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MODEL OF ARRANGING FISHERMEN'S SETTLEMENT AREAS BASED ON STILT HOUSES AND FLOATING HOUSES AS AN ADAPTIVE SOLUTION TO CLIMATE CHANGE AND STRENGTHENING REGIONAL RESILIENCE IN MUARA ANGKE, NORTH JAKARTA

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Abstract

The fishermen's settlement area in Muara Angke, North Jakarta, faces serious challenges due to tidal flooding, poor infrastructure, and a clean water crisis. The Republic of Indonesia Defense University (Unhan RI) initiated a pilot project for area arrangement using stilt houses and floating houses as adaptive solutions. This article examines a multidisciplinary approach involving physical development, clean water and sanitation systems, as well as strengthening the community's social capacity. The methodology includes field observation, community participation, and technical infrastructure analysis. The results show that the application of modular technology, desalination systems, and waste treatment can improve quality of life and environmental resilience. This model has the potential to be replicated in other coastal areas in Indonesia, strengthening community resilience and territorial defense through a community-based civil defense approach, while also supporting geostrategic strategies and national policies for coastal area management.

Keywords: ***Spatial planning, floating houses, stilt houses, regional resilience, and disaster mitigation***.

INTRODUCTION

Fishermen's settlements in coastal areas face various complex challenges, ranging from land limitations, flood and abrasion risks, to the increasingly real impacts of climate change. This condition requires innovation in spatial planning and housing development that can adapt to the dynamic coastal environment. Floating and stilt houses have emerged as one promising solution, combining adaptive construction technical aspects with the socio-economic needs of fishing communities. Fishermen's settlements in Muara Angke face a variety of complex and interrelated problems. One of the main problems is limited land due to the narrow and flood-prone coastal geographic conditions. This condition is exacerbated by coastal abrasion and increasingly frequent high tides, threatening the sustainability of residents' housing. Initial survey data shows that most residents' houses are in areas vulnerable to flooding and damage from tidal waves.

Figure 1. Initial Condition of Residents' Houses in the Empang Muara Angke Block

(Source: Floating and Stilt House Construction Document, p. 21)

In addition, the existing infrastructure is still very limited, especially in terms of road access, clean water installations, and waste management. Many houses do not have adequate sanitation systems, which has the potential to cause public health problems. The socio-economic conditions of residents are also a challenge, where most fishermen have unstable incomes and are vulnerable to changes in seasons and market conditions.

The following is a table of technical data for the construction of stilt houses which is the main solution in this project:

Technical Specifications of Stilt Houses	Information
Foundation and Pillars	Bamboo cone, hollow steel and plate
Walls and Roof	Weather-resistant and easy-care material
Solar Panel Installation	1000 watt capacity, supports home electricity
Waste Treatment System	Eco-friendly biofilter septic tank

(Source: Floating and Stilt House Construction Document, pp. 75-78)

Figure 2. Installation of Foundations and Pillars of a Stilt House
(Source: Floating and Stilt House Construction Document, p. 75)

The construction of floating and stilt houses not only functions as a place to live, but also as a means of improving the quality of life and socio-economic resilience of coastal communities. This concept integrates environmentally friendly technologies, such as the use of solar panels and waste treatment systems, which support environmental sustainability and public health. In addition, good spatial planning and planned relocation are important factors in reducing disaster risks and improving the welfare of residents.

The arrangement of the fishermen's settlement area in Muara Angke directly supports several SDGs goals, especially goal 11 which emphasizes the development of inclusive, safe, resilient, and sustainable cities and settlements. The provision of decent and adaptive housing to the risk of tidal flooding is a concrete step in reducing the vulnerability of coastal communities to natural disasters. In addition, providing access to clean water and adequate sanitation supports SDGs goal number 6 on clean water and sustainable sanitation. By implementing environmentally friendly desalination technology and waste treatment systems, the project also contributes to SDGs goal number 13 on climate action.

Increasing social capacity and community empowerment through active participation in regional development is also in line with SDGs goal number 16 on peace, justice, and strong institutions. Thus, this project is not only oriented towards technical aspects, but also towards inclusive and sustainable social development. This study aims to examine in depth the technical aspects of the construction of floating and stilt houses, the social impacts caused, and management policies that support the sustainability of fishermen's settlements. With a comprehensive approach, it is hoped that the results of this study can be a reference for the development of more adaptive and sustainable coastal settlements in the future.

1.2 Theoretical Framework

The theoretical framework used in this research refers to several main theories and concepts:

1. Sustainable Development Theory(Sachs, 2015) which emphasizes the integration of social, economic and environmental aspects in development to achieve long-term balance.
2. Adaptive Approach to Climate Change(IPCC, 2022) which underlines the importance of climate-responsive design and development strategies, particularly in coastal areas vulnerable to flooding and sea level rise.
3. The Concept of Regional Resilience and Civil Defense(Lemhannas RI, 2019) which places the community as the main actor in the non-military defense system by strengthening community capacity and preparedness.
4. Community Participation Theory(Arnstein, 1969) which emphasizes the importance of active citizen involvement in the development process to ensure program acceptability and sustainability.
5. Modular Construction Concept and Building Industrialization(Gibb & Pendlebury, 2006) which supports efficiency, flexibility, and quality in adaptive housing development.

1.3 Research Objectives and Benefits

The main objective of this study is to examine and document the model of arrangement of fishermen's settlement areas based on stilt houses and floating houses as an adaptive solution to climate change and strengthening regional resilience in Muara Angke, North Jakarta. This study aims to:

1. Describes the technical design and implementation of stilt houses and modular floating houses that are adaptive to tidal flooding and sea level rise.
2. Analyzing sustainable clean water supply and sanitation systems through desalination and wastewater treatment technologies.
3. Examining the role of community participation in area management and social empowerment.
4. Assessing the potential for replication of this model in other coastal areas in Indonesia and its contribution to national resilience and geostrategic strategy.

The benefits of this research are expected to be a reference for academics, practitioners, and policy makers in developing sustainable and adaptive coastal settlement solutions to climate change, while strengthening regional resilience through a community-based civil defense approach.

1.4 Data Collection Techniques

Data was collected through various techniques, including:

1. **Field Observation:**Conducting direct observations of the physical conditions of the area, development processes, and community activities at the project location.
2. **Interviews and Focus Group Discussions (FGD):**Engage residents, implementation teams, and stakeholders to gain perspectives and experiences related to project implementation and impacts.
3. **Development Activity Documentation:**Collect technical data, photos, and official reports that support the analysis.
4. **Technical Testing:**Conducting sounding tests to determine soil conditions, water quality tests to ensure health standards, and evaluating modular house structures in the field.

1.5 Data Analysis

The collected data were analyzed qualitatively using a thematic approach to identify patterns, challenges, and successes in project implementation. Technical analysis was conducted to assess the suitability of the design and effectiveness of the infrastructure built. This approach allows for the integration of empirical data and relevant theories. Active community involvement is one of the main focuses of this research. A participatory approach is applied from the planning stage to evaluation, to ensure that the solutions developed are in accordance with the needs and aspirations of the residents. This involvement also serves as a social empowerment mechanism that strengthens the community's capacity to manage and maintain residential areas.

METHOD

This study uses a qualitative descriptive approach based on an in-depth case study. This approach was chosen to provide a comprehensive picture of the process, results, and impacts of the arrangement of the fishermen's settlement area in Muara Angke. The case study allows for a rich contextual analysis of the interaction between technical, social, and environmental aspects in the stilt house and floating house development project.

RESULTS AND DISCUSSION

2.1 Technical Aspects of Development

The construction of floating and stilt houses in Muara Angke requires a comprehensive technical approach so that the buildings are not only resistant to dynamic coastal environmental conditions, but also environmentally friendly and sustainable.

2.2 Construction Methods and Structural Calculations

Foundation and Piles The foundation uses bamboo cerucuk, hollow steel and anti-rust coated plates that have high mechanical strength and natural resistance to sea water and termite attacks. These pillars are vertically embedded into the surface of the land which is a pile of green mussel shells with a depth adjusted based on the results of the geotechnical survey. Meanwhile, for floating houses, HDPE drums are used as floating vehicles. Structural calculations take into account dead loads (building weight), live loads (occupants and furniture), and environmental loads such as strong winds and tidal waves. The pillar and beam connection system uses welding and rust-resistant bolt connection techniques to ensure strength and ease of maintenance.

Modular Floor Platform The floor platform is designed modularly using lightweight fabricated materials such as strong and waterproof ferrocement. This modular system allows for quick assembly and replacement of damaged parts without dismantling the entire structure.

2.3 Materials and Alternatives

1. Hollow steel and plates were chosen because of their strength and easy availability in the market, as well as to reduce the use of natural wood, and alternatives such as fiber and resin-based composite materials were also considered for non-structural parts.
2. The roof and walls use weather-resistant materials such as light steel plates coated with anti-rust, as well as walls made of ferrocement and gypsum which are easy to maintain and have fairly good thermal insulation.

2.4 Supporting Installations and Environmentally Friendly Systems

1. The solar panel capacity is adjusted to the electricity needs of the fishermen's household, usually around 1000 watts. This system is equipped with a storage battery for night use.
2. Septic tank biofilter waste treatment system is used to treat domestic waste in an environmentally friendly manner, reducing water and soil pollution around residential areas.

2.5 Installation and Maintenance Techniques

1. Installation of poles is carried out using heavy equipment on open land and special tools and experts on narrow land by ensuring the correct depth and position.
2. Routine maintenance includes checking connections, replacing worn parts, and maintaining anti-rust coatings.

2.6 Environmental and Security Aspects

1. The structure is designed to withstand strong winds and tidal waves with a strong system of piles and ties on the floating house.
2. Spatial planning takes into account air circulation and natural lighting for occupant comfort and energy efficiency.

3. Technical Aspects and Management of Fishermen's Settlements in Muara Angke

3.1 Structure and Materials

The stilt house built in Muara Angke uses a light steel structure with a modular platform and bamboo cerucuk foundation and steel treads that are designed flexibly to anticipate differential settlement due to the non-homogeneous condition of the shell pile soil. The flexible connection system allows adjustment of the height of the foundation piles according to changes in soil conditions and tidal flooding that occurs periodically. The floating house is designed with a strong, corrosion-resistant ASTM A36 steel frame, and uses HDPE plastic float drums filled with construction polyurethane as buoyancy elements. These plastic drums were chosen for their resistance to chemicals and corrosion, as well as their ability to support loads of up to 207 kg per drum. With 35 float drums, the floating house has a net lifting capacity of 5,345 kg, enough to support the weight of the house and its contents.

Figure 3. Floor plan and perspective of a stilt house

3.2 Residential Support Facilities

Each stilt house and floating house unit is equipped with a 1,000-watt solar panel that provides independent electricity for residents. Clean water and bioseptic systems are also integrated into the design, ensuring the availability of drinking water and proper sanitation. Standard furniture such as beds, cupboards, and dining tables are provided to enhance the comfort of residents.

Figure 4. Residential Facilities and Support

3.3 Advantages of Modular Design

Modular design allows for faster construction times and cost efficiencies, as building components can be prefabricated off-site and quickly assembled on site. Design flexibility also allows for structural adjustments to meet changing needs and environmental conditions. This approach draws on the principles of industrialized construction that increase building productivity and quality through prefabrication and onsite assembly (Gibb & Pendlebury, 2006).

3.4 Clean Water and Drinking Water Supply System

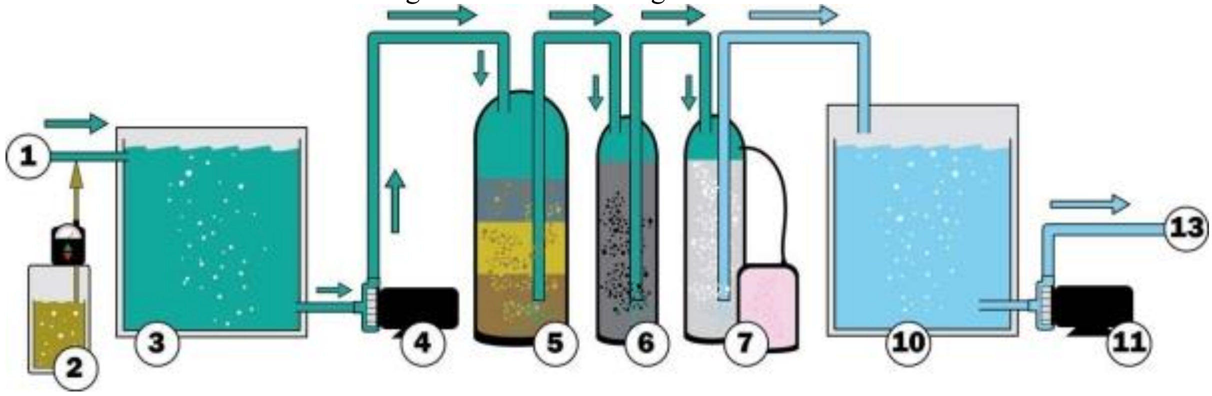
3.4.1 Reverse Osmosis Desalination System

The clean water crisis in Muara Angke was overcome by implementing a reverse osmosis (RO) desalination system with a capacity of 20,000 GPD (76,000 liters per day). This system processes brackish water from the Kali Adem estuary into fresh water that is suitable for consumption and is distributed directly to residents' homes through a network of HDPE pipes. Independent laboratory tests show that the desalinated water meets health standards, is free from pathogenic bacteria, and has a pH value close to alkaline, good for daily consumption.

3.4.2 Filtration System for MCK Needs

In addition to drinking water, filtration systems using activated carbon media and multimedia filters are applied to provide clean water for bathing, washing, and toilet (MCK) needs. Rainwater and brackish water are also used sustainably to reduce pressure on conventional water resources.

Figure 5. Modular design of water utilization



3.4.3 Social and Environmental Impacts of Independent Water Systems

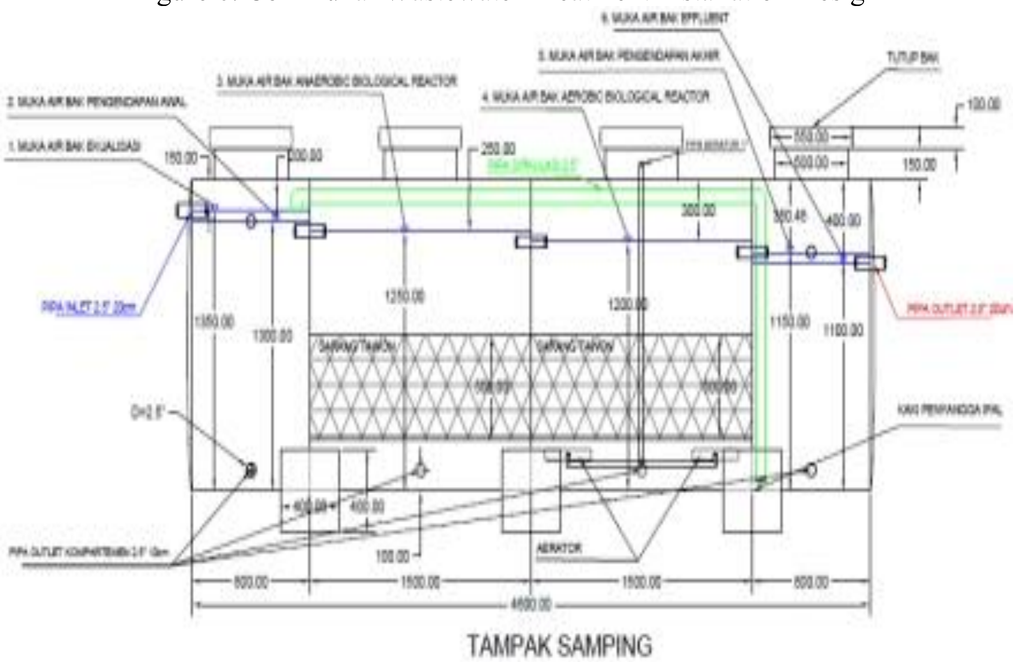
The implementation of this self-sufficient water system reduces the community's dependence on unstable and expensive external supplies. In addition, local water resource management increases environmental awareness and encourages sustainable practices at the community level, which contributes to improving the quality of life and public health.

3.5 Waste Management and Environmental Infrastructure

3.5.1 Communal Wastewater Treatment Plant (WWTP)

Communal wastewater treatment plants built using chemical, physical, and biological methods are able to process domestic wastewater into clean water that meets environmental quality standards. The process includes flocculation, coagulation, anaerobic, aerobic, zeolite and activated carbon filtration, and chlorine disinfection. This system not only protects aquatic ecosystems from pollution, but also provides processed water that can be reused for cleaning purposes.

Figure 6. Communal Wastewater Treatment Installation Design



3.5.2 Processing of Shell Waste into Paving Blocks

Figure 7. Management of Shell Waste into Paving Blocks

The abundant green mussel shell waste in Muara Angke is processed into paving blocks through a crushing process, mixing with sand and cement, and molding using a vibrator machine. Training is given to residents to operate the machine and produce paving blocks independently. This product not only reduces waste, but also provides additional economic value to the community.

3.5.3 Use of Incinerator for Waste Management

Simple incinerators with a burning capacity of 20-30 kg/hour are used to reduce the volume of domestic waste by 80-90%. The burning process at a temperature of 500°C minimizes the risk of environmental pollution and produces heat energy that can be used for drying fishery products. The use of incinerators also reduces the need for land for temporary waste disposal sites (TPS) and final waste disposal sites (TPA).

Figure 8. Simple Incinerator

3.5.4 Community Empowerment in Waste Management

Active community involvement in waste management is the key to the success of this program. Training and education are provided to increase the capacity of residents in operating wastewater treatment facilities, incinerators, and paving block production. This participatory approach strengthens the sense of ownership and social responsibility, in accordance with the theory of community participation (Arnstein, 1969).

3.6 Arrangement of Areas and Open Spaces

3.6.1 Road Widening and Paving Block Installation

The area development includes widening and paving the neighborhood roads using paving blocks made from processed shellfish waste and concrete shavings. The road level is raised to minimize inundation during tidal floods. The drainage system is also being improved to optimize water flow and reduce the risk of local flooding.

Figure 9. Installation of Paving Blocks

3.6.2 Floating Pedestrian Development

The floating pedestrian is designed as the main access to the floating house and connects between floating houses. This structure uses a galvanized hollow frame and light steel with HDPE plastic drum floats that are corrosion-resistant and can withstand loads of up to 200 kg per drum. This environmentally friendly design minimizes the impact on the aquatic ecosystem and increases user comfort and safety.

Figure 10. Installation of RO desalination system and HDPE pipe network

Source: Floating and Stilt House Construction Document 45

3.6.3 Green Open Space and Floating Futsal Field

Green open spaces in the form of children's playgrounds and floating futsal fields were built to improve the quality of life and social interaction of the community. The floating futsal field uses HDPE cubes with GRC flooring and synthetic grass, designed to be flood-resistant and environmentally friendly. This space functions as a center for physical activity, recreation, and environmental education, supporting the physical and mental health of residents.

Figure 11. Green Open Space

3.6.4 Naming of Streets and Strengthening of Area Identity

As part of strengthening the area's identity, nine roads in the RT06 and RT07 RW22 areas were given names that reflect the spirit of education and community service, such as Jalan Rektorat, Jalan Dekanat, and Jalan Sarjana. This naming facilitates administration, risk mitigation, and strengthens the positive image of the area as a knowledgeable and competitive community.

Figure 12. Installation of Street Names

4. Replication and Sustainability

After the success of the first phase of the construction of stilt houses and floating houses in Muara Angke, the project was continued to the second and third phases with a total target of 200 units. In this advanced stage, the expansion of supporting facilities such as solar power installations, wastewater treatment, and seawater desalination systems are the main priorities in order to reach more residents and improve their quality of life as a whole.

The principle of sustainability is the main foundation in the development of this settlement. Active community participation in every stage of development and management is the key to success, while ensuring that the technology used is environmentally friendly and easily adaptable. The modular design applied allows flexibility in future repairs and developments, so that the infrastructure can adapt to changes in environmental conditions and the socio-economic needs of the community.

From a policy perspective, the project is aligned with national programs such as the National Capital Integrated Coastal Development (NCICD) and the giant sea wall project aimed at strengthening coastal resilience. This integration of national policies and local initiatives strengthens Muara Angke's strategic position as a coastal area that not only functions as a settlement, but also as part of Indonesia's maritime defense system.

The community-based civil defense approach implemented in Muara Angke increases community preparedness for natural disasters and environmental threats. Through training, simulations, and strengthening social networks, communities become more resilient and able to manage risks independently. This also strengthens social stability and national security, especially in the densely populated northern coastal areas of Java which are the center of vital economic activity.

The role of government institutions, the private sector, and local communities is very important in maintaining the sustainability of this project. Synergy between stakeholders ensures effective and sustainable resource management. Continuous training and environmental education are integral parts to increase community capacity in managing infrastructure and preserving the environment.

However, major challenges remain, such as the impact of climate change causing sea level rise and extreme weather, as well as the increasing pressure of urbanization. Therefore, technological innovation and adaptive policies must continue to be developed to anticipate these changes. This floating and stilt house model has the potential to be replicated in other coastal areas with adjustments according to local characteristics, so that it can be a sustainable solution to the problems of fishermen's settlements in Indonesia.

Overall, the success of this project has not only had an impact on improving the quality of life of the Muara Angke community, but also provided a strategic contribution to national resilience and coastal security. This model is a real example of how sustainable development can be realized through multi-sectoral collaboration and active community participation.

5. Case Studies and Project Evaluation

The floating and stilt house construction project in Muara Angke is a strategic initiative designed to address the problems of flood-prone fishermen's settlements and land limitations. By using hollow steel structures, light steel and HDPE floating drums, this project has succeeded in building housing that is adaptive to tidal conditions and changes in the coastal environment.

Technically, the floating and stilt houses show good resistance to environmental loads such as waves and strong winds. The ASTM A36 steel structure used is proven to be strong and corrosion-resistant, while the HDPE plastic floating drum provides a net lifting capacity of 5,345 kg, sufficient to support the weight of the house and its contents. The modular system facilitates assembly and maintenance, thereby speeding up construction time and reducing operational costs. However, technical challenges such as differential settlement due to the non-homogeneous condition of the shell embankment soil require a flexible connection system and periodic adjustment of the height of the foundation piles. The installation of 1,000 watt solar panels and a bioseptic waste treatment system must also be routinely maintained to maintain optimal function.

From a social perspective, the project has succeeded in improving the quality of life of the community by providing safer and more comfortable housing. Active participation of residents in the construction and management of facilities strengthens the sense of ownership and social responsibility. Supporting facilities such as a 20,000 GPD seawater desalination system, clean water installations, sanitation, green open spaces, and floating futsal fields contribute to the health and well-being of the community. In addition, waste management training and the production of paving blocks from shell waste provide additional economic value and increase environmental awareness.

Some of the obstacles faced include limited funding, technical challenges in the field, and the need for ongoing training for the community. The solutions implemented include improving coordination between stakeholders, using more efficient technology, and intensive education programs. The use of simple incinerators for domestic waste management also helps reduce waste volume by 80-90%, while producing usable heat energy.

For further development, it is recommended to expand the scope of the project by involving more fishing communities in other coastal areas. Improving environmentally friendly technology and regular monitoring systems are also important to maintain the quality and sustainability of settlements. In addition, strengthening policies and government support are key factors for long-term success.

CONCLUSION

The implementation of the model for arranging a residential area for fishermen based on stilt houses and floating houses in Muara Angke, North Jakarta, shows that this approach is effective as an adaptive solution to climate change and strengthening regional resilience. With the use of flexible modular structures and corrosion-resistant materials, stilt and floating houses are able to face the challenges of tidal flooding and rising sea levels. The integration of environmentally friendly technologies such as solar panels, seawater desalination systems, and bioseptic waste treatment improves the quality of life and health of the community. In addition to technical aspects, active community participation in the development and management of the area strengthens the sense of ownership and social capacity of the community, supporting the sustainability of the project. This model not only provides an innovative local solution, but also has the potential to be replicated in other coastal areas in Indonesia, while strengthening national resilience through a community-based civil defense approach. The success of this project is a real example of the synergy between technology, policy, and community empowerment in facing environmental and social challenges in coastal areas.

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