

Nature-Based Solutions for Coastal Resilience: Case Studies from Southeast Asia

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Abstract: The purpose of this research is to determine how effective nature-based solutions (NbS) are in improving coastal resilience throughout Southeast Asia. The research begins by analyzing socio-economic aspects alongside environmental monitoring and case studies for the mangrove restoration, wetland conservation, and coral reef protection undertaken as NbS for coastal hazard mitigation. The results indicate multifaceted NbS offer more than just a layer of physical defense against sea-level rise and storm surge floods but also helps in biodiversity and local livelihood protection. The study focuses on the preservation of indigenous wisdom and policies at the regional level on scalability and sustainability to afford adequate action for urban and rural coastal development planning.

Keywords: Nature-based Solutions; Coastal Resilience; Southeast Asia; Mangrove Restoration; Ecosystem Services; Climate Adaptation; Community Engagement; Sustainable Development.

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I. Introduction

As with other regions of the world, Southeast Asia has been greatly impacted by climate change with the coastal areas bearing the brunt of the effects, now more than ever. Being home to a dense population, critical ecosystems alongside expansive shorelines has put the region at greater risk from flooding, coastal erosion, as well as storm surges. Historically, coastal areas have been dealt with using infrastructure like braces and sea walls, which come with their own costs, ecological or otherwise. Nature-based solutions (NbS), however, use instead natural systems like wetlands, mangroves, coral reefs, etc. for protection, and provide additional benefits like helping mitigate climate change by storing carbon and supporting biodiversity.

There has been growing attention on Nature-based Solutions (NbS) as alternatives to hard infrastructures due to their cost effectiveness and ecological sustainability. Countries such as Indonesia, the Philippines, and Vietnam, with aid from international organizations and local communities, have implemented and expanded varying NbS initiatives. These initiatives, alongside their international counterparts, help tackle the social and economic challenges posed around geo-political frameworks like the Sendai Framework for Disaster Risk Reduction and the United Nations Sustainable Development Goals.

The areas which lie in the peripheries of major cities enable the creation of park space where nature could be restored, and are dubbed as Nature-Based Solutions NbS. Gap on usufruct rights, lack of Capital, and neglect in survey and town planning pose as challenges towards smooth implementation of NbS. Also, analyzing NbS using a tailor-made approach will require methodologies crafted for the context at hand and stakeholder participation. This comparative study aims to offer Southeast Asian case studies with their socio-economic impact and address the existing policy gaps for effective implementation.

II. Literature Survey

There is significant and growing focus on the application of NbS for coastal resilience in literature. In Vietnam, a study (McIlveen & Hung (2019)) highlighted the protective role of mangrove forests, which was shown to reduce wave energy and halt shoreline erosion. There were also noted increases in biodiversity and income in the local economy that were linked to community-driven restoration of coral reefs documented (Hai et al. (2020)).

A multi-country report by the International Union for Conservation of Nature IUCN focuses on Southeast Asia, reviewing all of the existing NbS projects, particularly emphasizing the role of multi-actor governance and financial structures in the perpetuation of these projects (IUCN, 2023). Nehren et al. (2017) suggested that blending modern technological frameworks with traditional ecological practices increases the flexibility of NbS, particularly in the rural coastal areas of Indonesia.

Developing the punchline and planning remark, the Asian Development Bank also argues for the application of NbS into the urban framework alongside the assessment of risks and urban planning (Nguyen et al. (2020)). Other literature studied the impact of various digital technologies like GIS and remote sensing on the monitoring of coastal ecosystems and dynamic processes, which improves adaptive management.

From other side, scholarly works converge towards the understanding of the combination of ecological policy science and community participation as critical for the effective implementation of NbS (Tri et al. (2002)). Yet, there are some issues around the assessment of impacts over longer periods of time, as well as around the scaling of pilot projects to national implementation plans (Schmitt & Albers (2023)). This is a case study focus that I illustrate in the following pages using some selected examples from Southeast Asia that address these questions.

III. Methodology

This research was conducted using a combination of qualitative and quantitative techniques, also known as a mixed-methods approach. This study starts with a selection of five case studies in Southeast Asia: two in Indonesia (Java and Kalimantan) one in the Philippines (Leyte), and two in Vietnam – Mekong Delta and Da Nang. The chosen sites have ongoing NbS initiatives with data diversity and ecosystem availability.

Interviews were conducted with local stakeholders including community members, leaders, environmental NGOs, and relevant governmental agencies. The interviews were conducted on the steps regarding community participation, funding, and socio-ecological outcome evaluation. This is supplemented with project reports, peer-reviewed literature, and satellite images to assess ecological changes over time.

Using a Geographic Information System (GIS), a spatial analysis of land use change over time and vegetation cover growth, especially in mangrove regions, was conducted. Also evaluated through local government statistics and provided surveys were household income, employment in eco-tourism, and productivity levels in fisheries.

As for social advantages, generated income, and education where ecological stability (the rate of erosion and biodiversity indices) will be put under feasibility check by examining funding, regulatory support, and pre-existing bias on the legislation or governmental backing. These measures are taken in comparison to other engineering methods put in place around the placed region as a means to measure benefits and drawbacks.

IV. Results and Discussion

The results highlight the numerous advantages of NbS in coastal resilience. For instance, in Leyte, Philippines, coral reef regeneration resulted in a 20% increase in fish catch and a 35% increase in eco-tourism revenues within three years. In Kalimantan, Indonesia, the reforestation of mangroves led to a 40% reduction in annual erosion.

Also, GIS analysis indicated an increase of 15-30% in vegetative cover within restored zones over five years. This is in stark contrast to control areas where there was ongoing shoreline degradation while using concrete barriers.

Table 1: Socio-Economic Impact of NbS in Case Study Areas

| Region | Increase in Household Income (%) | Growth in Eco-tourism Employment (%) |
|----------------|----------------------------------|--------------------------------------|
| Leyte, PH | 25 | 35 |
| Kalimantan, ID | 18 | 22 |
| Mekong Delta | 20 | 28 |

Table 2: Comparative Effectiveness of NbS vs. Hard Infrastructure

| Parameter | Nature-Based Solutions | Hard Infrastructure |
|--------------------------|------------------------|---------------------|
| Erosion Reduction (%) | 30–40 | 15–20 |
| Biodiversity Enhancement | High | Low |
| Cost per km (USD) | 20,000–30,000 | 50,000–70,000 |

The findings suggest that NbS offer not only participatory implementation cost-effective solutions, but also strengthen community cohesion. However, policies, capacity building, and sustained funding are critical for deeper sustainability.

V. Conclusion

As demonstrated in this study, nature-based solutions, using real life examples, have the potential to strengthen and protect the coastlines in Southeast Asia. This research showcases the coastal region's socio-economical and ecological advantages along with the nature-based solutions' counteracting and appreciating solutions. More focus on initiated models in the socioclimatic adaptation strategies along with measurability of outcomes should be the focus moving forward.

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