

Analysis of Mangrove Damage to Coastal Settlements in Muara Angke, North Jakarta

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Abstract: The coastal area of Muara Angke in North Jakarta is facing increasingly serious environmental pressures due to the destruction of its mangrove ecosystem. Mangrove forests, which previously served as natural protection against ocean waves, abrasion, and tidal flooding, are now experiencing significant degradation. This phenomenon occurs in tandem with human activities such as reclamation, land conversion, and pollution. This research aims to examine in-depth the impact of mangrove destruction on coastal settlements and assess the extent to which implemented adaptation strategies can mitigate ecological and social risks. A qualitative approach with a case study design was used in this research. Data were obtained through direct field observations, interviews with the community and stakeholders, and a review of supporting documents. The analysis was conducted using a combination of descriptive techniques and evaluative instruments such as SWOT, IFAS, and EFAS to identify the strengths, weaknesses, opportunities, and threats facing the coastal area due to mangrove ecosystem degradation. The results show that mangrove destruction has a significant impact on the environmental quality of coastal communities, primarily through increased tidal flooding, abrasion, and decreased marine catches. Mitigation strategies implemented, such as the construction of stilt houses and the development of silvofishery areas, have not been fully successful due to a lack of community involvement and weak oversight. Therefore, a more participatory, integrated, and sustainability-oriented approach is needed to improve environmental conditions while enhancing the socio-economic resilience of Muara Angke residents.

Keywords: Coastal Settlements; Mangrove Destruction; Muara Angke

Introduction

Mangrove forests are vital coastal ecosystems, serving as natural barriers against abrasion and seawater intrusion, breeding grounds for marine life, carbon sinks, and waste filters. Ideally, settlements surrounding mangrove areas enjoy a decent quality of life with adequate sanitation and clean water, reflecting public awareness and sustainable government policies (Arifanti et al., 2022; Awuku-Sowah et al., 2023). However, the reality on the ground is often far from this ideal. The coastal area of Muara Angke, North Jakarta, is

a prime example of environmental degradation due to development pressures and weak governance. From 2013 to 2020, extensive changes in mangrove vegetation occurred due to land conversion for residential areas, shopping centers, fish ponds, and ports, as well as illegal logging (Asyri & Utary, 2024; Ballut-Dajud et al., 2022; Rumondang et al., 2024). The Pantai Indah Kapuk (PIK) reclamation project, built for luxury housing, actually worsened environmental conditions for Muara Angke residents, altering the hydrological system, triggering sedimentation and abrasion, and destroying the mangrove ecosystem that is supposed to protect against

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tidal flooding (Takagi, 2018; Winterwerp et al., 2020). Furthermore, pressure from local communities also contributed to the damage. Mangrove clearing for firewood and the clearing of shrimp ponds is often carried out without long-term ecological considerations (Firdaus et al., 2021; Malik et al., 2015), exacerbated by a lack of public understanding of the mangroves' function as a life-support system (Akram et al., 2023; Ebeler et al., 2025).

Housing is also problematic; Muara Angke is a densely populated slum area with poor sanitation, suboptimal waste management, and inadequate drainage, making residents vulnerable to environmental disasters such as tidal flooding and pollution. This situation reflects a clear disparity between the elite's vision of development and the lived reality of lower-class coastal communities, where the poor face economic pressures and a declining quality of life due to development projects that are not in their favor. Destruction of mangrove ecosystems increases environmental risks to settlements, while slums contribute to coastal pollution, creating a cycle of degradation (Bhowmik et al., 2022; Sutanto et al., 2022). This discrepancy between ideal conditions and reality highlights significant gaps in coastal planning and management, particularly those involving vulnerable communities, necessitating research to formulate more equitable and sustainable policy solutions (Mafra et al., 2024; Sagala et al., 2024). As an Environmental Science student with a background in architecture based in Jakarta, the author has a particular interest in urban issues, particularly those concerning poor villages and slums. My experience as a member of the award-winning team involved in the planning of the Bukit Duri slum area in 1990, supported by the Ministry of Public Housing, the Indonesian Architects Association (IAI), and the Kompas daily newspaper, has shaped my concern for this issue.

This interest prompted me to delve deeper into the impact of the PIK reclamation project, which was intended for upper-class residents but ironically reduced the quality of life for the surrounding lower-class residents, particularly the residents of Kampung Muara Angke. This research aims to deeply analyze the relationship between mangrove destruction and the quality of coastal settlements in Muara Angke, using a qualitative approach that explores the narratives, experiences, and perceptions of affected residents. The findings of this study are expected to not only enrich academic studies in the field of environment and urban planning but also inform recommendations for inclusive and socially just policies.

Method

This research uses a qualitative descriptive method with a case study approach to obtain an in-depth overview of the observed phenomena (Busetto et al., 2020; Lim, 2025). The researcher served as the primary instrument in data collection through observation, interviews, and document analysis, enabling a holistic understanding of the problem. The case study approach was chosen to explore the relationships between variables and delve deeper into specific situations, with a focus on inductive data analysis.

Research Location and Time

This research was conducted in the mangrove area and coastal settlements of Muara Angke, North Jakarta. This location was chosen because it is a mangrove ecosystem facing serious environmental pressures due to urbanization, pollution, and land conversion, and because it is home to coastal communities dependent on local natural resources. The research period was designed to be sufficiently long to ensure the accuracy and validity of the data collected.

Data Collection Instruments and Techniques

The research instruments included questionnaires, recording devices (audio/video), journals, and field notes. Data were collected using three main techniques:

Direct Observation

Observing the physical conditions of the mangroves and settlements to obtain empirical data and understand phenomena not revealed through verbal data, was conducted using a participatory approach.

In-Depth Interviews

Gathering information from key informants such as community members, local government officials, and environmental experts using a semi-structured guide to understand the causes, impacts, and solutions to mangrove destruction.

Document Analysis

Analyzing reports, policies, and other relevant documents to strengthen observation and interview data and provide a broader perspective. Triangulation was used to ensure the validity of data from various sources.

Data Analysis Technique

The data analysis technique used was SWOT (Strength, Weakness, Opportunity, Threat) analysis. This analysis helps identify the organization's internal strengths and weaknesses (through the IFAS (Internal Factors Analysis Summary) and external opportunities

and threats (through the EFAS (External Factors Analysis Summary)).

SWOT Analysis Stages

Evaluation of the research's strategic objectives; Analysis of the strategic environment (external and internal); Implementation of the IFAS and EFAS analyses; Preparation of the SWOT and IE matrices (Internal-External Matrix); Development of a grand strategy based on the SWOT analysis results.

The Four Quadrants of SWOT Strategy

Quadrant I (SO Strategies - Strength-Opportunity): Aggressive strategies to capitalize on opportunities using existing strengths; Quadrant II (ST Strategies - Strength-Threat): Diversification strategies to address external threats using internal strengths; Quadrant III (WO Strategies - Weakness-Opportunity): Turnaround strategies to capitalize on opportunities while minimizing internal weaknesses; Quadrant IV (WT Strategies - Weakness-Threat): Defensive strategies to minimize weaknesses and avoid external threats.

Results and Discussion

Muara Angke, in North Jakarta, has a long history as a port and fishing village. The area's name is said to originate from Tubagus Angke, a warlord of the Banten Kingdom. In fact, in the early 16th century, the area served as a base for Bantenese troops assisting the Demak Kingdom in fighting the Portuguese. Muara Angke was once known for its spooky past, with dense mangrove forests and large waves making it a haven for pirates. However, fishermen from Makassar and Banten were the first to settle there. Over time, Muara Angke developed into a vital integrated fishing port for Jakarta, and there were even government plans to build an integrated fishing settlement.



Figure 1. Buildings around the Muara Angke Residential Area that are Always Affected by Tidal Floods Visualization during Research

However, large-scale projects such as the giant sea wall have raised concerns about fishermen's access. Another version states that the name "Angke" originates from the Hokkien language, referring to a river whose waters turned red as a result of the massacre of ethnic Chinese in 1740. Geographically, Muara Angke is located in Pluit Village, Penjaringan District, North Jakarta (approximately 6°06'21" South Latitude and 106°46'29.8" East Longitude). This coastal area is crucial for supporting Jakarta's coastal ecosystem, particularly thanks to its mangrove forests, which provide a natural habitat for various flora and fauna.



Figure 2. Ecomarine Muara Angke is located at the end of the Muara Angke Settlement



Figure 3. Muara Angke Port

The Muara Angke area covers approximately 964.98 hectares, divided into several zones, including the Fish Landing Base (PPI) and the Angke Kapuk Nature Tourism Park (TWAAK). This area also includes the Muara Angke Nature Reserve, one of the few remaining mangrove conservation areas in Jakarta. However, in recent decades, this area has experienced ecological pressure due to land conversion, residential

development, and environmental pollution. The social conditions of the community around Muara Angke are dominated by fishermen and informal sector workers who live in densely populated settlements. These settlements are generally located in areas vulnerable to tidal flooding, abrasion, and environmental degradation. The community's dependence on coastal resources, including mangroves, makes this area highly relevant for analysis in the context of environmental damage and its impact on residents' lives (Lukman et al., 2025; Mallick et al., 2021; Nyangoko et al., 2020).

*Mangroves in the Muara Angke Residential Area
Mangrove Vegetation in Muara Angke*

Types and number of surviving mangrove species, regeneration rates, and growth patterns. The dominant mangrove species among the nine species are the Bako tree, the Api Api tree, and the Pidada tree. In the Muara Angke area, Pluit, North Jakarta, various forms of mangrove damage were found, significantly affecting both the extent of damage and the impact on coastal residential areas. Changes in the Color of the Muara Angke Area 2010 - 2024

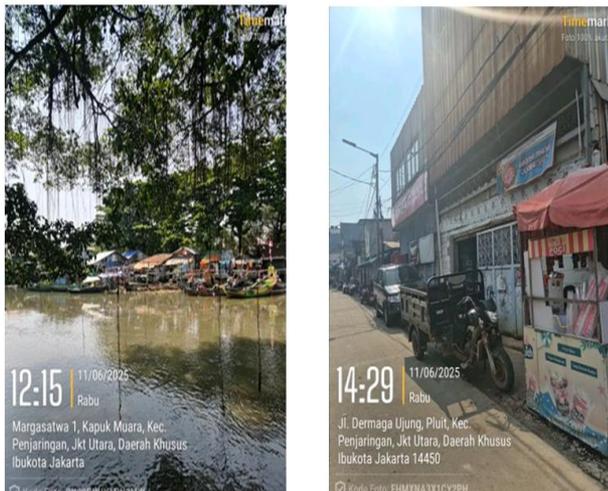


Figure 4. Research Area: Residential Areas Affected by Tidal Flooding

Ecologically, the mangrove forests in Muara Angke serve as natural protection from ocean waves, waste filters, and breeding grounds for various fish and bird species. However, mangrove damage due to reclamation, illegal logging, and seawater pollution has reduced the capacity of this ecosystem to provide vital environmental services. Against this backdrop, Muara Angke is a strategic location to study the relationship between mangrove damage and its impact on residential areas, both in terms of the physical environment and the socio-economic aspects of the community (Van Cauwenberg et al., 2022).

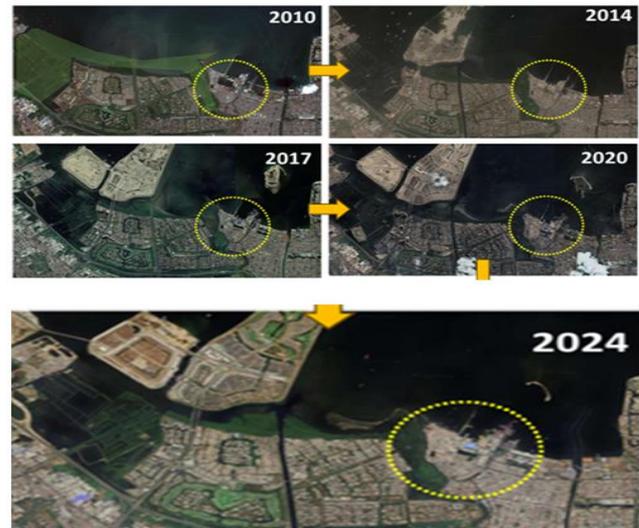


Figure 5. Changes in the Muara Angke Mangrove Area Due to the PIK Reclamation. The circled area represents the research object: Residential Areas Affected by Tidal Flooding.

Caption for Figure 5

As seen in the image above, the construction of the North Coast reclamation project from 2010 to 2024 has resulted in the reduction and destruction of mangrove forests, negatively impacting the environment of the Muara Angke fishing settlements. The circled area represents the affected residential area, which is the object of this research.

Table 2. Types of Mangrove Damage and their Impacts

Types of damage	Brief description	Main impacts
Decreased vegetation cover	Land conversion to fish ponds, residential areas, or open spaces.	Loss of natural protection against abrasion and tidal flooding
Solid waste piles	Plastic and organic waste cover the soil, inhibiting the growth of new seedlings.	Disrupted natural regeneration, reducing biodiversity.
Low salinity	Excessive freshwater inflow reduces the salinity of the mangrove soil.	Encourages invasive species, suppressing the growth of native mangroves.
Decreased species diversity	Of the 14 native species, only 9 survive.	Decreased ecosystem stability and ecological function.
Invasion of alien species	Plants such as <i>Acrostichum aureum</i> dominate the damaged mangrove areas.	Competition for resources, inhibiting the regeneration of local species.

Types of Mangrove Damage

Decreased vegetation cover: Many mangrove areas have been converted into fishponds, settlements, or vacant land; Piles of solid waste: Plastic and organic waste cover the mangrove soil surface, inhibiting natural regeneration; Low salinity: Due to development and excessive freshwater flow, invasive plants dominate; Species decline: Of the 14 mangrove species once recorded, only 9 remain; Invasion of alien species: Invasive plants such as *Acrostichum aureum* inhibit the growth of local mangroves.

Impact of Mangrove Destruction in Muara Angke

Mangrove destruction in Muara Angke has caused various serious impacts, threatening the lives and sustainability of coastal communities:

Increased Coastal Abrasion

Mangrove Function: Mangrove roots buffer ocean waves, maintain soil stability, and bind sediment, preventing coastal erosion. Without mangroves, wave energy directly impacts the land, causing severe erosion. Consequences of Mangrove Loss: Abrasion increases rapidly, eroding coastal soil material, narrowing the land, and eroding the foundations of residents' homes. Direct Impact on Settlements: Coastal houses (such as in Muara Angke) are vulnerable to collapse, forcing residents to frequently repair or evacuate. Emergency infrastructure is often ineffective. Destruction of mangrove forests in Muara Angke has removed the natural barrier against abrasion, causing continued shoreline erosion and directly threatening residents' settlements.

Decreased Water Quality, Impacting Public Health and Sanitation

Mangrove Function: Mangroves function as natural filters for organic waste, heavy metals, and pollutants from land, absorbing pollutants and breaking down hazardous chemicals. Consequences of Mangrove Destruction: Waste flows directly into the sea without filtration, causing eutrophication and oxygen depletion, as well as making the water cloudy, smelly, and potentially infectious. Impact on Health & Sanitation: Polluted water causes skin diseases, diarrhea, itching, and gastrointestinal infections. Residents who come into direct contact with polluted water are highly vulnerable. Environmental sanitation deteriorates, especially in densely populated and coastal areas that rely on surface water sources. Mangrove conservation is a crucial strategy for the health and sanitation resilience of coastal communities.

Loss of Livelihoods

Mangroves as Economic Habitat: Mangroves provide spawning, nursery, and protection for various marine life such as fish, shrimp, mangrove crabs, and shellfish, which are the livelihoods of fishermen and crabbers. Impact of Mangrove Destruction: The loss of mangroves means the loss of habitat, causing a decline in marine life populations, a decline in catches, and a drastic reduction in fishermen's income. Many are forced to change professions or venture farther out to sea, at higher costs and risks. Socioeconomic Consequences: Increased coastal poverty and unemployment, discouraged youth from fishing, increased dependence on social assistance, and potential resource conflicts. Mangrove destruction is not only an ecological crisis but also an economic and social one, making its preservation crucial to protect traditional occupations and local culture.

Increased Environmentally-Based Diseases

Root Problem: Healthy mangroves function as natural filters for waste and pollutants. If damaged, wastewater flows directly into open drains, and the accumulation of waste creates a dirty environment. Types of Diseases Increased: Diarrhea and digestive disorders, skin diseases, acute respiratory infections (ARI), as well as dengue and chikungunya fever (because stagnant water becomes a breeding ground for mosquitoes). Most Affected: Children, the elderly, communities without access to clean water and sanitation, and workers exposed to water on a daily basis. Mangrove destruction exacerbates environmental conditions and directly impacts public health.

Economic Losses

Damage to Coastal Infrastructure: Without mangroves, waves and abrasion directly damage roads, homes, fishing ports, and fish farming facilities. Infrastructure repair costs become expensive and recurring. Declining Marine Catches: The loss of mangrove habitat has led to a drastic decline in fish, shrimp, and crab populations. Fishermen are forced to venture farther out to sea, increasing costs and reducing daily income by 30-70%. Pond productivity has also declined. Long-Term Impacts: Reduced incomes for coastal families have led to reduced purchasing power, underemployment, and increased dependence on social assistance (Hallegatte et al., 2020; Touch et al., 2024).

The potential for regional economic losses increases if mangroves are not restored.

Conditions of Affected Settlements and Their Factors

Mangrove destruction in Muara Angke is not only an ecological issue, but also a social and economic crisis. This study focused on 423 households (KK) in

neighborhood units (RT) 005, 006, and 007, community unit (RW) 022, whose settlements were affected by tidal flooding due to mangrove destruction. An Internal Factors Analysis Summary (IFAS) analysis identified strengths such as the ecological function of mangroves as a barrier against abrasion, traditional stilt houses, biodiversity as an economic driver, and the role of NGOs and academics in conservation and development. However, weaknesses include land conversion into densely populated settlements without adequate sanitation, low community awareness of mangrove cleanliness and preservation, weak environmental law enforcement, and less environmentally friendly infrastructure and drainage conditions in the settlements.

This research focused on 423 households (KK) in neighborhood units (RT) 005, 006, and 007, community unit (RW) 022, Muara Angke, whose settlements are frequently affected by tidal flooding due to mangrove damage.

Internal Factor Analysis (IFAS)

The IFAS matrix was used to identify strengths and weaknesses affecting the sustainability of the Muara Angke coastal area, emphasizing the direct impact of mangrove damage on the physical and social conditions of the settlements.

The identified internal strengths include

The ecological function of mangroves as a barrier against abrasion (Blanton et al., 2024; Indarsih & Masruri, 2019; Sunkur et al., 2023). The presence of traditional stilt houses; Biodiversity that supports the economy of fishing villages; Support from NGOs and academics for settlement conservation and planning (Winanti et al., 2023). Meanwhile, the identified internal weaknesses include: Land conversion for densely populated settlements without adequate sanitation; Low community awareness of cleanliness and mangrove preservation; Weak environmental law enforcement; and less environmentally friendly settlement infrastructure and drainage.

Tabel 3. Matriks IFAS: Dampak Kerusakan Mangrove terhadap Pemukiman di Muara Angke

Strengths	Weight	Rating	Score	Description
Mangroves and traditional stilt houses protect against abrasion and tidal flooding	0.10	4	0.40	Natural protection and adaptation of coastal settlements
Biodiversity supports the economy of fishermen and coastal villages	0.08	3	0.24	Livelihood sources and potential for village development
Potential for ecotourism based on fishing villages	0.07	3	0.21	Economic diversification and community education
Conservation areas support the protection of residential areas	0.06	2	0.12	Limited coverage
Support from NGOs and academics for conservation and village planning	0.04	2	0.08	Cross-sector collaboration
Weaknesses				
Land conversion into dense residential areas and unsanitary fishponds	0.12	3	0.36	Threat of slums
Low public awareness of mangrove conservation and village cleanliness	0.10	3	0.30	Socio-educational approach needed
Minimal legal oversight of environmental and residential areas	0.10	4	0.40	Weak law enforcement
Environmentally unfriendly residential infrastructure and drainage	0.08	3	0.24	Triggers flooding
Economic dependence on damaged resources and limited space	0.05	2	0.10	Alternatives and relocation needed
Total internal score	1.00		2.45	

Interpretation:

A total score of 2.45 indicates that internal factors in the area are still relatively supportive of mangrove rehabilitation and settlement planning, but significant challenges remain, including physical and social weaknesses.

Solutions for Muara Angke Residential Settlement

Given the limited land area and population density in Muara Angke, solutions for residential settlements

require a planned approach and active community participation. The following are the proposed steps:

Community Involvement

It is important to involve all residents in building a strong community. The goal is to plan and promote settlement solutions that are clean, healthy, and well-organized according to standards.



Figure 6. Conditions during tidal flooding in the Muara Settlement Angke

Vertical Settlement Development with a Stilt Concept

Design: Vertical buildings with a stilt concept, where the ground floor is left open as a public space for community activities. Residential spaces begin from the second floor and above; **Tidal Flood Resistance:** This design will protect residents' homes from the impacts of tidal flooding (Gaby & Trisno, 2023); **Materials:** Reinforced concrete with a full ceramic finish on the ground floor. These materials were chosen because they are durable, easy to clean after tidal flooding, and resistant to corrosion in coastal environments (Manap et al., 2017; Rubinato et al., 2020).

Supporting Facilities

Waste Management: Construct vertical waste channels directly connected to trash bins that are easily accessible by collection vehicles (Longo et al., 2021; Pardini et al., 2020). This will encourage community participation in maintaining environmental cleanliness. **Access to Electricity and Clean Water:** Ensure that each housing unit has electricity and clean water from the local water company (PAM).

Economic Development and Public Facilities

Vertical Economic Buildings: In addition to 10 residential towers for 423 families, open vertical buildings should also be constructed for community economic activities (e.g., shellfish peeling) with planned sanitation circulation to prevent the emergence of illegal structures. **Health Clinics and Kiosks:** Plan for health facilities such as clinics and kiosks that are well-organized and managed by residents themselves to maintain cleanliness (Anderson et al., 2021).

Environmental Planning and Flood Management

Greening: A more open site plan concept with vertical buildings allows for the cultivation of mangroves and other coastal plants to create a beautiful environment (Kamau et al., 2024; Meutia, 2022; Waleed et al., 2025). **Agency Guidance:** Guidance from relevant agencies is needed to ensure Muara Angke becomes a healthy and well-maintained environment. **Water Circulation Management:** Thorough planning for water circulation during tidal flooding, including the construction of sea fences or retention ponds to mitigate the impact on community activities (Irawanto et al., 2023).

The Importance of Community Collaboration

Ultimately, the key to the success of all these efforts is community collaboration and mutual cooperation in planning, building, maintaining, and caring for the environment, as well as abandoning habits that contribute to slums (Surya, Saleh, et al., 2020; Surya, Syafri, et al., 2020; Van Hoof et al., 2021).

Conclusion

This study confirms that the degradation of the mangrove ecosystem in Muara Angke, North Jakarta, significantly worsens the quality of life for coastal communities. Damage triggered by reclamation, land conversion, and pollution has eliminated the vital function of mangroves as natural barriers. As a result, vulnerable communities in Muara Angke now experience more frequent tidal flooding and abrasion, which damage infrastructure and reduce income from marine resources. Despite mitigation efforts such as the construction of stilt houses and the development of silvofishery, their impact has not been optimal due to minimal community participation and weak oversight. Therefore, a more integrated and participatory approach is needed between the government, communities, and the private sector to rehabilitate mangroves and manage the coast sustainably. As recommendations, this study emphasizes the importance of stronger mangrove protection policies, community-based rehabilitation programs, the development of green infrastructure such as green belts and vegetative embankments, and increasing public awareness about mangrove conservation. These steps are crucial for restoring the environment and enhancing the socio-economic resilience of Muara Angke in the future.

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Author Contributions

Conceptualization; methodology; validation; formal analysis; investigation; resources; data curation: writing – original draft preparation; writing – review and editing; visualization: H., E. K. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

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