areas face significant challenges, such as land conversion for aquaculture, coastal development, and deforestation, causing severe pressure on these vital habitats and leading to degradation and loss in many regions, particularly in Indonesia. (Akram et al., 2023)

The development of the tourism sector has the potential to cause negative impacts, especially due to human activities that harm the natural environment. This situation underscores the urgent need for sustainable tourism concepts. Ecotourism is one such approach with great potential for further development by applying sustainability principles (Yumnaristya, 2024).

Ecotourism is a tourism concept that focuses on tourism activities that minimize negative impacts on the environment and educate visitors about the importance of protecting ecosystems, while promoting local economic growth through nature-based tourism. Mangrove ecotourism emphasizes the conservation of mangrove forests, raising awareness about mangrove forests among tourists, and providing economic benefits to local communities (Heymans et al., 2019).

Developing mangrove forests as ecotourism areas can be an effective way to provide economic benefits while preserving these areas as conservation zones. This approach allows environmental utilization without damaging the existing mangrove ecosystem, and encourages preservation efforts as a buffer zone for conservation areas (Karlina, 2015).

In Indonesia, particularly in DKI Jakarta Province, mangrove forests are distributed along the Tegal Alur-Angke Kapuk mangrove area and around the Kepulauan Seribu. There are several mangrove forests in Jakarta that are open to the public as mangrove ecotourism areas, including Muara Angke Wildlife Sanctuary, Mangrove Ecotourism Centre, Pantai Indah Kapuk, and Angke Kapuk Mangrove Nature Park. These three areas are the mangrove ecosystem areas closest to the population center and capital of the Republic of Indonesia, easily accessible and play an important role in maintaining the balance of the coastal ecological system. In recent years, the PIK mangrove forest has the potential to become an attractive natural and educational tourism destination for the community (Febriyanto, 2020).

The ecological architecture approach is becoming increasingly relevant in the modern era, where development must align with environmental sustainability. According to (Heinz Frick & Tri Hesti Mulyani, 2006), ecological architecture is a humanitarian architectural

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design concept that takes into account the harmony between humans and their environment. This approach emphasizes harmonizing buildings with nature by incorporating sustainability principles into design and construction.

The term "ecology" was first introduced by Ernst Haeckel. Derived from the Greek words *oikos* means (home or lifestyle) and logos means (knowledge or science). Thus, ecology refers to the study of home or living environments. Ecology can also be interpreted as a science that studies the reciprocal relationships between living organisms and their environment (Frick & Suskiyatno, 2007).

Ecological architecture is a design approach that seeks harmony with the surrounding environment by creating environmentally conscious buildings, by utilizing natural energy resources and minimizing the adverse effects caused by the establishment of a building (Ma'sum & Indradjaja, 2021).

Based on the opinions of experts belonging to Frick, Widigdo, and Metallinaou in (Anisa & Nazarudin, 2020) & (Novia K, 2022) about Ecological Architecture, there are several principles of ecological architectural approaches such as adaptive design to the surrounding environment, conservation and restoration of the environment, utilization of energy efficiency used, water, air, and soil management, waste management, and the use of local materials.

If wetlands primary function as a regulator of water such as controlling floods and tides is replaced by landfilling for construction, the function as an abrasion preventer and maintaining ecosystems will be disrupted. Thus, buildings in flooded wetland areas should adopt stilt-house systems (Heinz Frick & Tri Hesti Mulyani, 2006).

Water and waste management is generally not too difficult because the floor surface of stilt houses is usually located higher than the nearest land. Therefore, wastewater should be channeled to the nearest land and can use basic pond systems, which involves digging a hole in the ground to prevent water from entering, provided the soil is permeable (gravel, rock, tras soil, etc.) (Heinz Frick & Tri Hesti Mulyani, 2006).

In the selection of structures in wetland or mangrove areas is quite simple, such as frame structures, are typically used. Buildings in wetland areas, the foundations are often set locally, with construction materials including wood, natural stone, or concrete. In the use of wood construction materials it should be noted that wood submerged in water will rot, using durable wood is recommended to prevent decay, such as *ulin* (ironwood) (Heinz Frick & Tri Hesti Mulyani, 2006).

2. RESEARCH METHODOLOGY

This study employs a Descriptive-Comparative method with qualitative approach. This approach aims to provide a comprehensive overview of the characteristics of the observed area. And the data collected comes from the results of observations, literature studies, and documentation from Angke Kapuk Nature Tourism Park, Mangrove Ecotourism Centre, Pantai Indah Kapuk, and a comparative study at Mangrove Paradise Resort.

The analysis conducted involves comparison between the three locations aimed at evaluating ecological architecture based on literature studies which include the application of ecological architecture principles and development concepts in mangrove forest areas (building forms and structures). The focus of the variables analyzed in this study related to the application of ecological architecture is presented in Table 2.1.

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Table 2.1 Research Variables

No.	Element	Indicator
1.	Application of Ecological Architecture Principles	Adaptive design to the surrounding environment
		Conservation and restoration of the environment
		Utilization of energy efficiency used
		Water, air, and soil (waste) management
		Use of local materials
2.	Building Form	Building form
		Building style
3.	Structure	Application of the structure used
		Current condition of the structure

(Source: Heinz Frick & Tri Hesti Mulyani, 2006)

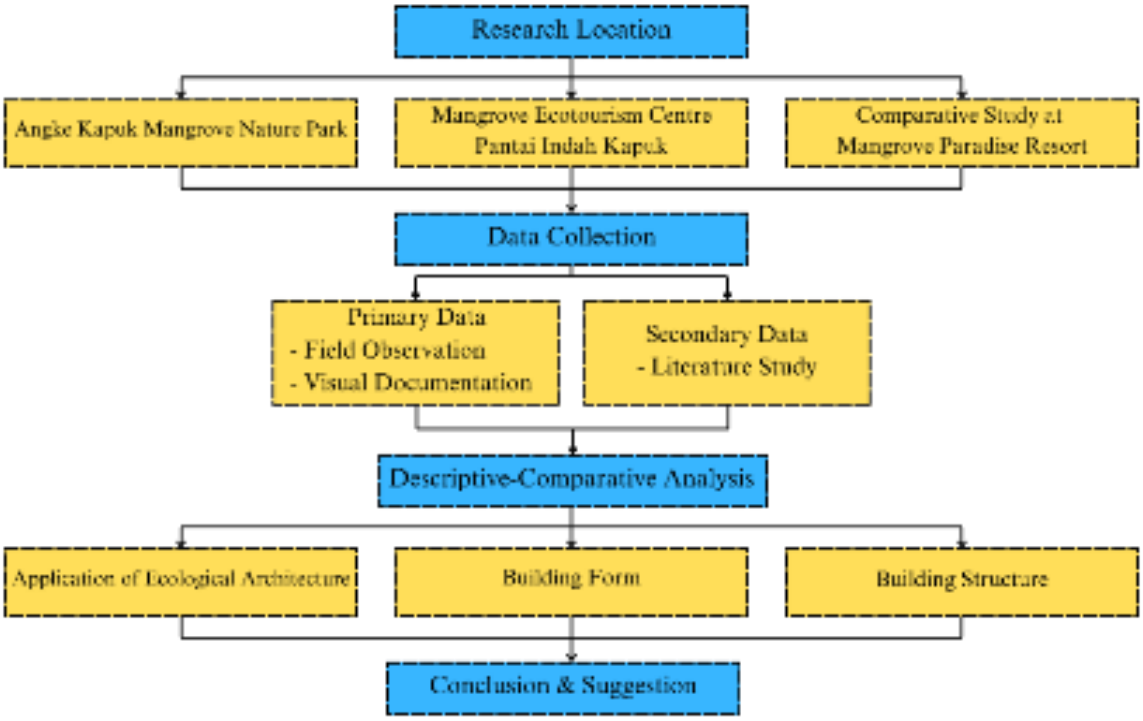

Figure 2.1 Research Stages
(Source: Personal Data, 2024)

3. RESULTS AND DISCUSSION

3.1 Location Overview

3.1.1 Angke Kapuk Nature Tourism Park

The Angke Kapuk Nature Tourism Park is a mangrove ecotourism area located in Kapuk Muara Village, Penjaringan Subdistrict, North Jakarta. This area serves as an ecotourism site, a conservation area for mangrove ecosystems, and a place for environmental education for the community (Taman Wisata Alam Mangrove Angke Kapuk, 2018).

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Figure 3.1 Angke Kapuk Nature Tourism Park Entrance
Source: Survey Documentation, October 2024

The ecotourism area spans 99,82 Ha, consisting of several accommodation complexes, conservation areas, and viewing decks that surround the existing mangrove forest. Below is the site plan of the Angke Kapuk Nature Tourism Park:

Figure 3.2 Siteplan of Angke Kapuk Nature Tourism Park Area
Source: Angke Kapuk Nature Tourism Park, 2024

3.1.2 Mangrove Ecotourism Centre, Pantai Indah Kapuk

This mangrove ecotourism site is also located in Kapuk Muara Village, Penjaringan Subdistrict, North Jakarta. The area is dedicated to mangrove ecosystem conservation and functions as a recreational and educational venue for the public. Activities include walking along elevated pathways through the mangrove forest and fishing in nearby reservoirs. Facilities include mangrove conservation areas, viewing decks, connecting bridges, and gazebos (Mangrove Tag, 2024).

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Figure 3.3 3.1.2 Mangrove Ecotourism Centre, Pantai Indah Kapuk Entrance
Source: Survey Documentation, October 2024

The site covers approximately ± 8,4 Ha and features simple building arrangements such as gazebos, seating areas, and prayer rooms. The main focus of the area is the viewing deck stretching across the site.

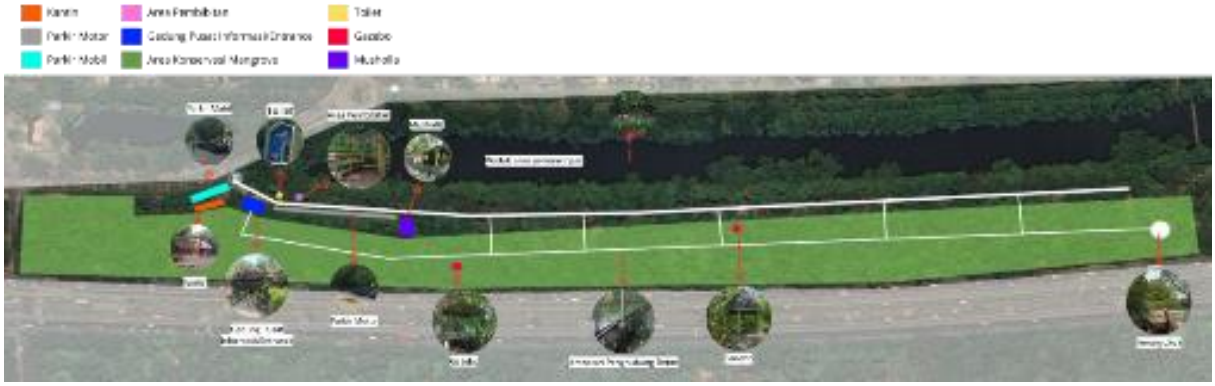

Figure 3.4 Siteplan of Mangrove Ecotourism Centre, Pantai Indah Kapuk
Source: Personal Data, October 2024

3.1.3 Mangrove Paradise Resort

This area is one of the villa destinations in Brunei Darussalam located in the Srunei Riverbank area which is directly adjacent to the mangrove forest. Visitors can do various activities in this resort such as mangrove forest tours and lodging. This area is a mangrove forest ecosystem conservation area, and has tourist facilities such as villas, restaurants, and connecting bridges (Mangrove Paradise Resort, 2014).

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Figure 3.5 Mangrove Paradise Resort Area
Source: Mangrove Paradise Resort, 2023

The area comprises several accommodation complexes and viewing decks built along the mangrove forest edges. Below is the site plan of the Mangrove Paradise Resort:

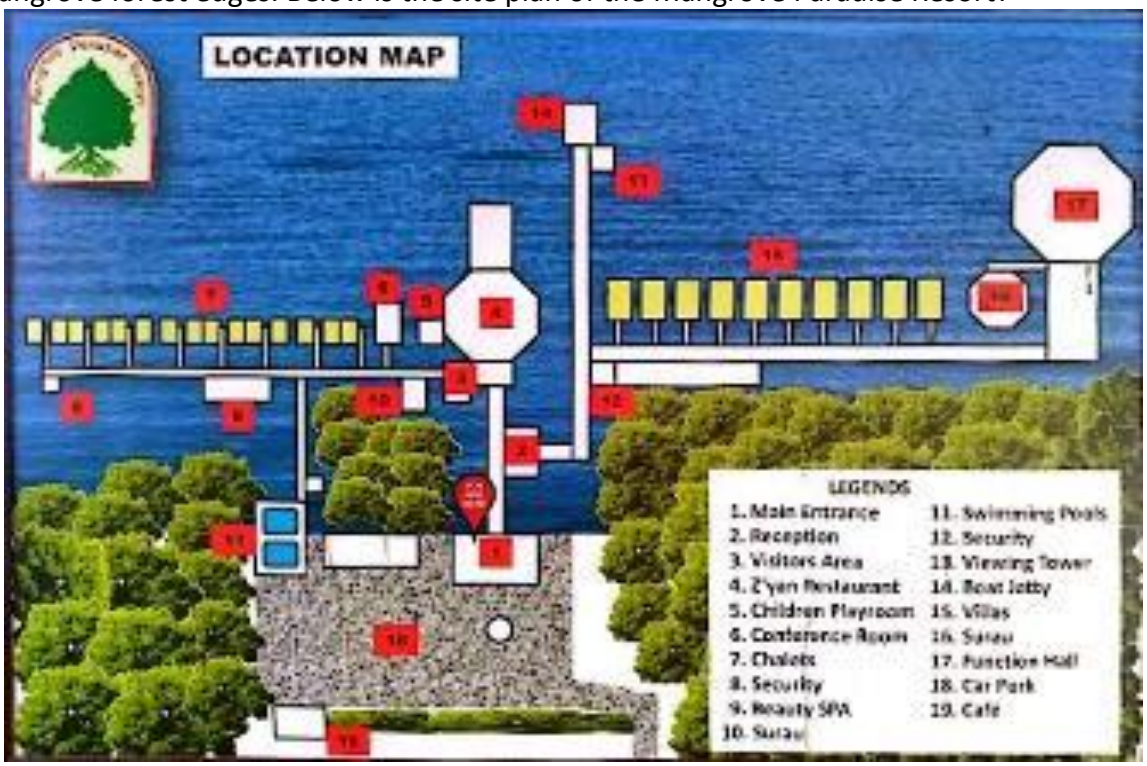

Figure 3.6 Siteplan of Mangrove Paradise Resort
Source: Mangrove Paradise Resort, 2022

3.2 Analysis of the Application of Ecological Architecture

This section will contain the results of the research analysis that has been carried out on the three buildings on the application of ecological architecture applied to the ecotourism area.

3.2.1 Angke Kapuk Nature Tourism Park

The following are the results of the research analysis of the application of ecological architecture that has been carried out at Angke Kapuk Nature Tourism Park.

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Table 3.1 Analysis of Angke Kapuk Nature Tourism Park

No.	Principle/Element	Application to Buildings	Documentation
Application of Ecological Architecture Principles			
1.	Adaptive design to the surrounding environment	• The construction of the building design and pedestrian paths adapts to the existing mangrove forest. • Buildings are made on stilts so as not to damage the mangrove forest ecosystem below, even though the location of the building is not located directly in the wetlands area.	 Figure 3.7 Buildings and pedestrian paths made to fit the environment Source: Survey Documentation, October 2024  Figure 3.8 Stilt-House on the water Source: Survey Documentation, October 2024  Figure 3.9 Stilt-House on the land Source: Survey Documentation, October 2024
2.	Environment conservation and restoration	In addition to tourist areas such as lodging, this area also prioritizes conservation efforts, as evidenced by the many nursery areas and areas that are being planted with mangrove tree seedlings.	 Figure 3.10 Conservation Efforts at TWA Angke Kapuk Source: Survey Documentation, October 2024

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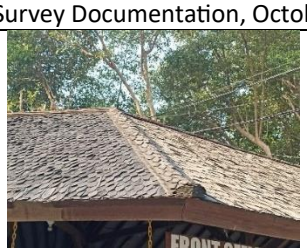
No.	Principle/Element	Application to Buildings	Documentation
3.	Utilization of energy efficiency used	• Maximizing natural lighting is achieved through numerous openings that allow light to enter the building. • The multipurpose building still relies heavily use of air conditioning; however, most other buildings utilize natural ventilation.	 Figure 3.11 Energy Efficiency Analysis of the Mosque Source: Survey Documentation, October 2024  Figure 3.12 Energy Efficiency Analysis of Multipurpose Building Source: Dokumentasi Survey, October 2024
4.	Water, air and soil (waste) management	• Use of septic tank system for wastewater management. • A dedicated area exists for managing waste generated by visitors or from the river. • There are numerous open spaces designed for water infiltration and plants that serve as natural air filtration.	 Figure 3.13 Waste Management Source: Survey Documentation, October 2024  Figure 3.14 Waste Water Management (Septic Tank) Source: Survey Documentation, October 2024
5.	Use of local materials	Use of natural materials such as wood (roofs, structures, bridges and walls) and bamboo (bridges).	 Figure 3.15 Roof Application Wooden Shingle Source: Survey Documentation, October 2024

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p- ISSN 2621-1610 e- ISSN 2620-9934

No.	Principle/Element	Application to Buildings	Documentation
			 Figure 3.16 Overall Application of Wood Materials Source: Survey Documentation, October 2024
			 Figure 3.17 Application of Bamboo Material Source: Survey Documentation, October 2024
		Building Form	
5.	Building form	Stilt house structures are utilized, along with two types of bridges made of wood and bamboo.	 Figure 3.18 Building Form of Angke Kapuk Nature Tourism Park Source: Survey Documentation, October 2024
6.	Building style	Traditional tropical architecture is combined with simple modern architecture, incorporating sloped roofs and local materials.	 Figure 3.19 Building Style of Angke Kapuk Nature Tourism Park Source: Survey Documentation, October 2024
		Structure	
7.	Application of Structures Used	• For large buildings situated in water, such as cafes and mosques, concrete is used for foundations and beams, while other components utilize wood. • Other buildings and bridges rely on wooden or bamboo structures.	 Figure 3.20 Concrete Structure Source: Survey Documentation, October 2024

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No.	Principle/Element	Application to Buildings	Documentation
			 Figure 3.21 Timber and Bamboo Structure Source: Survey Documentation, October 2024
8.	Current structure condition	Some buildings and bridge structures require maintenance and repairs due to damage or deterioration from the water. However, overall, they remain in fairly good condition.	 Figure 3.22 Structures that need to be repaired Source: Survey Documentation, October 2024

(Source: Analysis, 2024)

3.2.2 Mangrove Ecotourism Centre, Pantai Indah Kapuk

The following are the results of the research analysis of the application of ecological architecture that has been carried out at Mangrove Ecotourism Centre.

Table 3.2 Analysis of Mangrove Ecotourism Centre, Pantai Indah Kapuk

No.	Principle/ Element	Application to Buildings	Documentation
Application of Ecological Architecture Principles			
1.	Adaptive design to the surrounding environment	The design of buildings and bridges above the conservation area uses a stilt house system in order to preserve the mangrove forest ecosystem.	 Figure 3.23 Stilt-House In the Mangrove Area Source: Survey Documentation, October 2024

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p- ISSN 2621-1610 e- ISSN 2620-9934

No.	Principle/ Element	Application to Buildings	Documentation
2.	Environment conservation and restoration	This area focuses primarily on educating the public about mangrove conservation by involving local communities in mangrove forest preservation efforts.	 Figure 3.24 Conservation Efforts at Mangrove Ecotourism Centre Pantai Indah Kapuk Source: Survey Documentation, October 2024
3.	Utilization of energy efficiency used	The area's layout prioritizes open spaces rather than enclosed buildings, maximizing natural lighting and ventilation during the day, thereby reducing energy consumption.	 Figure 3.25 Use of Open Space in Buildings Source: Survey Documentation, October 2024
4.	Water, air and soil (waste) management	• Use of organic and inorganic waste bins are provided along the observation bridge. • There is compost management for organic waste.	 Figure 3.26 Waste Management Organic and Inorganic Source: Survey Documentation, October 2024  Figure 3.27 Compost Management Organic Waste Source: Survey Documentation, October 2024

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No.	Principle/ Element	Application to Buildings	Documentation
5.	Use of local materials	More use of modern materials such as concrete and iron/steel are predominantly used, while wood is only utilized for bridge railings.	 Figure 3.28 Application of Materials Source: Survey Documentation, October 2024
		Building Form	
5.	Building form	The observation bridges and buildings located above the conservation area are designed with stilt structures.	 Figure 3.29 Building Form at Mangrove Ecotourism Centre, Pantai Indah Kapuk Source: Survey Documentation, October 2024
6.	Building style	Tropical architecture is adopted, ensuring compatibility with the surrounding environment.	 Figure 3.30 Building Style at Mangrove Ecotourism Centre, Pantai Indah Kapuk Source: Survey Documentation, October 2024
		Structure	
7.	Application of Structures Used	Most structures use concrete due to its easier maintenance and durability, while lightweight steel is used for roofing structures.	 Figure 3.31 Bridge Concrete Structure Source: Survey Documentation, October 2024

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No.	Principle/ Element	Application to Buildings	Documentation
8.	Current structure condition	The condition of the concrete structures, including bridges and other buildings, is well-maintained. However, some wooden railings have deteriorated due to insect damage.	 Figure 3.32 Damaged Railing Source: Survey Documentation, October 2024

(Source: Analysis, 2024)

3.2.3 Mangrove Paradise Resort

The following are the results of the research analysis of the application of ecological architecture that has been carried out at Mangrove Paradise Resort.

Table 3.3 Analysis of Mangrove Paradise Resort

No.	Principle/Element	Application to Buildings	Documentation
		Application of Ecological Architecture Principles	
1.	Adaptive design to the surrounding environment	The building design is constructed above water along the riverbanks of the mangrove forest, employing a stilt-house system to minimize impacts on the mangrove ecosystem.	 Figure 3.33 Stilt-House Design at Mangrove Paradise Resort Source: Mangrove Paradise Resort, 2023
2.	Environment conservation and restoration	Although it is part of the mangrove forest ecosystem, no conservation programs are implemented at the location.	-
3.	Utilization of energy efficiency used	• Maximizing natural lighting is evident through the numerous windows that allow light to enter the building. • Many buildings still use air conditioning systems, while some rely on natural ventilation.	 Figure 3.34 Energy Efficiency Analysis of Mangrove Paradise Resort Source: Mangrove Paradise Resort, 2022
4.	Water, air and soil (waste) management	Wastewater and garbage management is simple, utilizing systems such as septic tanks.	-

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No.	Principle/Element	Application to Buildings	Documentation
5.	Use of local materials	The materials used tend to be more modern, with concrete as the main structural material, but wood is also employed as a natural, locally sourced material.	 Figure 3.35 Application of Local Materials Source: Mangrove Paradise Resort, 2022
		Building Form	
5.	Building form	The resort comprises small wooden chalets designed with stilt-house systems built above the water.	 Figure 3.36 Shape of Resort above the water Source: Mangrove Paradise Resort, 2022
6.	Building style	The architectural style adopts a modern tropical design combined with traditional local elements, such as sloped roofs and wooden structures.	 Figure 3.37 Mangrove Paradise Resort Building Style Source: Mangrove Paradise Resort, 2022
		Structure	
7.	Application of Structures Used	• Most of the foundation, beams, and walls use concrete structures due to their easier maintenance and durability, especially as they are directly submerged in water. • Other structures are predominantly made of wood.	 Figure 3.38 tructure at the Resort Source: Mangrove Paradise Resort, 2022  Figure 3.39 Deck Structure

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p- ISSN 2621-1610 e- ISSN 2620-9934

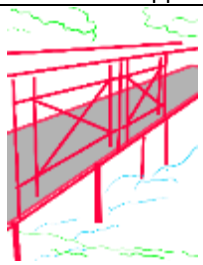
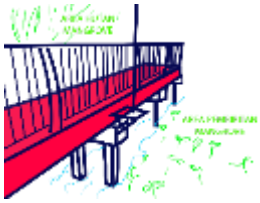
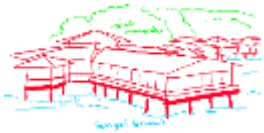
No.	Principle/Element	Application to Buildings	Documentation
			Source: Mangrove Paradise Resort, 2022
8.	Current structure condition	Based on previous photographs, the resort's structures are still well-maintained, mainly due to the use of concrete for most parts of the structure, which requires less maintenance.	 Figure 3.40 Structure Condition Source: Mangrove Paradise Resort, 2023

(Source: Analysis, 2024)

3.2.4 Overall Analysis Results

The following table is a comparison of the three buildings that have been analyzed in order to see the implementation of architectural principles in each building.

Table 3.4 Overall Comparative Analysis

Principle/ Element	Angke Kapuk Nature Tourism Park	Mangrove Ecotourism Centre, Pantai Indah Kapuk	Mangrove Paradise Resort
Application of Ecological Architecture Principles			
Adaptive design to the surrounding environment	 • Stilt-House System. • Created around existing mangroves.	 • Stilt-House System. • Built on a mangrove area.	 • Stilt-House System. • Created on the riverbank next to the mangrove area.
Environment conservation and restoration	 It is a mangrove conservation area	 It is a mangrove conservation area	Villas located in a mangrove forest area, but there are no restoration efforts.
Utilization of energy efficiency used	 • Natural lighting from the sun. • Partial natural ventilation and air conditioning	 • Natural lighting from the sun. • Natural ventilation with many openings.	 • Natural lighting from the sun. • Partial natural ventilation and air conditioning
Water, air and soil (waste) management			Simple waste water and garbage management.

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Principle/ Element	Angke Kapuk Nature Tourism Park	Mangrove Ecotourism Centre, Pantai Indah Kapuk	Mangrove Paradise Resort
	 • Septic tank • Waste Management Area. • Many infiltration areas and plants	 • Organic and inorganic waste bins • Compost waste management Facility.	
Use of local materials	 Mostly wood and bamboo.	 Mostly concrete, wood only on the railings.	 Mostly concrete and wood.
Building Form			
Building form	 All the villas use Stilt-House form.	 All the building in the mangrove area use Stilt-House form.	 All the villas above the water use Stilt-House form.
Building style	 Traditional tropical architecture.	 Tropical architecture.	 Tropical modern architecture.
Structure			
Application of Structures Used	 Main structure is a mix of concrete and wood or bamboo	 Concrete main structure, light steel roof	 The main structure uses concrete.
Current structure condition	 Need maintenance and structural repair in some area.		 Very well maintained, as it uses durable concrete.

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p- ISSN 2621-1610 e- ISSN 2620-9934

Principle/ Element	Angke Kapuk Nature Tourism Park	Mangrove Ecotourism Centre, Pantai Indah Kapuk	Mangrove Paradise Resort
		Fairly good, but needs more maintenance on the wooden railing.	

(Source: Analysis, 2024)

From the comparative table above, it can be seen that Angke Kapuk Nature Tourism Park, Mangrove Ecotourism Centre, Pantai Indah Kapuk, and Mangrove Paradise Resort have applied ecological architecture principles in various aspects, reflecting environmentally friendly and sustainable designs.

The impact of implementing ecological architecture in these three areas can be observed in the integration of building designs with the surrounding environment, creating comfortable ecotourism areas without damaging the natural habitat of the mangrove forest ecosystem itself.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Conclusions

Based on the results of the research that has been done, it can be concluded as follows:

- The research conducted is to find out the application of ecological architecture that has been applied to development in the ecotourism areas of Angke Kapuk Nature Tourism Park, Pantai Indah Kapuk Mangrove Ecotourism Area, Mangrove Paradise Resort with assessment variables namely, application of ecological architecture principles, building forms, and structures.
- There have been significant efforts from the three ecotourism areas in applying the principles of ecological architecture. Each location applies a design that is adaptive to the surrounding environment, environmental conservation and restoration, energy efficiency, waste management, and the use of local materials. However, the level of application varies according to the needs of each location and regional priorities. The impact that can be felt by applying these principles is the creation of a balance between the building and the environment of a sustainable mangrove forest ecotourism area.
- The use of building forms entirely uses a house on stilts system to minimize the impact on mangrove ecosystems or coral reefs and also integrates the design with the existing natural landscape.
- The application of structures in submerged areas varies such as the full use of timber or concrete structures, as well as the use of a combination between the two. The main challenge of using structures in flooded areas is the maintenance of the building structure due to the damp conditions resulting in structures that are susceptible to damage.

4.2 Suggestions

Based on the findings above, the following recommendations are proposed for the development of mangrove forest ecotourism areas:

- It is recommended to develop the use of local materials that are more durable against high humidity to reduce maintenance costs.
- Collaboration between government and private sectors is needed in terms of regulation and funding to support sustainable management and maintenance of the area.
- The ecological architecture concepts applied to these mangrove ecotourism areas can serve as a model for other ecotourism sites, with adaptations to suit the characteristics of their respective environments.

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