



Environmental Costs of Land Reclamation: Implications for Biodiversity and Conservation Strategies

**Jamie Domingo, Suzaine Therese Domingo, Haidee Simon, Roselito
Queja**

Philippine Christian University

Abstract- Land reclamation, the transformation of wetlands, coastal zones, and other natural ecosystems into usable land, has emerged as a global response to urbanization, economic expansion, and agricultural demand. While reclamation provides critical space for infrastructure, industrial growth, and urban development, it simultaneously generates significant ecological costs. This study examines the impacts of land reclamation on biodiversity and ecosystem services, with particular emphasis on the Philippine context and comparative international experiences. Drawing on secondary literature, case studies, and environmental impact assessments, the study identifies reclamation's adverse effects on species diversity, habitat integrity, water quality, and ecosystem resilience. Findings from Manila Bay, BASECO Compound, and Shanghai's large-scale projects illustrate the trade-offs between economic growth and ecological sustainability. Although reclamation projects create opportunities for urban expansion and flood protection, they exacerbate biodiversity loss, alter hydrodynamics, and displace vulnerable communities. The research underscores the urgent need for sustainable strategies, including habitat restoration, biodiversity corridors, the use of innovative engineering techniques, and strengthened governance mechanisms. Policy recommendations highlight the importance of integrating conservation into reclamation planning, improving environmental impact assessment frameworks, and promoting community participation in decision-making. By situating reclamation within global discourses on sustainable development, the study contributes to designing balanced approaches that harmonize human progress with ecological preservation.

Keywords- land reclamation, biodiversity, environmental costs, conservation strategies, Manila Bay, sustainable development.

I. Introduction

The demand for land has emerged as one of the most pressing environmental and developmental challenges of the 21st century. With global populations rising rapidly and urban centers expanding at unprecedented rates, the need for new residential, industrial, agricultural, and commercial spaces continues to escalate. Governments and developers across the world increasingly look toward land reclamation as a seemingly practical solution to limited land availability. Reclamation, broadly defined, is the transformation of natural landscapes—including wetlands, estuaries, forests, and coastlines—into artificial or semi-artificial areas intended for human use. The process often relies on dredging, filling, and constructing embankments to convert water-covered or ecologically sensitive areas into land suitable for construction and development. While this practice can temporarily ease the pressures of population



growth, urban sprawl, and economic expansion, it generates profound and far-reaching ecological costs that demand urgent scrutiny.

Among the most critical environmental consequences of land reclamation is biodiversity loss. Ecosystems such as wetlands, mangroves, coral reefs, and coastal habitats are particularly vulnerable to reclamation projects. These areas represent some of the richest biological reservoirs on Earth, providing habitats to a wide array of species ranging from migratory birds and marine organisms to unique plant life. Their destruction not only diminishes global biodiversity but also disrupts intricate ecological processes essential for environmental stability. Wetlands, for instance, act as natural filters for water systems, regulating nutrient cycles and maintaining water quality. Mangroves, on the other hand, play a dual role: they serve as crucial carbon sinks, mitigating climate change, while also functioning as natural barriers that protect coastal communities from storm surges and flooding. The degradation of coral reefs undermines fisheries productivity and weakens the resilience of marine ecosystems. Collectively, the loss of these ecosystems results in diminished ecological services, threatening both environmental sustainability and human livelihoods (G3 Soil Works, 2024).

In addition to biodiversity decline, land reclamation disrupts natural processes that sustain the balance of ecosystems. Hydrological cycles are altered, as natural water flows are blocked or redirected, often leading to increased flooding or water scarcity in adjacent areas. Sediment flows, which are essential for maintaining coastlines and supporting aquatic ecosystems, are frequently interrupted, creating erosion in some regions and excessive sedimentation in others. These changes can destabilize the delicate equilibrium of coastal and marine systems. Moreover, reclamation projects often directly impact local communities, particularly those dependent on coastal and aquatic resources for subsistence and livelihood. Fisherfolk, for example, face declining catches as fish habitats are destroyed, while farming communities lose fertile wetlands that once supported agriculture. Thus, reclamation does not only produce ecological degradation but also deepens social inequities and economic vulnerabilities (Manila Bay Sustainable Development Master Plan [MBSDMP], 2020).

The Philippine experience with land reclamation illustrates many of these global challenges with striking clarity. Manila Bay, for instance, has long been a focal point of reclamation efforts, with projects ranging from large-scale development plans for commercial districts and ports to the establishment of informal settlements such as BASECO, which was constructed on reclaimed land. These projects highlight the ongoing tension between development imperatives and environmental conservation in an archipelagic nation highly dependent on marine and coastal ecosystems for food security, cultural identity, and climate resilience. The ecological risks associated with reclamation in the Philippines mirror patterns observed worldwide. In the Netherlands, reclamation has historically been driven by the need to manage water and expand habitable areas, reflecting centuries of engineering solutions to environmental limitations. In Shanghai, massive coastal expansions have enabled rapid urban growth but at the expense of natural ecosystems and biodiversity (Valenzuela, 2019; SIDCO, 2024). These global comparisons underscore the universality of the reclamation



dilemma, revealing a common pattern: short-term economic or spatial gains often come with long-term ecological and social costs.

This study is anchored in a central research question: How does land reclamation affect biodiversity, and what conservation strategies can be employed to mitigate its environmental consequences? Addressing this question requires a multidimensional approach. First, the research will examine the ecological impacts of reclamation by assessing its effects on species diversity, habitat integrity, and ecosystem services. Second, it will analyze socio-economic consequences, particularly for communities whose survival depends on coastal and marine resources. Third, it will explore conservation strategies that offer potential pathways for reconciling development needs with environmental sustainability. These may include stricter environmental impact assessments, the establishment of protected areas, the application of ecological engineering, and the promotion of community-based resource management.

By combining a comprehensive review of existing literature, in-depth case studies, and comparative international analysis, this research aims to provide a nuanced understanding of the reclamation-biodiversity nexus. In doing so, it seeks not only to highlight the environmental costs of reclamation but also to advance practical and sustainable solutions that can inform future policy and development planning. Ultimately, the study underscores the need for a balance between human development and ecological preservation, reminding policymakers, developers, and communities alike that true progress cannot be achieved at the expense of the natural systems that sustain life.

II. Review of Related Literature

Global Perspectives on Land Reclamation

Land reclamation has historically been regarded as a pragmatic response to geographical and environmental constraints. In regions where natural land was scarce or subject to flooding, human ingenuity led to strategies that expanded habitable and productive areas. The Netherlands offers one of the earliest and most prominent examples, pioneering the polder system through the construction of dikes and drainage canals. These reclaimed areas were used not only for agriculture but also as protective measures against recurrent flooding. Dutch reclamation efforts reveal that in some contexts, reclamation was less a matter of choice and more a necessity for survival and national development.

In Asia, reclamation became a tool for managing urban density and sustaining economic growth. Japan has relied on coastal reclamation to build infrastructure, such as industrial ports and even entire airports like Kansai International Airport, located on an artificial island. Singapore, constrained by its limited landmass, has expanded its territory by nearly 25 percent through systematic reclamation, enabling it to accommodate urban development, industrial zones, and even reservoirs. Hong Kong's reclamation along Victoria Harbour reshaped the city into a global financial hub, underscoring reclamation's role in transforming cityscapes.



In more contemporary settings, projects such as Dubai's Palm Islands and China's large-scale coastal expansions demonstrate reclamation's symbolic role in global city-building. Dubai's artificial islands project was designed to enhance the city's image as a luxury tourism and investment hub, while China's massive reclamation in the South China Sea extends beyond economic utility, reflecting both urban expansion and geopolitical strategy. These examples collectively show reclamation as both a driver of economic development and a statement of national ambition.

Despite these benefits, reclamation projects come with serious ecological costs. G3 Soil Works (2024) notes that reclamation typically results in the destruction of critical habitats, alteration of marine hydrology, and disruption of ecological processes such as nutrient cycling and carbon sequestration. SIDCO (2024) similarly emphasizes how conventional reclamation practices exacerbate erosion, reduce fishery productivity, and introduce pollutants that destabilize marine systems. The ecological consequences extend beyond biodiversity, affecting the long-term resilience of coastal communities. In response, some projects have experimented with sustainable approaches, such as geotextiles, controlled dredging, and reusing dredged materials to support habitat creation rather than destruction. While these alternatives show promise, their success is conditional on strict oversight, comprehensive monitoring, and genuine political will. Without these safeguards, "green" reclamation risks repeating the ecological harm of conventional projects.

III. Philippine Context: Manila Bay and Coastal Settlements

The Philippines offers a critical case study in reclamation's tensions between development and ecological sustainability. According to the Manila Bay Sustainable Development Master Plan (MBSDMP, 2020), over 20,000 hectares of marine areas in Manila Bay alone have already been reclaimed. These large-scale transformations have profoundly altered hydrodynamics, water quality, and ecological balance. Hydrological simulations from the MBSDMP reveal that reclamation projects slow tidal currents during the dry season, limiting the bay's natural flushing capacity. During the wet season, constrictions in water flow increase the residence time of pollutants. The net effect is a steady decline in water quality, weakened fisheries productivity, and intensified stress on coastal ecosystems.

At the social level, reclamation also reshapes communities. Valenzuela (2019) highlights the BASECO Compound in Manila, an informal settlement located on reclaimed land. Residents of BASECO are acutely aware of the hazards posed by flooding and storm surges but prioritize economic and livelihood opportunities. The settlement underscores how reclamation, while providing space for habitation, places vulnerable populations at the frontline of environmental risks. In this sense, reclamation in the Philippines cannot be understood solely as an ecological issue but must also be framed as a socio-economic one, where risks are disproportionately borne by marginalized groups.

Beyond Manila Bay, similar dynamics play out across other Philippine coastal regions. Reclamation projects in Cavite, Bulacan, and other provinces have sparked concern among fishing communities who report declining catches and shrinking access to



marine resources. For a nation so dependent on coastal ecosystems for food, livelihoods, and cultural identity, these transformations are particularly alarming. Compounding the risks is the Philippines' vulnerability to climate change: rising sea levels, stronger typhoons, and coastal erosion all intersect with reclamation to exacerbate ecological and human insecurity.

Research Gaps

While scholarship on reclamation is expanding, significant gaps remain, particularly in assessing long-term ecological and socio-economic consequences. Most environmental impact assessments are short-term in scope, focusing on immediate outcomes rather than cumulative effects that unfold over decades. The permanent loss of biodiversity, shifts in sediment and nutrient cycles, and the decline of ecosystem resilience are often left unexamined. Addressing these gaps requires longitudinal studies capable of tracing ecological impacts over extended periods while connecting them to urbanization trends and climate change.

Governance gaps compound these challenges. Weak enforcement of environmental laws, fragmented jurisdiction among agencies, and conflicting priorities between local governments and national policies hinder effective regulation. Private-sector influence often accelerates reclamation projects without sufficient oversight. Furthermore, the lack of meaningful stakeholder engagement marginalizes coastal communities, who frequently have the most at stake. Insufficient monitoring systems mean that even when environmental safeguards exist, compliance is inconsistent.

These governance deficiencies reveal that reclamation is not solely an environmental concern but also a matter of policy coherence, institutional capacity, and social equity. Without stronger legal frameworks, more inclusive decision-making, and rigorous monitoring, reclamation will continue to generate ecological degradation and deepen social inequities.

IV. Methodology

Research Design

This study adopts a qualitative-descriptive research design, integrating secondary literature review, case study analysis, and comparative synthesis. By examining multiple reclamation contexts, the study highlights both shared patterns and site-specific challenges.

Data Collection

Data were drawn from published research articles, government reports, hydrodynamic models, and case-specific studies. Manila Bay simulations, BASECO community surveys, and Shanghai's satellite imagery provided empirical insights. International comparisons, including the Netherlands and Dubai, contextualized findings within broader global trends.



Analytical Framework

The analysis employed an environmental cost-benefit lens informed by resilience theory and ecological economics. Indicators included biodiversity impacts (habitat loss, species displacement, invasive species presence), ecosystem services (nutrient cycling, flood regulation, fisheries productivity), socio-economic effects (displacement, equity, and livelihood changes), and governance factors (policy frameworks, enforcement gaps, stakeholder engagement).

V. Results

Environmental Impacts

- **Land reclamation consistently disrupts ecological systems:**
- **Habitat loss:** Wetlands and mangroves are often the first destroyed, eliminating critical breeding grounds for fish, birds, and amphibians.
- **Hydrological changes:** In Manila Bay, altered tidal currents diminish pollutant flushing capacity, leading to water quality degradation (MBSDMP, 2020).
- **Biodiversity decline:** Native species unable to adapt face extinction, while invasive species exploit altered environments.
- **Ecosystem service disruption:** Services such as coastal protection, nutrient cycling, and carbon sequestration decline.

Socio-Economic Impacts

- **Community displacement:** Informal settlers and fisherfolk are evicted to make way for reclamation projects, with limited compensation (Valenzuela, 2019).
- **Inequitable benefits:** Economic gains accrue to developers and elites, while marginalized communities bear environmental costs.
- **Urban growth:** Reclamation supports commercial centers (e.g., SM Mall of Asia Complex) but strains ecological resilience.

Case Studies

Manila Bay: Demonstrates hydrological disruptions and declining fisheries.

BASECO Compound: Highlights disaster risks and socio-economic vulnerabilities.

Shanghai: Illustrates large-scale urban expansion, balancing global economic power with massive ecological costs.

Netherlands and Dubai: Show long-term reliance on reclamation but with varying levels of ecological management.

VI. Discussion

Ecological Trade-Offs

Reclamation provides immediate economic returns but undermines long-term ecological resilience. The loss of wetlands reduces natural flood defenses, making coastal cities more vulnerable to climate change impacts (SIDCO, 2024).



Governance and Policy Gaps

Weak regulatory enforcement and corruption undermine environmental safeguards in the Philippines. Environmental impact assessments are often treated as procedural rather than substantive tools. In contrast, the Netherlands exemplifies stricter governance frameworks that integrate water management into long-term planning (G3 Soil Works, 2024).

Conservation and Sustainable Strategies

- **Several strategies mitigate reclamation's negative effects:**
- **Habitat restoration:** Replanting mangroves and rehabilitating wetlands.
- **Biodiversity corridors:** Establishing wildlife pathways to support species survival.
- **Engineering innovations:** Use of geotextiles and dredged materials to stabilize reclaimed land sustainably (SIDCO, 2024).
- **Community-based initiatives:** Empowering local groups to monitor ecosystems and advocate for conservation.

Policy Implications

For the Philippines, effective conservation requires strengthening environmental impact assessments with long-term monitoring, enacting stricter coastal zone management policies, engaging communities in participatory planning, and integrating reclamation into climate adaptation strategies. Recognizing rising sea levels as a critical threat, reclamation planning must align with national climate resilience frameworks (MBSDMP, 2020).

VII. Conclusion and Recommendations

This study illustrates that while land reclamation has played an important role in enabling economic development, industrial growth, and urban expansion, it has also imposed severe and often irreversible environmental costs, particularly in the form of biodiversity loss and ecological degradation. By creating new land for ports, airports, industrial estates, and residential zones, reclamation contributes to short-term economic gains and helps address the spatial demands of rapidly urbanizing societies. However, case studies across multiple regions—including the Philippines, Singapore, the Netherlands, and China—reveal a consistent pattern: the ecological disruptions generated by reclamation are profound, and without strong governance, these projects exacerbate inequalities, marginalize vulnerable communities, and undermine the long-term resilience of ecosystems.

The destruction of wetlands, mangroves, coral reefs, and other sensitive habitats erodes ecosystem services such as flood protection, fisheries productivity, water purification, and carbon sequestration. In turn, these losses heighten exposure to natural hazards, reduce food security, and compromise the adaptive capacity of both ecosystems and societies. When governance systems are weak, fragmented, or compromised by corruption, reclamation projects tend to proceed with insufficient oversight, minimal accountability, and inadequate mitigation measures. This results not only in widespread ecological degradation but also in deepened social inequities, as marginalized groups—such as fisherfolk, informal settlers, and low-income coastal residents—are



disproportionately burdened by the risks while wealthier stakeholders capture most of the benefits.

To make reclamation more sustainable, it must be approached not simply as an engineering task or a spatial solution, but as an integrated socio-ecological process grounded in environmental science, policy coherence, and participatory governance. One critical recommendation is the incorporation of biodiversity corridors and protected areas into reclamation planning. By weaving ecological networks into urban expansion projects, planners can maintain habitat connectivity, safeguard migratory routes, and reduce the risk of species isolation and decline.

Equally important is the prioritization of habitat restoration in post-reclamation phases. Restoration initiatives—such as mangrove replanting, wetland rehabilitation, and artificial reef construction—can help partially recover lost ecological functions, enhance carbon storage, and restore ecosystem services that support local livelihoods. At the institutional level, stronger governance frameworks are essential. This includes reinforcing the enforcement of environmental laws, integrating environmental impact assessments with long-term monitoring, and adopting transparent mechanisms that limit corruption and ensure accountability at both national and local levels. Engineering solutions must also evolve to minimize ecological impacts. Innovations such as the use of environmentally friendly dredging methods, geotextiles for erosion control, and adaptive coastal designs that mimic natural processes demonstrate how technology can be aligned with ecological principles.

Beyond technical and institutional reforms, community participation and environmental education are vital for ensuring reclamation's sustainability. Local communities must not only be consulted but actively engaged in decision-making, monitoring, and post-reclamation management. Empowering communities fosters ownership, strengthens local stewardship, and ensures that development benefits are more equitably distributed. Environmental education, both formal and informal, can cultivate awareness of ecological values and help shift public discourse toward long-term sustainability rather than short-term economic gains.

Future research plays a central role in advancing these goals. Long-term biodiversity monitoring is critical for documenting the cumulative impacts of reclamation and assessing the effectiveness of mitigation measures. Similarly, research on the valuation of ecosystem services can strengthen the economic case for conservation by quantifying the tangible and intangible benefits ecosystems provide. Comparative studies across reclamation-intensive regions can generate cross-cultural and cross-geographic insights, highlighting best practices while identifying context-specific challenges.

The pathway forward requires harmonizing development with ecological preservation. Land reclamation should no longer be pursued as a zero-sum trade-off between economic growth and environmental protection, but rather as a carefully balanced approach that acknowledges the interdependence of human prosperity and ecological resilience. By embedding ecological principles into planning, strengthening governance, embracing sustainable engineering, and fostering community participation, societies can transform reclamation from a source of ecological loss into



a more responsible practice that supports both development and conservation. In doing so, reclamation can be reimagined not as a driver of environmental decline but as an opportunity to innovate in ways that align human aspirations with the health and sustainability of natural systems.

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