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Integration of Ecological Architecture Principles in the Design of Sustainable Fishermen's Settlement Facilities and Infrastructure

Sherly Asriany, Ardi Basri, Rahmat Latif
Department of Architecture, University of Khairun, Ternate, Indonesia
Email: sherly@unkhair.ac.id

Abstract

Background. Fishermen's settlements are coastal residential areas with different spatial, social, economic, and environmental characteristics than other residential areas. Because fishing communities depend on marine resources, residential facilities and infrastructure should be designed with visibility of fishery activities, coastal environmental conditions, space needs, and the risk of ecological damage in mind.

Aims. This article aims to formulate an approach to designing fishermen's settlement facilities and infrastructure based on ecological architecture by integrating functional needs, environmental characteristics, and sustainability principles.

Methods. The study uses a descriptive-qualitative approach in the framework of architectural design research. Based on the design document, the methodological stages include observation, interviews, literature studies, and analysis of human, environmental, and building aspects.

Result. The conceptual synthesis shows that fishermen's settlement patterns can be classified into linear, grouped, and mixed patterns influenced by geographical conditions, economic, socio-cultural, infrastructure, and disaster risk. The integration of ecological architecture focuses on zoning arrangements, optimizing natural lighting and ventilation, using materials suited to the local environment, managing water and waste, and strengthening the relationship between housing and fishery activity facilities. This article contributes a conceptual design framework that connects the needs of fishing communities with ecological adaptation strategies for coastal areas.

Conclusion. This framework can serve as a basis for developing functional, environmentally responsive, and sustainability-oriented fishing settlement designs. Empirical evaluation of the design's performance is still needed to test the effectiveness of its implementation.

Keywords: ecological architecture; coastal areas; sustainability; fishermen's settlements; facilities and infrastructure.

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INTRODUCTION

Fishermen's settlements are part of the coastal area system, with a close relationship among the natural environment, economic activities, social structures, and infrastructure needs. These settlements are shaped not only by the need for housing, but also by the sea as the community's main source of livelihood. Fishing activities, transportation of marine products, processing of fishery products, and distribution of products require a spatial and infrastructure system that supports the mobility and productivity of fishing communities. Therefore, developing fishermen's settlements requires a design approach that considers the relationship between residential functions, economic activities, and the carrying capacity of the coastal environment.

Studies of fishermen's settlement patterns show that the spatial configuration of the area generally develops along coastlines, rivers, canals, or road networks connected to fishery activities. These patterns can take the form of linear, grouped, or mixed settlements, depending on geographical conditions, infrastructure development, and the community's social characteristics. Beyond spatial planning, fishing settlement areas face environmental challenges such as coastal abrasion, tidal inundation, climate change, waste management, and sanitation and clean water needs. These conditions demand a design strategy that not only meets buildings' physical needs but also supports environmental adaptation and regional sustainability. One relevant approach is ecological architecture, which considers the reciprocal relationship between buildings, people, and the natural environment. Its implementation includes adjusting design to the local climate, improving energy and resource efficiency, using appropriate materials, and reducing the negative impact of human activities on the environment.

State of the Art

The study summarized in the source document shows three trends in the discussion. First, the study on the spatial patterns of fishermen's settlements emphasizes the relationship between residential configuration and access to the sea. For example, the study of fishermen's settlements in Untia, Makassar, illustrates the role of road and canal networks in supporting the mobility of fishing communities. Second, studies of coastal settlements identify how geographical, socio-cultural, relocation, and disaster-risk conditions shape changes in settlement patterns. Linear patterns can shift to mixed or clustered patterns when environmental conditions and regional planning policies change. Third, the ecological architecture approach emphasizes adapting buildings to natural conditions, including natural lighting, cross-

ventilation, and material selection that considers local environmental characteristics. Together, these approaches provide a basis for developing a design model that integrates the characteristics of fishermen's settlements with the principles of ecological architecture.

Research Gap

Based on the initial synthesis of the source document, a design framework is needed to systematically connect patterns of fishermen's settlements, the needs of fishery facilities, building design parameters, and the principles of environmental sustainability. The cited literature discusses spatial configuration and ecological principles. However, integrating these two aspects into the stages of analysis and design decision-making still requires a more operational formulation. This gap underpins the development of a conceptual framework for designing fishermen's settlement facilities and infrastructure based on ecological architecture.

Novelty

The conceptual novelty proposed in this article lies in the integration of the three dimensions of planning, namely:

1. Functional dimensions, including housing needs, fishery activities, accessibility, and supporting facilities.
2. The ecological dimension includes climate adaptation, resource efficiency, waste management, and environmental risk reduction.
3. Spatial and social dimensions, including settlement patterns, interspatial relationships, community characteristics, and the sustainability of coastal community activities.

This novelty is a conceptual contribution that still needs systematic comparison with previous research before it can be claimed as an empirical novelty.

Research Objectives

This study aims to analyze the characteristics and factors that shape fishermen's settlement patterns, identify design parameters relevant to the ecological architecture approach, and formulate a conceptual framework for developing functional and sustainable fishermen's settlement facilities and infrastructure.

LITERATURE REVIEW

Getting to Know the Infrastructure of the Bajo Tribe Settlement in Laluin

On the eastern horizon of South Halmahera, North Maluku, in Laluin Village, a unique way of life seems separate from the mainland. Across the blue sea, wooden houses stand neatly lined up on stilts. This is the infrastructure of the Bajo Tribe, a maritime community known as sea nomads for hundreds of years. Walking on the wooden bridge that connects the houses, the sound of water ripples becomes daily background music. Bajo children run without fear of falling into the sea; even most of them are more fluent in swimming than walking on land. Their houses are simple, with plank walls, zinc roofs, or thatch roofs, but they hold symbolic value (https://trigger.id/mengenal-settlement-tribe-bajo-di-Laluin/, accessed June 3, 2025).

The sea as the lifeblood of life:

For the Bajo Tribe, the sea is not just a living space, but also an identity. They depend on fish catches, sea cucumbers, and lobsters. With small boats called *soppe*, Bajo men sail from the early hours of the morning, while women prepare seafood for sale or consumption. They do this not only to make a living, but also because the sea is a social space. There, they hold celebrations, chat, and pass down oral traditions from generation to generation.

Traditions and beliefs

The Bajo tribe has a strong tradition that reflects a spiritual relationship with the sea. They believe the sea must be protected because ancestral spirits dwell in it. Some rituals, such as *maccera tasi* (purification of the sea), are carried out as respect and prayer so marine products abound and danger is avoided. Although modernization is slowly coming in, most of the Bajo Tribe still follows local wisdom in managing life, from environmentally friendly fishing methods to customary rules about marriage and brotherhood.

Maintained harmony

Amid the onslaught of modernization, the Bajo Tribe's biggest challenge is maintaining harmony with nature. The sea that gives life must remain sustainable, even as economic pressure and resource exploitation increase. Yet one thing has not changed: their identity as seamen. The Bajo tribe in Laluin are still an ocean explorers who choose to settle on water, proving that home is not only on land but where hearts and traditions cling to the sea.

METHODS

Research Approach

This article uses a descriptive-qualitative approach based on architectural *design research*. The approach aims to identify user needs, environmental characteristics, building technical parameters, and relationships between spaces as the basis for developing design concepts. The method is structured around data collection, human aspect analysis, environmental analysis, building analysis, and design concept development.

Data Collection Techniques

Data collection techniques in the methodological design include field observations, interviews, and literature studies. Observations are directed to identify site characteristics and physical conditions of the area. Interviews are intended to obtain information about user needs and activities. Literature studies examine the theory of fishing settlements and ecological architecture. The data are classified as primary data, in the form of direct observations and documentation, and secondary data sourced from literature and supporting documents.

Analytical Techniques

The analysis was carried out through three main groups.

Aspects of analysis	Variables studied
People and activities	User activity, space needs, activity relationships, space capacity
Environment and footprint	Climate, sun orientation, wind, accessibility, noise, circulation, zoning
Buildings and infrastructure	Building shapes, structures, materials, utilities, lighting, clean water, sewage

The analysis results were used to compile design criteria and develop a concept for structuring fishermen's settlement facilities and infrastructure.

Planning Stages

1. Identify the needs of fishermen's settlements
2. Study of the principles of ecological architecture
3. Observations
4. Interview
5. Literature study
6. Human, environmental, and building analysis
7. Formulation of design parameters and concepts

8. Proposed ecological planning of fishermen's settlements

DISCUSSION

Sustainable Settlement Infrastructure Development Policy

Sustainable settlement infrastructure is a development concept that integrates social, economic, and environmental aspects to provide livable, affordable, and environmentally friendly housing. The Government of Indonesia has issued various policies and regulations to support sustainable settlement infrastructure, in line with the Sustainable Development Goals (SDGs), especially SDG 11: Sustainable Cities and Settlement Facilities and Infrastructure.

Related regulations and policies

Law

1. Law number 1 of 2011 concerning housing and residential infrastructure areas regulates the implementation of decent, healthy, safe, and affordable housing and residential infrastructure facilities in a sustainable manner. Mention the principles of sustainability and social justice in the provision of housing.
2. Law Number 26 of 2007 concerning Spatial Planning regulates spatial planning that integrates residential facilities and infrastructure with other spatial functions in a sustainable manner.
3. Law Number 32 of 2009 concerning Environmental Protection and Management is the basis for the integration of environmental principles in the development of residential facilities and infrastructure.

Government regulations

1. Government Regulation No. 14 of 2016 concerning the implementation of housing and settlement infrastructure areas describes the implementation of Law No. 1/2011 technically, including the principles of sustainable development in public housing.
2. Government Regulation number 21 of 2021 concerning the implementation of spatial planning strengthens the integration of settlement development in spatial planning based on a sustainability and disaster risk approach.

Ministerial Regulation (Ministerial Regulation)

1. The Minister of Public Works and Housing Regulation No. 12 of 2020 concerning community participation in the implementation of housing and settlement infrastructure areas encourages active community participation in creating sustainable settlement

infrastructure.

2. Permen PUPR No. 10 of 2018 concerning guidelines for the implementation of community-based housing supports development based on local and social wisdom.
3. The Minister of ATR/BPN Regulation No. 11 of 2021 concerning procedures for the preparation of regional spatial plans emphasizes the integration of residential infrastructure facilities in an environmentally friendly spatial planning system.

Characteristics of Fishermen's Settlement Patterns

The literature review in the source document identified three forms of fishermen's settlement patterns, namely linear, grouped, and mixed.



Figure 1. Linear Pattern

Settlements develop along coastlines, rivers, canals, or main roads. This pattern facilitates access from residences to fishing activities.



Figure 2. Grouped Patterns

Buildings form residential groups that can develop based on social proximity, community facilities, or environmental adaptation needs.



Figure 3. Mixed Patterns

It combines linear patterns, groups, and grid-shaped road networks. This pattern can be formed due to infrastructure development and regional rearrangement.

Visual illustration of the type of settlement; not documentation of the research location.

The three patterns show that fishermen's settlement arrangements should consider the relationship between accessibility, site conditions, social needs, and economic activities. The linear pattern provides proximity to fishery activities, but requires attention to coastal risks. Meanwhile, grouped and mixed patterns provide alternative zoning arrangements that can be adjusted to environmental conditions.

Factors Influencing the Design of Fishermen's Settlements

Based on a synthesis of the literature, five main groups of factors emerge.

Factors	Planning implications
Geographical conditions	Determination of building orientation, road network patterns, and facility location
Fishing activities	Provision of access to docks, processing areas, and distribution of catches
Socio-cultural	Provision of a space for community interaction and maintenance of residential character
Policy and infrastructure	Zoning adjustment with regional development and service needs
Disaster risk	Consideration of safe zones, evacuation routes, and building adaptations

These factors cannot be analyzed in isolation because changes in one aspect can affect the overall structure of the settlement space.

Application of Ecological Architecture Principles

Applying ecological architecture to the design of fishermen's settlement facilities and infrastructure aims to reduce environmental impact and improve user comfort. Climate adaptation and site conditions. Building orientation should consider sun direction, wind patterns, soil characteristics, and coastal environmental conditions. Cross-ventilation and natural lighting are passive design strategies that can reduce reliance on artificial energy. Resource use efficiency. Using local materials that meet technical requirements, efficient water use, and well-managed utility systems can support regional resource management.

Waste management of fishery activities. Fish processing activities can produce organic waste and wastewater. Therefore, facility design should consider separating waste streams, providing treatment facilities, and controlling environmental pollution. Integration of residential and economic spaces. The design needs to connect residences, waste processing facilities, distribution rooms, and social facilities through an effective circulation system and prioritize environmental health.

Integrated Design Conceptual Model

Based on the synthesis results, the proposed conceptual model connects three main components: the community's functional needs, the characteristics of the coastal area, and the principles of ecological architecture. The model bases design decisions on the analysis of user and environmental needs. Thus, the ecological approach applies not only to building elements but also to spatial systems and regional infrastructure.

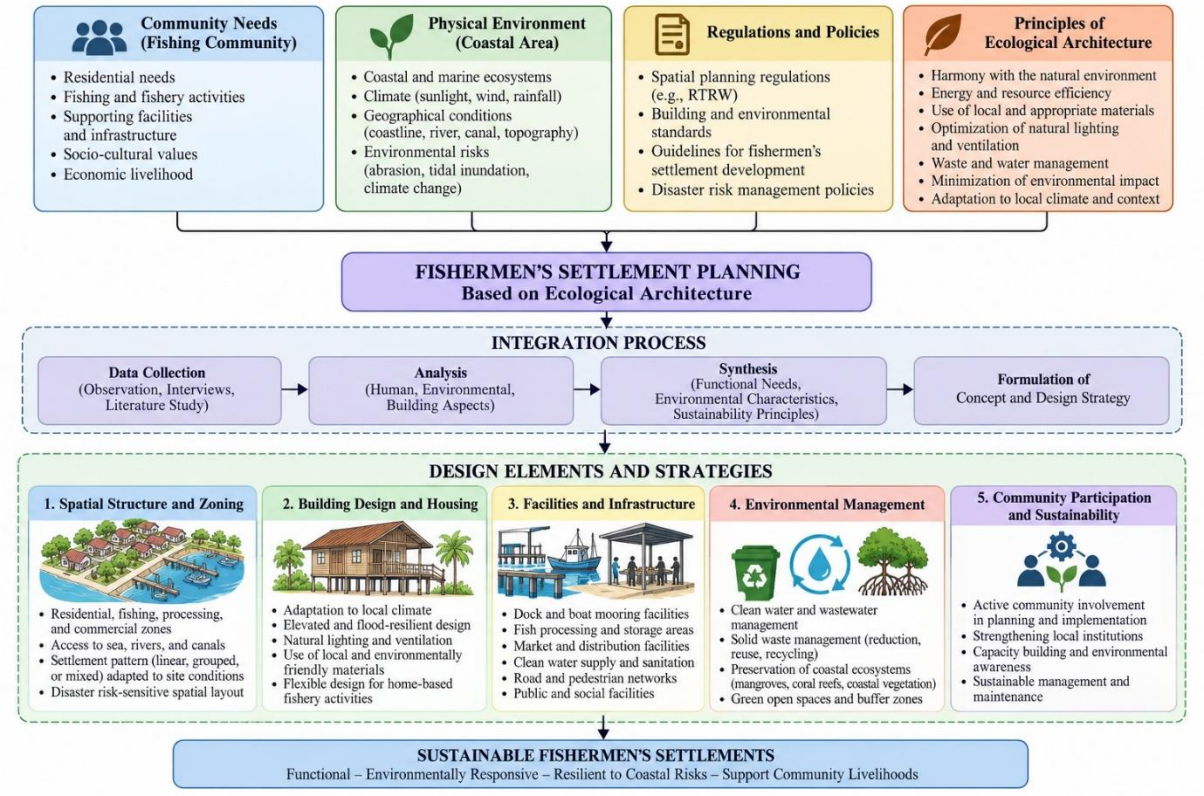


Figure 4 Conceptual Model Chart of Fishermen's Settlement Planning Based on Ecological Architecture

The conceptual model illustrates the integration of fishing communities' functional needs, coastal environmental characteristics, regulations, and ecological architecture principles into sustainable settlement planning. The framework comprises five interconnected design

strategies: spatial structure and zoning, climate-responsive housing, facilities and infrastructure, environmental management, and community participation.

Implications of Design on the Sustainability of Coastal Areas

The approach formulated has three main implications. First, from an environmental perspective, integrating ecological design can reduce pressure on resources through energy efficiency, water management, and waste-control strategies. Second, from a social perspective, providing spaces and facilities aligned with community characteristics can improve the quality of the residential environment and support community interaction. Third, from an economic perspective, regulating the relationship between housing, transportation access, and fishery product processing facilities can support the efficiency of fishing communities' productive activities. However, these three benefits remain theoretical. Design evaluation, technical analysis, and user assessment are needed to determine the magnitude of these benefits in real terms.

CONCLUSION

This study shows that designing fishermen's settlement facilities and infrastructure requires an integrated approach that considers the spatial characteristics, community needs, and ecological conditions of coastal areas. Fishermen's settlement patterns can be linear, grouped, or mixed, which are influenced by geographical conditions, fishery activities, socio-cultural characteristics, infrastructure development, and disaster risk. The ecological architecture approach provides a conceptual basis for integrating climate adaptation, resource efficiency, waste management, and structuring relationships between spatial functions. The main contribution of this article is the formulation of a design framework that connects functional, environmental, and ecological dimensions in the development of fishermen's settlements. Further research is recommended to test the framework through field case studies, simulations of building environmental performance, and evaluation of the needs and satisfaction levels of fishing communities. The testing is necessary so that the design concept can be developed into measurable and actionable technical recommendations.

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