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Transforming Fishermen's Settlements Towards Sustainable Coastal Areas Through an Ecological Architecture Approach: A Case Study of Laluin Village

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Abstract

Background. The fishing settlement in Laluin Village, South Kayoa District, South Halmahera Regency, North Maluku, has above-water residential characteristics closely tied to the economic and social activities of coastal communities. However, limited sanitation, waste management, accessibility, and the vulnerability of coastal ecosystems require an integrated design approach.

Objectives. This article aims to formulate a model for designing fishermen's settlement facilities based on ecological architectural principles.

Methods. The method used is a design research with data collection through observation, interviews, literature studies, and documentation, followed by analysis of user activities, space needs, site characteristics, climate, circulation, buildings, and utilities.

Results. The design results are in the form of arrangement of public and semi-public zones, integration of fishery facilities and communal spaces, pier design that takes into account tides, utilization of mangrove vegetation, rainwater storage, wastewater and waste management, and lighting and natural ventilation strategies.

Conclusion. The contribution of the article lies in the integration of the productive needs of fishermen with the management of the coastal environment at the regional scale. The result is a conceptual design proposal; its ecological effectiveness has not been tested through post-construction measurements.

Keywords: ecological architecture; fishermen's settlements; area design; coastal infrastructure

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INTRODUCTION

Fishermen's settlements cannot be understood solely as a collection of houses, because residential spaces are directly connected to fishing, landing, trading, and processing marine products. In Laluin Village, some of the dwellings are above the water and are connected through wooden bridges and piers. This condition shows a close relationship between the form of settlement, coastal culture, and access to fishery resources. This article identifies sanitation issues, domestic waste disposal into waters, infrastructure quality, accessibility, and pressure on mangrove ecosystems. Sectoral handling risks ignoring the relationship between fishermen's production space and environmental carrying capacity. For this reason, a design approach is needed that connects the needs of space, infrastructure, and ecological principles.

The literature discussed in the article includes fishing settlement patterns, ecological architectural principles, and comparative studies of coastal areas. The gap that this article focuses on is the need for a synthesis of the design of productive facilities, social spaces, and environmental utilities in a single design framework that is specific to the character of settlements on water. The novelty proposed is contextual and conceptual, not claims of new technologies or measurable advantages compared to other designs. The purpose of this article is to explain the analysis process and formulate a model for structuring fishermen's settlement facilities in Laluin Village that is adaptive to water conditions, while supporting economic activities and environmental management.

LITERATURE REVIEW

Fishermen's Settlement Infrastructure

The formation of a pattern of residential infrastructure facilities is greatly influenced by the culture of the local community. This is in line with the opinion of Snyder (1985, in https://jurnal.umj.ac.id/index.php/nalars/article/view/612, accessed August 6, 2025). which states that the formation of the residential infrastructure environment is possible because of the process of forming housing as a functional container based on human activity patterns and the influence of the setting (environmental hue) both physical and non-physical (socio-cultural) which directly affects the pattern of activities and the process of the container.

Understanding the Infrastructure of Fishermen's Settlements

Fishermen's settlement infrastructure is a residential area where the majority of the population makes a living as fishermen and is closely related to fishery activities in the surrounding waters. This settlement infrastructure is equipped with infrastructure facilities that support the life and work of fishermen, such as fish auction sites, boat moorings, and fish drying facilities. According to the Regulation of the Minister of State for Public Housing of the Republic of Indonesia Number 15/Permen/M/2006, fishermen's settlement infrastructure facilities are special area housing to support marine and fishery function activities.

The Government of Indonesia through the Ministry of Public Works and Public Housing (PUPR) has implemented various programs to arrange and improve the quality of fishermen's settlement infrastructure. One of the important initiatives is the arrangement of fishermen's settlement and waterfront infrastructure facilities in 11 locations, including Pontianak, Banjarbaru, Makassar, and Jayapura. This program includes the construction and improvement of infrastructure such as environmental roads, drainage, public open spaces, communal toilets, bridges, street lighting, and other facilities that support fishermen's activities and improve their quality of life, (https://pu.go.id/berita/penataan-kawasan-sarana Infrastructure settlements-fishermen-also-done-in-pontianak-banjarbaru-makassar-to-jayapura, accessed 3 June 2025).

Characteristics of Fishermen's Settlement Infrastructure

Fishermen's settlement infrastructure is a form of housing that grows in coastal areas and is an important part of the socio-economic landscape of marine communities in Indonesia. These settlement infrastructure facilities have distinctive characteristics, both physically, socially, economically, and environmentally.

Physical Characteristics

Fishermen's settlement infrastructure facilities are generally located in coastal areas that are close to fishery resources such as seas, estuaries, or lakes. Its strategic location facilitates access to sea and port activities. The pattern of settlement infrastructure tends to be irregular and follows coastlines or rivers, with high building density and low infrastructure quality, Widjajanti, (2022, in Prasarana Permukiman_Nelayan_Kawasan_Pantai_Selatan_Malang, accessed June 3, 2025).

Social and Cultural Characteristics

Fishermen's settlement infrastructure shows a high level of social change, where the value of mutual cooperation and solidarity between fishing families is very strong. Social interaction often occurs in open spaces such as ports, docks, or multifunctional yards, (Munirwan, 2021).

Economic Characteristics

Most of the population in fishing settlement infrastructure depends on capture fishery activities. In addition, supporting economic activities such as seafood processing, trade, and fishery services are also growing in this region. However, dependence on the fisheries sector makes them vulnerable to fluctuations in catch and seasons, (Pawitro, 2015, in https://www.bing.com/ck/a?!&&p=dc26mltdHM9MTc1NTY0ODAwMA&ptn=3&ver=2&hsh=4&fclid=167f3073-53fd-6efd-39b3-, accessed June 3, 2025).

Environmental Challenges

Fishermen's settlement infrastructure faces high risks of disasters such as flash floods, abrasion, and high waves. Dense environmental conditions and lack of sanitation and drainage infrastructure exacerbate these vulnerabilities, (Husna 2022, in https://www.researchgate.net/profile/Tsabita-Aqila-Husna, accessed August 6, 2025).

Structuring Efforts

Various programs for the arrangement of fishermen's settlement infrastructure have been carried out, both by the government and NGOs. One of them is the integration of spatial planning based on climate mitigation which leads to more resilient and sustainable residential infrastructure, (LCDI, 2023, in https://lcdi-indonesia.id, accessed August 6, 2025).

Problems in Fishermen's Settlement Infrastructure

Fishermen's settlement infrastructure in Laluin Village, Kayoa District, South Halmahera Regency, North Maluku Province, faces various problems that affect community welfare and environmental sustainability. Here are some of the main issues identified:

Damage to the coastal environment

Population growth and the expansion of residential infrastructure facilities to coastal areas have led to the logging *of mangrove forests* around Laluin Village. Mangrove forests that previously dominated coastal areas are now degraded, threatening coastal ecosystems and reducing natural protection against abrasion and other natural disasters.

Environmental pollution

The habit of people throwing household waste, such as laundry residues containing detergents, directly into the sea causes water pollution and damages marine ecosystems,

including coral reefs. In addition, the construction of infrastructure such as highways that do not pay attention to the circulation of tidal water causes the accumulation of mud under stilt houses, worsening environmental conditions, (https://id.scribd.com/document/367680533/Desa-Laluin-Kayoa-South District, accessed May 26, 2025).

1. Over exploitation of marine resources shows that sea cucumber stocks in the waters of Laluin Village have decreased due to overexploitation. Without sustainable management, this condition can threaten the sustainability of the livelihoods of fishermen who depend on these marine resources, (https://text-id.123dok.com/document/ozlk6d2q-ecobiology-and-dynamics-stocks-of-sandfish-holothuria-scabra-black-sea-cucumber-holothuria-edulis-and-relation-with-exploitation-at-laluin-village-north-maluku-province, accessed 26 May 2025).
2. Limited infrastructure and fuel access
   Fishermen in South Halmahera, including Laluin Village, face difficulties in obtaining Fuel Oil (BBM) such as diesel and kerosene. This fuel scarcity hinders seagoing activities, so that it has a direct impact on the income and welfare of fishermen, (https://www.okebaik.id/2024/12/04/bbm-step-fisherman-in-south halmahera-menjerit/, accessed May 26, 2025).

Problems of governance and financial transparency in the village

Laluin Village experienced problems in village financial governance, including allegations of misappropriation of village funds by village heads in the 2019 and 2020 fiscal years with total state losses reaching nearly one billion rupiah. In addition, there is a lack of transparency in management budget, such as no Presence billboard APBDes, causing public distrust of the village government, (https://www.malutline.com/2025/01/04/korupsi-dana-desa-ratusan-million-rupiah-law-enforcer-fear-touching-kades-laluin, accessed May 26, 2025).

Limited human and technological resources

Fishermen in this region generally have limitations in mastering technology and capital, making it difficult to increase the productivity and efficiency of fishery businesses. This is exacerbated by the lack of training and assistance from related parties to increase capacity

https://123dok.com/article/pembahasan-profil-lokasi-penelitian-pengembangan-perikanan-berkelanjutan-kayoa.eqovmpmz, accessed 26 May 2025).

Competition with large tonnage fishing vessels

Local fishermen complained about the presence of large-tonnage fishing boats from outside North Maluku that entered their fishing areas. The presence of these boats reduces the catch of local fishermen and causes conflicts and injustices in the use of marine resources. The above problems show the need for an integrated approach in handling the issues faced by the facilities and infrastructure of fishermen's settlements in Laluin Village. Collaborative efforts between the government, the community, and related parties others are indispensable to realize sustainable development and improve the welfare of the fishing community.

METHODS

This study uses a case-study-based architectural design approach in Laluin Village, South Kayoa District, South Halmahera Regency, North Maluku Province. Data collection techniques include direct on-site observation, interviews, literature studies, documentation, and the use of primary and secondary data. The source manuscript does not detail the number and technique of selecting informants or interview instruments; therefore, the article does not claim that the survey is representative or that statistical testing has been carried out.

The analysis is arranged in three groups. First, the human aspect includes actors and activities, the grouping of activities, the relationship between spaces, and the need and amount of space. Second, the environmental aspect includes the determination of the site, the path of the sun, wind, view, access, circulation, noise, outdoor space, mass orientation, and zoning. Third, the building and utility aspects include shape, structure, materials, clean water, wastewater, waste management, security, lighting, and ventilation. The findings of the analysis are translated into the concepts of zoning, buildings, landscapes, and utility networks. The evaluation in the article is mainly analytical-conceptual, not a quantitative simulation of building performance.

DISCUSSION

Characteristics and problems of the tread

Laluin Village has a direct spatial relationship between residential areas and waters. Fishermen's movements, boat moorings, and catch distribution activities require safe and easily accessible access. At the same time, domestic waste and economic activities above the waters

pose the need to control pollution. The site analysis in the article considers the sun, wind direction, rainfall, vegetation, access, boat parking, noise, and the orientation of building masses. Thus, spatial planning needs to be treated as an interconnected socio-ecological system.

Organization of functions and zoning of areas

The design concept distinguishes public and semi-public zones based on the intensity and character of the user. Public facilities in the design include fish markets, piers, terminals, gazebos, and culinary areas, while semi-public facilities include village offices, meeting halls, and worship facilities. This arrangement aims to separate the flow of visitors and certain service activities without severing the relationship between fishermen's activities and communal spaces.

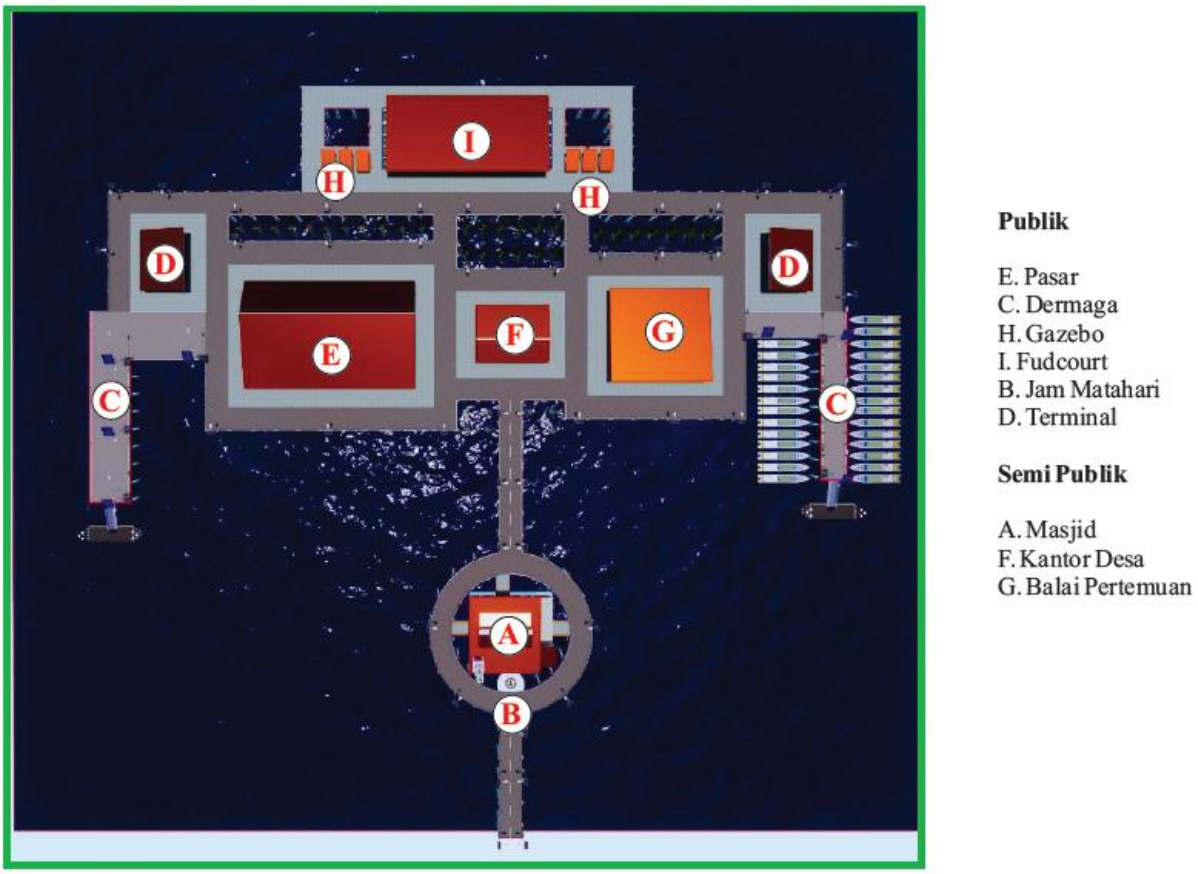


Figure 1 Macro zoning scheme

The concept of in-building zoning in the Design of Fishermen's Settlement Facilities is compiled based on data and analysis results, especially from the human aspect as a user of

space. This aspect is the main focus because the activities that occur in the building are dominated by interaction and user needs. Building zoning is divided into several categories, namely public zones, and semi-public zones. The division of these zones is determined based on the type of activity and characteristics of the users of the space in the building.

The design of loading and unloading docks is directed to support the distribution of marine products and logistics, while boat moorings take into account tidal variations as well as access safety. The main road connects the site with the surrounding environment. Mangrove vegetation is positioned as an element of coastal protection, sediment containment, and biota habitat, while outdoor space lighting is proposed using energy-efficient or solar lights. The overall strategy is displayed in the concept of outdoor space management

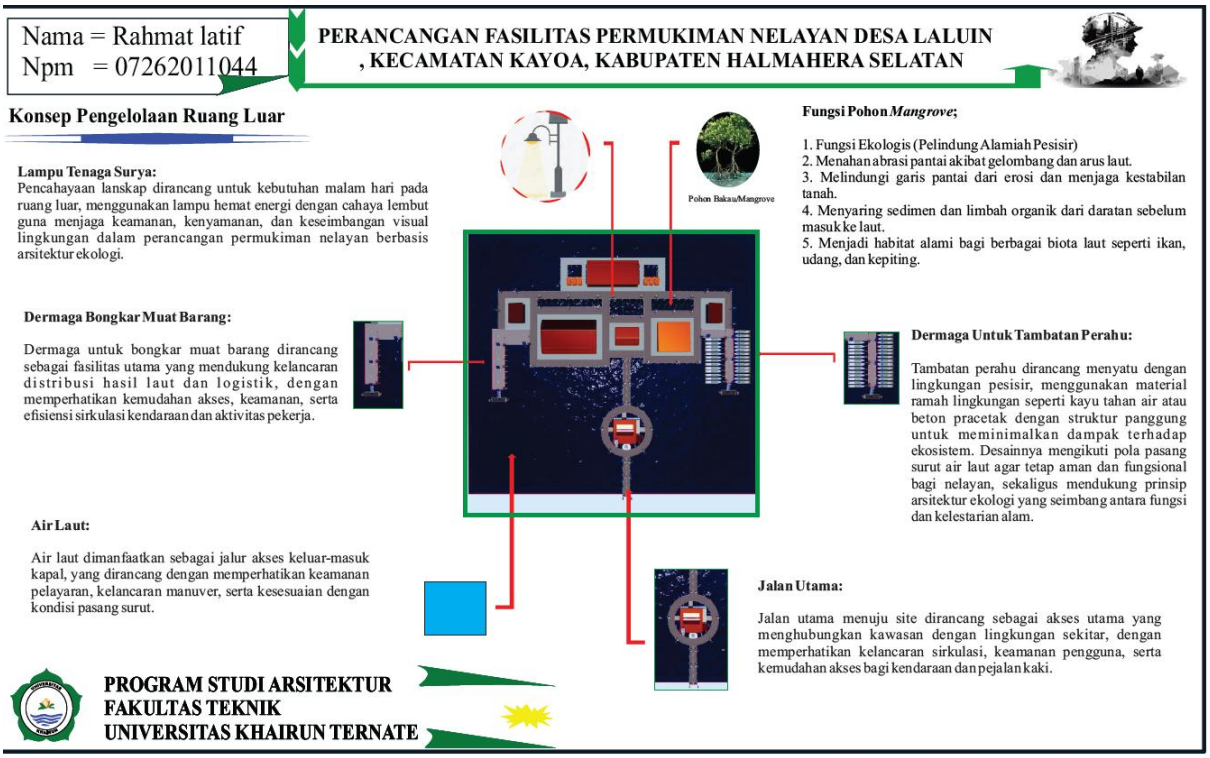


Figure 2. Designing Fishermen's Settlement Facilities

Application of ecological architecture principles

The application of ecological principles is carried out through the adaptation of buildings to the climate, the arrangement of openings for natural lighting and ventilation, the selection of materials and structures that are suitable for coastal conditions, and utility planning. Rainwater is stored on the roof and directed to the reservoir for non-consumption use after filtering. Wastewater is planned through a treatment system before being discharged or reused

according to the quality of the processed products. Waste is sorted based on its characteristics; organic waste from fishery activities requires special treatment so as not to directly pollute the waters. The electricity concept uses PLN and spare generators, while solar energy strategies are mainly mentioned for landscape lighting. These systems still require capacity calculations and technical feasibility tests.

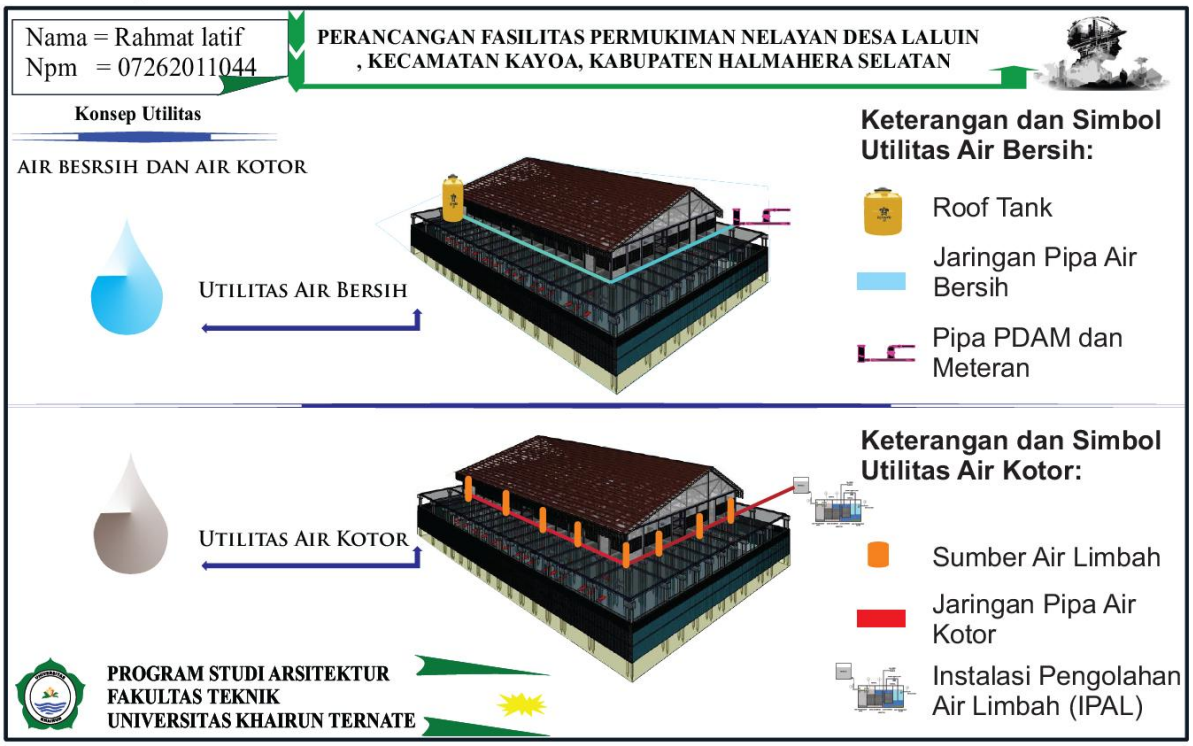


Figure 3. Water Utility Concept

Synthesis of design and contribution models

The resulting conceptual model connects five components: (1) aquatic environmental character and coastal risk; (2) fishermen's socio-economic needs; (3) zoning and spatial connectivity; (4) site-responsive design of buildings and docks; and (5) water, energy, waste, and vegetation management. This integration avoids the separation between economic facilities and environmental infrastructure. The contribution is a design framework that can be the basis for discussions on the arrangement of similar fishing areas, with adjustments to their respective local data.

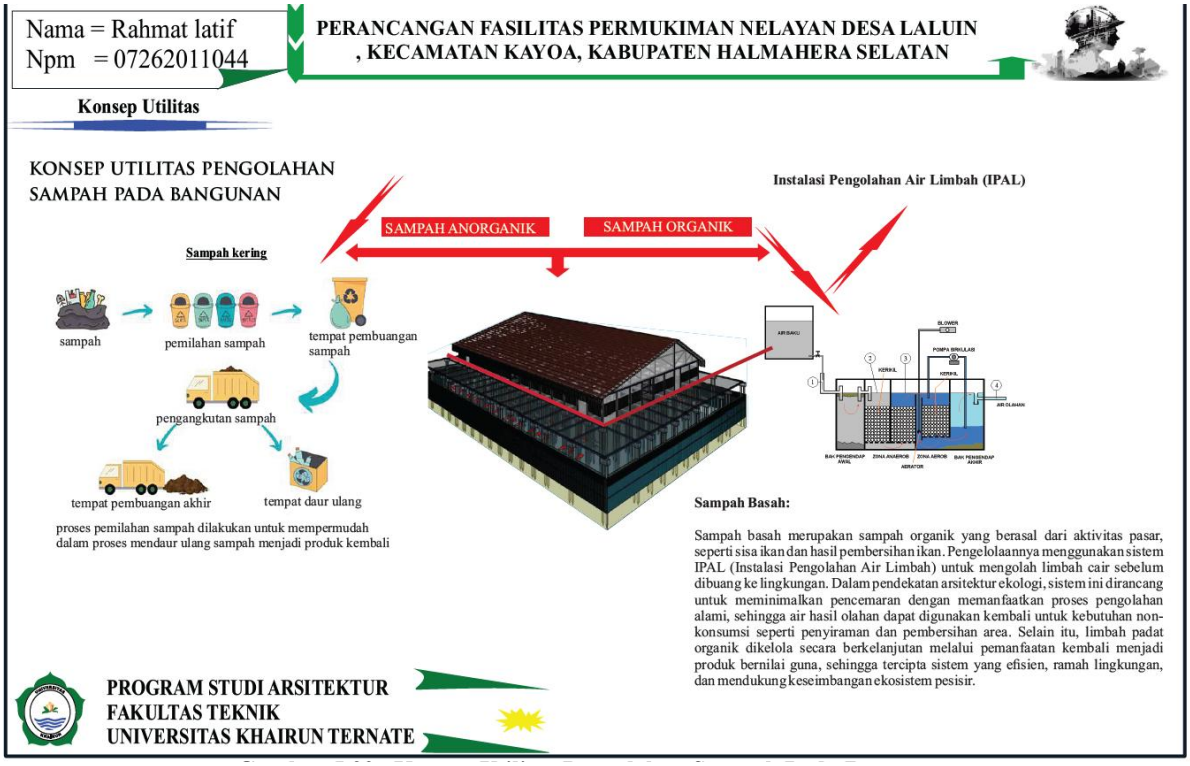


Figure 4. Concept of Waste Processing Utility

Limitations

This article is sourced from the final project of the design. Details of the number of respondents, water quality test data, energy simulations, material life cycle assessments, and post-implementation performance measurements are not available in the methods section. Therefore, benefits such as reduced pollution, energy efficiency, and increased fishers' income should be understood as design objectives, not as proven impacts.

CONCLUSION

The design of fishermen's settlement facilities in Laluin Village with an ecological architecture approach resulted in a conceptual model of the area that combines fisheries functions, social space, dock connectivity, landscape management, and environmental utilities. Ecological principles are realized through building orientation and ventilation, rainwater and wastewater management, waste segregation, and the use of coastal vegetation. This design offers a contextual arrangement direction for fishermen's settlements on water, but still requires technical validation, user participation, cost analysis, and environmental impact evaluation before implementation.

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