Report #02

Nature-based Solution Characterisation & Typology Development for ASEAN Region

March 2025

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The report is one of several undertaken under the TAF-GTEI to provide insights into the awareness, role and uptake of nature-based solutions across ASEAN. It has not been formally endorsed by the European Union, ASEAN or ASEAN Member States.

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List of Abbreviations

Abbreviations	Definitions
AMS	ASEAN Member States
APAEC	ASEAN Plan of Action for Energy Cooperation
ASEAN	Association of South-East Asian Nations
CB	Capacity Building
CCM&A	Climate Change Mitigation & Adaptation
DRR	Disaster Risk Reduction
EbA	Ecosystem based Approach
EE	Energy Efficiency
EU	European Union
EUD	European Union Delegation
IRENA	The International Renewable Energy Agency
ICZM	Integrated Coastal Zone Management
IWRM	Integrated Water Resources Management
JNKE	Junior Non-key Expert
KE	Key-expert
NbS	Nature-based Solutions
PAM	Protected Areas Management
RE	Renewable Energy
SNKE	Senior Non-key Expert
SLM	Sustainable Land Management
TA	Technical Assistance
TAF-GTEI	Technical Assistance Facility of the Green Team Europe Initiative
TOR	Terms-of-Reference
WWF	World Wildlife Fund

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Executive Summary

Nature-based Solutions (NbS) offer transformative opportunities to address the region's pressing societal and environmental challenges. In the context of Southeast Asia, the unique and diverse landscapes provide fertile ground for integrating NbS to advance sustainable development, climate resilience, and socio-economic well-being. This report presents a strategic framework for categorising NbS in Southeast Asia, aligned with IUCN's seven societal challenges: climate change adaptation and mitigation, disaster risk reduction, water security, food security, human health, economic and social development, and biodiversity conservation.

Key Objectives and Scope

The primary goal of this study is to propose a robust categorisation approach for 70 NbS tailored to the ASEAN region. Building on previous analyses, we focus on three overarching NbS types and propose eight typologies to encapsulate the range of NbS applications. The study emphasises the critical need to align NbS implementation with the region's socio-economic priorities, environmental conditions, and cultural contexts. Furthermore, the proposed categorisation highlights nine complex landscape categories where NbS can create meaningful synergies and scale-up opportunities.

Proposed NbS Typologies

The proposed NbS typologies encompass a diverse range of applications. Ecosystem restoration and conservation focuses on protecting and revitalising degraded ecosystems, while sustainable management of ecosystems ensures their long-term viability through responsible practices. Green infrastructure integrates natural solutions into urban, industrial, and semi-rural areas to enhance resilience and livability. Climate-resilient landscapes and seascapes adapt ecosystems to mitigate climate impacts, and ecosystem-based disaster risk reduction (Eco-DRR) leverages natural systems to reduce vulnerability to hazards. Nature-based agricultural systems promote sustainable farming practices, hybrid solutions combine ecological approaches with technology, and community-based NbS prioritise local engagement and empowerment.

Landscape Categories for NbS Implementation

The report identifies nine key landscape categories where NbS can deliver significant benefits. Flood-responsive riverine landscapes enhance water management and mitigate flood risks. Adaptive sandy shorelines and coastal mangroves provide natural protection against erosion and storm surges. Climate-smart cities integrate green and blue infrastructure to boost urban resilience, while eco-industrial areas and ports adopt sustainable practices. Regenerative agriculture supports food security and soil health, and healthy forests and natural habitats preserve biodiversity and ecosystem services. Wildlife corridors improve ecological connectivity, and regenerative marine habitats safeguard vital ocean ecosystems.

Alignment with IUCN's Societal Challenges

The proposed NbS typologies and landscape categories align closely with the IUCN's seven societal challenges. Climate change adaptation and mitigation are addressed through carbon sequestration and resilient ecosystems, while disaster risk reduction is supported by natural buffers like mangroves and wetlands. Water security is enhanced by improved water management in urban and riverine areas. Food security benefits from sustainable agricultural systems, and human health is bolstered through cleaner air and water. Economic and social development is advanced by creating green jobs and fostering sustainable livelihoods. Finally, biodiversity conservation is integral to all proposed approaches, ensuring the protection and restoration of critical habitats.

Strategic Recommendations

1. Contextualisation and Scalability: Tailor NbS to the unique ecological, social, and economic contexts of ASEAN countries to maximise impact and scalability.
2. Policy Integration: Integrate NbS into national and regional policies, including ASEAN's climate and development agendas.
3. Capacity Building and Community Engagement: Empower local communities to lead and sustain NbS initiatives.
4. Monitoring and Evaluation: Develop robust mechanisms to assess the effectiveness and co-benefits of NbS projects.
5. Regional Collaboration: Foster cross-border partnerships to address shared challenges and promote knowledge exchange.

By categorising and contextualising NbS for Southeast Asia, this report provides a roadmap for scaling up nature-based approaches across diverse landscapes and societal challenges. The proposed typologies and landscape categories underscore the potential of NbS to foster resilience, sustainability, and prosperity in ASEAN Member States. With coordinated action, Southeast Asia can harness the power of nature to build a climate-resilient and equitable future.

1. Inventory of NbS Attributes and NbS Societal Challenges in the context of Southeast Asia

The first phase of the NbS characterisation study aimed to reach a holistic understanding of NbS to be presented in the catalogue. Before developing a categorisation of NbS in targeted geomorphological and socio-economic contexts of AMS, we identified the main types and attributes of NbS, based on the typology defined by Eggermont et al. (2015)[1] and considered as a reference by the ThinkNature – ClimateAdapt EU project,[2] as well as defined by the UNDRR 2021 report.[3]

We distinguish the following NbS attributes:

- 3 NbS types following the level of human intervention on nature and bio-engineering techniques applied
- 7 Biophysical Conditions in relation with 5 Land Use Categories in Southeast Asia
- 11 Ecosystem-based Approaches (EbA) addressed by NbS
- 10 NbS Challenges
- 4 types of Ecosystem-based Services provided: supporting, provisioning, regulating and maintaining, supporting social and cultural traditions and cohesion

The first efforts of categorisation of nature-based solutions (NbS) have been based on the level of intervention and the type of engineering involved in ecosystem management. This typology helps clarify the extent of human intervention in ecosystems and highlights varying goals, from conservation to urban and ecological restoration. The three types address each different ecological and societal needs.

NbS Type 1: Better Use of Protected/Natural Ecosystems

Type 1 NbS involves minimal intervention, aiming to preserve and enhance ecosystem services (ES) through protection and conservation. Strategies under this type include managing natural reserves, marine protected areas (MPAs), and coastal ecosystems like mangroves. In Southeast Asia, mangrove forests are a typical example, offering coastal protection from storms, supporting biodiversity, and providing sustainable resources to local communities. However, challenges arise in managing these protected areas effectively due to issues such as overharvesting, coastal development, and climate change impacts, which threaten these fragile ecosystems.

NbS Type 2: NbS for Sustainability and Multifunctionality of Managed Ecosystems

Type 2 NbS focuses on sustainable management practices for extensively or intensively managed ecosystems, such as agricultural landscapes, urban green spaces, and coastal zones. This approach aims to balance human use with ecological resilience, as seen in agroecological practices that increase biodiversity and forest resilience. In Southeast Asia, agricultural and coastal management is crucial, as many rural communities depend on these landscapes. However, challenges include balancing productivity with environmental health, addressing soil degradation, and ensuring water resource management in the face of droughts and floods.

NbS Type 3: Design and Management of New Ecosystems

Type 3 NbS involves high levels of intervention, including the creation of artificial or heavily modified ecosystems. Examples include green infrastructure like green roofs, urban green corridors, and water management systems that mitigate urban flooding and improve air quality. In Southeast Asian cities, where rapid urbanisation leads to issues like heat islands and pollution, Type 3 solutions are valuable for enhancing urban livability. However, implementing such intensive

[1] Nature-based Solutions: New Influence for Environmental Management and Research in Europe, H Eggermont 2015
[2] https://climate-adapt.eea.europa.eu/en/knowledge/adaptation-information/research-projects/ThinkNature
[3] Nature-based Solutions for Disaster Risk Reduction: Engaging for resilience in support of the Sendai Framework 2015-2030, UNDRR 2021.

interventions presents challenges, such as high initial costs, the need for maintenance, and aligning designs with local biodiversity needs.

Figure 1. Three types of NbS

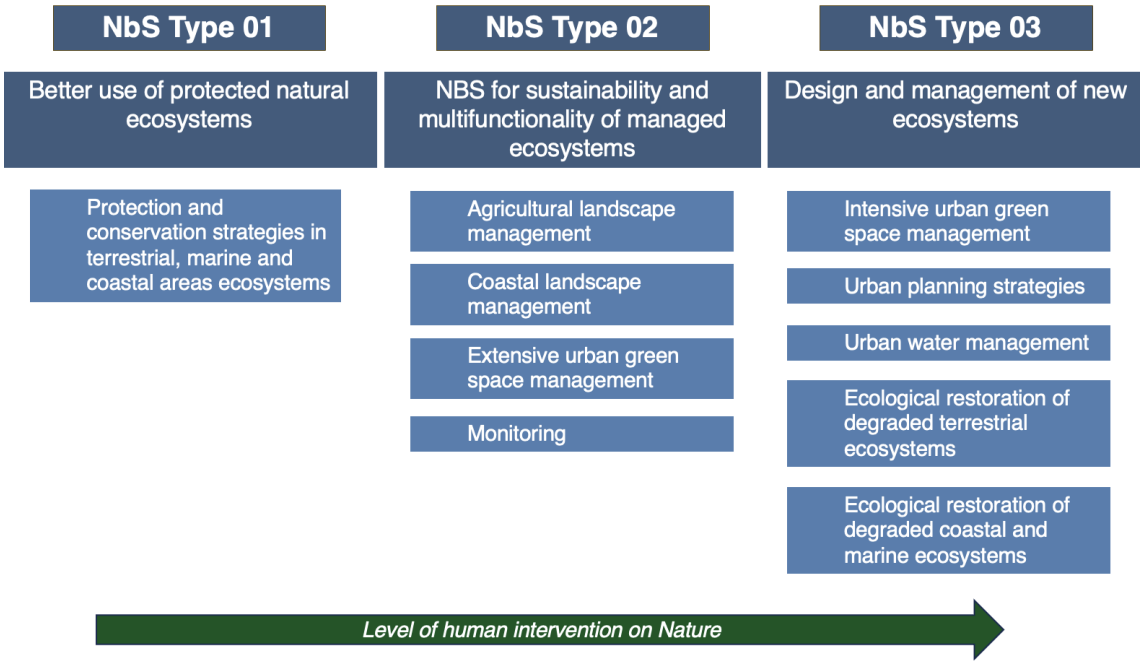


Figure 2. Seven biophysical conditions and five land use categories with complex relations in the local contexts of Southeast Asia

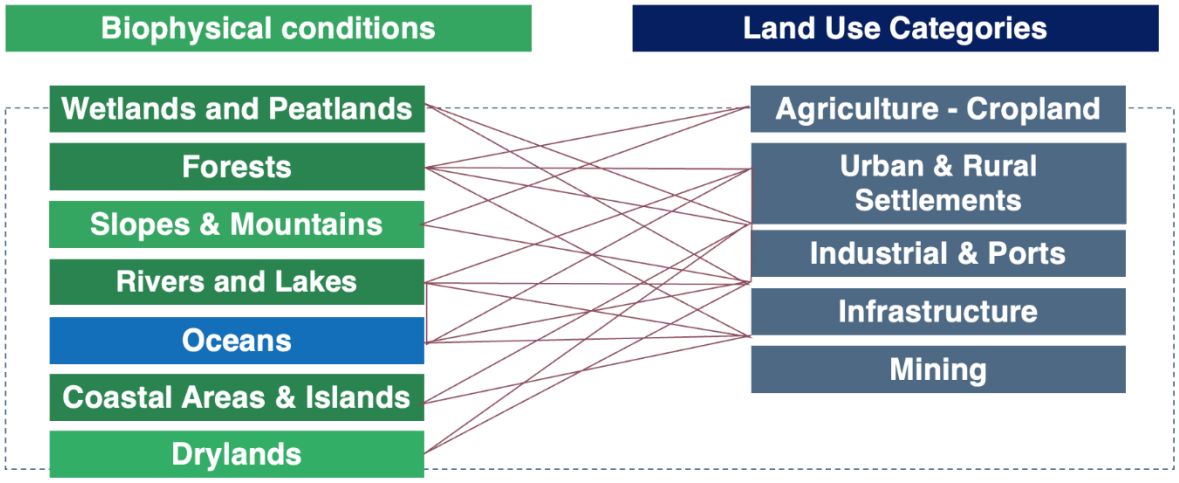


Table 1. Eleven (11) Identified Ecosystem-based Approaches (EbA) addressing climate adaptation with NbS applications in Southeast Asia

No	Ecosystem-based Approach (EbA)	Description
1	Ecosystem-based Disaster Risk Reduction (Eco-DRR)	Restoration of mangroves, wetlands, riverbanks and dune ecosystems to buffer against storms, floods, tsunamis, and coastal erosion — crucial for delta regions like the Mekong and Chao Phraya.
2	Ecosystem-based Adaptation (EbA) to Climate Change	Integrated management of agroforestry, wetlands, and coastal ecosystems to enhance resilience of farming, fisheries, and settlements to sea level rise, extreme weather, and salinisation.
3	Integrated Coastal Zone Management (ICZM)	Planning for sustainable use of coastal mangroves, sandy beaches, seagrass beds, balancing urban development (e.g., ports, resorts) with conservation in areas like the Sulu-Sulawesi Marine Ecoregion.
4	Integrated River Basin Management (IRBM)	Restoration and sustainable management of rivers, estuaries, and floodplains, ensuring sediment flow, reducing upstream pollution, and maintaining water security in areas like the Ayeyarwady and Mekong basins.
5	Marine Spatial Planning (MSP)	Zoning and co-management of marine parks, fisheries zones, ports, to balance biodiversity protection, livelihoods, and marine traffic in biodiverse seascapes like the Coral Triangle.
6	Forest and Landscape Restoration (FLR)	Reforesting degraded catchments, buffer zones and wildlife corridors, using native species (e.g., dipterocarps in Malaysia) to reduce erosion, enhance biodiversity, and support carbon sinks.
7	Sustainable Agriculture and Agroecology	Diversified farming systems — such as polyculture, organic farming, aqua silviculture, and paludiculture (wetland agriculture) — adapted to increasingly saline and flood-prone landscapes.
8	Urban Green Infrastructure (UGI)	Greening cities through urban parks, bioswales, green roofs, and river revitalisation projects (e.g., Sungai Klang River of Life) to manage stormwater, heat stress, and air pollution.
9	Community-based Natural Resource Management (CBNRM)	Local stewardship of fisheries, forests, mangroves, and agricultural lands through community-managed protected areas, indigenous knowledge integration, and participatory governance.
10	Ecological Engineering	Designing infrastructure (e.g., eco-ports, permeable pavements, living breakwaters) that mimic natural processes — for instance, hybrid grey-green solutions for coastal protection.
11	Protected Area Networks and OECMs (Other Effective Area-based Conservation Measures)	Expanding marine parks, riverine conservation areas, and wildlife sanctuaries, while recognising community-managed and culturally significant areas as key biodiversity strongholds outside formal protected zones.

Table 2. Ten (10) Identified Challenges to Nature-based Solutions (NbS) Application and Success in the context of Southeast Asia

No	NbS Application Challenge	Description
1	Fragmented Governance and Institutional Silos	Ministries and agencies often work in isolation (e.g., separate water, forestry, fisheries authorities), leading to disjointed NbS implementation without cross-sector coordination, especially in river basins and coastal zones.
2	Limited Technical Capacity at Local Levels	Many local governments and community groups lack the skills for NbS planning, ecosystem restoration, monitoring, or adaptive management — particularly outside urban centers.
3	Insufficient Sustainable Financing Mechanisms	Most NbS projects rely on short-term grants. There are few financial models to sustain NbS efforts over 10–20 years, which restoration projects need.
4	Low Community Ownership and Appropriation	Without early and meaningful participation, local communities (e.g., fisherfolk, farmers, indigenous groups) may view NbS as external interventions rather than as their own solutions, reducing effectiveness and long-term stewardship.
5	Rapid and Intensifying Climate Change Impacts	The pace of sea level rise, extreme storms, and droughts sometimes outstrips NbS adaptation rates (e.g., mangroves can't keep pace with sudden salinity increases), especially in deltas and low-lying islands.
6	Maintenance and Long-Term Stewardship Gaps	NbS projects often fail after the initial funding ends because ongoing maintenance (e.g., replanting, invasive species control, monitoring) is neglected or unfunded. This is critical in reforestation, wetland restoration, and green urban spaces.
7	Transboundary Management and Political Complexity	Rivers like the Mekong, Salween, and major marine ecosystems cross national borders, but regional cooperation is often weak or politically sensitive, undermining basin-wide NbS efforts.
8	Land Use Conflicts and Inadequate Spatial Planning	Expanding agriculture, aquaculture, mining, and urbanization often outcompete or destroy potential NbS sites, particularly in deltas and coastal zones where land is economically valuable.
9	Short-Term Development Pressures	Governments often prioritise rapid economic gains (e.g., tourism, port construction, export agriculture) over longer-term resilience strategies, making NbS politically less attractive.
10	Lack of Robust, Context-Sensitive Data	Good NbS design depends on detailed local data (e.g., ecosystem services mapping, climate risk projections), which are often missing or outdated in Southeast Asian countries, especially in rural and remote areas.

Table 3. Contributions of the four types of Ecosystem-based Services (EbS) to the environment, economy and local communities in Southeast Asia

Ecosystem-based Service (EbS)	Descriptions
1. Supporting Services	**NbS enhances the underlying ecological processes** that make other services possible — such as nutrient cycling, soil formation, and habitat provision. Examples include wetland restoration supporting fish nurseries, agroforestry improving soil health, and coral reef protection sustaining marine biodiversity.
2. Provisioning Services	NbS ensures the sustainable supply of natural resources like food (fish, fruits, rice), freshwater (through watershed protection), timber, fiber, and medicinal plants. Initiatives like mangrove-friendly aquaculture and rainforestation farming in Southeast Asia support both livelihoods and ecosystems.
3. Regulating Services	NbS strengthens natural regulation of climate, water, and biological processes, reducing risks such as floods, droughts, coastal erosion, and heat waves. Mangrove belts buffer storm surges, forested hills reduce landslide risks, peatlands sequester carbon, and green urban spaces mitigate urban heat.
4. Cultural Services	NbS revitalises cultural identity, traditional practices, recreation, and community cohesion. Protected sacred forests, community-managed coastal zones, and ecotourism initiatives reconnect people with nature, support indigenous stewardship, and maintain the spiritual and aesthetic values tied to Southeast Asia's rich natural landscapes.

We identify the following seven key societal challenges that NbS aim to address in the context of Southeast Asia:

- **Climate Change Mitigation and Adaptation.** NbS aim to reduce greenhouse gas emissions, enhance carbon sinks, and build resilience to climate-related risks. In Southeast Asia, mangroves and peatlands play pivotal roles in sequestering carbon and buffering coastal communities from rising sea levels and storm surges.
- **Disaster Risk Reduction.** Natural ecosystems like forests, wetlands, and coral reefs provide critical services that mitigate risks from floods, landslides, and tsunamis. NbS in riverbeds and coastal zones of the Mekong Delta or upland watersheds in Indonesia integrate ecological restoration with disaster preparedness, safeguarding livelihoods.
- **Food Security.** Agroforestry and sustainable agricultural practices enhance food production while preserving ecosystem services. In Southeast Asia, NbS are essential to mitigate soil degradation and drought in farming communities and ensure sustainable rice and aquaculture systems.
- **Water Security.** NbS improve water availability, quality, and management through watershed restoration, wetland conservation, and urban greening. This is particularly critical in urbanising regions like Hanoi and Jakarta, where water pollution and scarcity are mounting challenges.
- **Human Health.** By enhancing air and water quality and reducing urban heat islands, NbS contribute to healthier environments. Urban parks and green corridors in cities like Bangkok and Manila also provide mental health benefits and spaces for recreation.
- **Economic and Social Development.** NbS create green jobs, support sustainable tourism, and foster inclusive economic opportunities. Southeast Asia's reliance on ecotourism, fisheries, and smallholder farming underscores the need for NbS that empower local economies while preserving biodiversity.
- **Biodiversity Conservation.** NbS protect and restore habitats, ensure species connectivity, and combat ecosystem degradation. From reforestation in wildlife corridors of the Philippines

to coral reef restoration in Indonesia, conserving biodiversity is integral to sustaining ecosystem services.

Figure 3. Seven key societal challenges

In Southeast Asia, these societal challenges are deeply interlinked with the region's biophysical diversity and human livelihoods. Riverbeds are not just hydrological systems but spaces for fisheries and agriculture. Forests serve as biodiversity hotspots, carbon sinks, and sources of livelihoods for indigenous communities. Coastal and marine ecosystems are vital to fisheries, storm protection, and tourism but face threats from overexploitation and climate change. Similarly, cities, ports, and industrial areas embody human-induced transformations, demanding NbS that bridge ecological restoration and urban resilience.

Complexity and Integration in Southeast Asia

In Southeast Asia, applying these NbS typologies is particularly challenging due to complex land-use pressures, high population density, and significant climate vulnerabilities. Although this first effort of categorisation poses the bases of the understanding of NbS types globally, it doesn't address all specific biophysical conditions and land use categories adding pressure on ecosystems within socio-cultural conditions observed in ASEAN Member States.

Recent meetings and discussions with regional partners (IUCN, ADB, WWF, UNDRR) have highlighted the importance of the understanding of local landscape and climate conditions in Southeast Asia, the higher potential of NbS projects when implemented in synergy with other NbS and the need to scale-up NbS to reach more sustainable results on climate adaptation and mitigation, disaster risk reduction, renaturation and restoration of ecosystems and biodiversity in the long term.

The missions on site and meetings with regional, national and sub-national stakeholders have inspired us to elaborate a socio-economic and biophysical landscape-based approach of CMM and Eco-DRR to reach a sustainable approach of NbS implementation in Southeast Asia, rather than starting from the 'technical solution's perspective'.

2. Introduction to NbS Typologies

Through extensive characterisation efforts, we define Nature-based Solutions (NbS) typologies as categories (or types of interventions) that use natural processes and ecosystems to address societal challenges, such as climate change, disaster risk reduction, food security, and biodiversity conservation, following the IUCN definition presented in previous report. These NbS typologies are being addressed in the context of Southeast Asia and are based on the scale, ecological context, and specific objectives of the interventions.

Our effort of contextualisation in ASEAN State Members have led to the elaboration of characterised "Landscape Categories" where Climate Adaptation & Mitigation, Disaster Risk Reduction and all Ecosystem-based Approaches can be best applied through NbS in synergy with local communities, natural environments, coordinate land governance and existing land use systems.

We identify the following eight (8) NbS Typologies which address the NbS attributes and societal challenges in the context of Southeast Asia, described earlier and discussed in Report #01:

1. Ecosystem Restoration and Conservation
2. Sustainable Management of Ecosystems
3. Green Infrastructure in Urban, Industrial and Semi-Rural Areas
4. Climate-Resilient Landscapes and Seascapes
5. Ecosystem-Based Disaster Risk Reduction (Eco-DRR)
6. Nature-Based Agricultural Systems
7. Hybrid Solutions (Nature + Technology)
8. Community-Based NbS

1. Ecosystem Restoration and Conservation

Restoring degraded ecosystems like mangroves, coral reefs, forests, and peatlands is essential in Southeast Asia, given the region's high biodiversity and vulnerability to natural disasters. Conservation efforts often blend with traditional ecological knowledge and local stewardship, crucial for managing these ecosystems sustainably.

Main Landscape Categories addressed: Healthy forests, Regenerative Marine Habitats, Muddy and Sandy Coasts, Flood-resilient Riverine Landscapes, Wildlife Corridors

2. Sustainable Management of Ecosystems

Southeast Asia's rich biodiversity supports vital ecosystems like rice terraces, tropical forests, and marine habitats. Integrating sustainable practices such as agroforestry or community-managed fisheries aligns with traditional farming and fishing practices while supporting livelihoods and reducing overexploitation.

Main Landscape Categories addressed: Healthy forests, Regenerative Marine Habitats, Regenerative Agriculture, Muddy and Sandy Coasts, Flood-resilient Riverine Landscapes, Wildlife Corridors

3. Green Infrastructure in Urban, Industrial and Semi-Rural Areas

Rapid urbanisation in Southeast Asian cities like Jakarta, Bangkok, and Manila exacerbates flooding, heat islands, and pollution. Green infrastructure such as vertical gardens, urban wetlands, and tree-lined streets offers culturally appropriate, low-cost solutions to mitigate these issues while enhancing public spaces.

Main Landscape Categories addressed: Climate-smart and Resilient Cities, Green & Blue Eco-Industrial Areas and Ports

4. Climate-Resilient Landscapes and Seascapes

The region's coastlines, deltas, and uplands require integrated approaches to address flooding, erosion, and water scarcity. Efforts like sustainable watershed management in the Mekong Delta and coral reef restoration in the Philippines promote resilience while supporting fisheries, agriculture, and tourism.

Main Landscape Categories addressed: Flood-resilient Riverine Landscapes, Healthy forests, Regenerative Marine Habitats, Regenerative Agriculture, Muddy and Sandy Coasts

5. Ecosystem-Based Disaster Risk Reduction (Eco-DRR)

With frequent typhoons, landslides, and floods, Southeast Asia can greatly benefit from Eco-DRR. Examples include mangroves in Vietnam to buffer storm surges, reforestation on Philippine uplands to stabilise soils, and restoring natural floodplains in Thailand for water retention.

Main Landscape Categories addressed: Flood-resilient Riverine Landscapes, Wildlife Corridors Healthy forests, Muddy and Sandy Coasts, Climate-smart and Resilient Cities

6. Nature-Based Agricultural Systems

Agriculture dominates much of Southeast Asia's landscapes, with rice paddies, plantations, and smallholder farms. Nature-based practices like agroforestry, integrated pest management, and organic farming improve soil health and reduce vulnerability to droughts, pests, and shifting rainfall patterns.

Main Landscape Categories addressed: Regenerative Agriculture, Muddy and Sandy Coasts, Healthy forests, Flood-resilient Riverine Landscapes

7. Hybrid Solutions (Nature + Technology)

Southeast Asia's dense populations and economic development demand hybrid solutions. Examples include combining mangrove planting with seawalls in Jakarta, using constructed wetlands for wastewater treatment in Cambodia, and integrating urban parks with drainage systems in Singapore.

Main Landscape Categories addressed: Climate-smart and Resilient Cities, Green & Blue Eco-Industrial Areas and Ports

8. Community-Based NbS

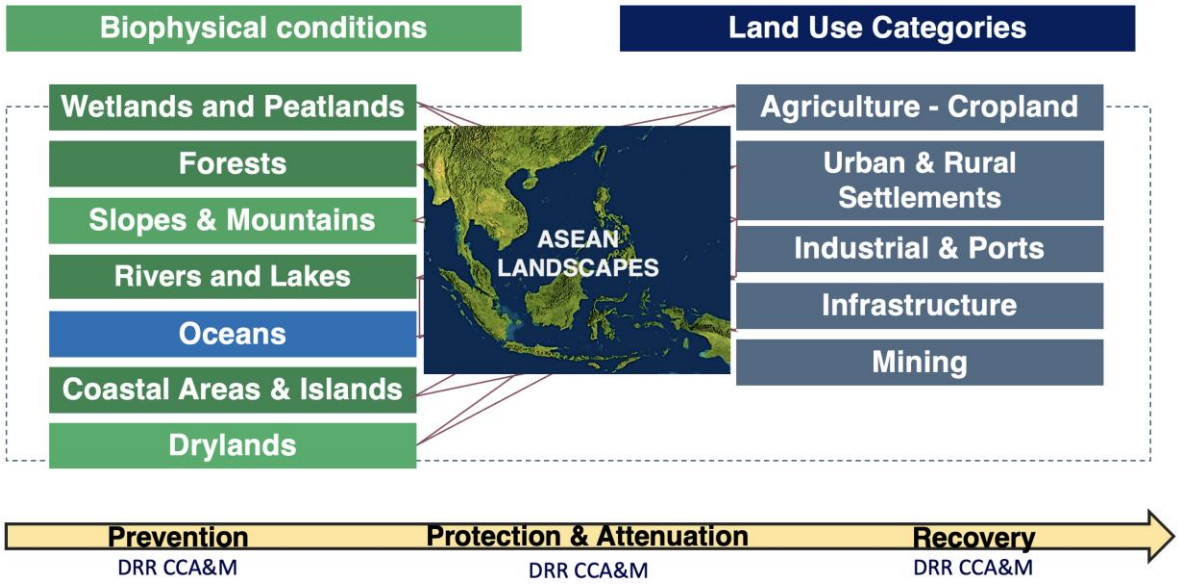
Local communities in Southeast Asia have deep cultural connections to nature. Community-led projects, such as mangrove replanting in Indonesia or participatory watershed management in Laos, integrate indigenous knowledge and ensure equitable benefits, enhancing both social and ecological resilience.

Main Landscape Categories addressed: Muddy and Sandy Coasts, Regenerative Agriculture, Healthy forests, Flood-resilient Riverine Landscapes.

3. Characterisation of Nature-based Solutions in Synergy per Landscape Category

Nine categories of landscapes and seascapes in ASEAN countries have been identified as holistic landscape profiles where multiple NbS and their ecosystem-based approaches can be planned, implemented and scaled up in synergy to let emerge climate-sensitive and resilient regions. Based on the characterisation of biophysical conditions and land use categories in Southeast Asia, a spatial and geomorphological analysis of ASEAN countries in relation with land use systems provides a better visibility on climate, ecosystems and human activity interact.

Figure 4. Biophysical Conditions and Land Use Categories affecting to ASEAN Region



Our first phase of observation has brought in parallel the footprint of biophysical conditions (natural ecosystems) and the footprint of land use systems (and related human activity), in relation with climatic / non-climatic natural disaster risks and human-induced disaster risks. The capacity of resilience of terrestrial or marine ecosystem, urban and rural settlements or industrial sites to climate events largely depends on the spatial coherence of land use and symbiosis between natural ecosystems and local communities. Geomorphological features (rivers, deltas, forests, valleys, natural harbours and accessibility, existing natural resources, etc.) are often at the origin of concentration of human settlements, which paradoxically threaten local sustainability of local ecosystems which provide essential resources.

In this context, we have prioritised the opportunity of synergising NbS in characterised landscapes illustrating best the ecological, socio-economic and cultural dimensions of Indonesia, the Philippines, Laos, Cambodia, Vietnam, Thailand and to some extent the four other ASEAN countries.

We distinguish those 9 climate-sensitive landscapes in 3 groups:

Group 01: Riverine and Coastal Ecosystems

The first group refers to terrestrial ecosystems located along rivers, deltas and lakes and along humid and dry coasts and shorelines, where local communities and major parts of the economy have a strong relation to water and require holistic water-sensitive approaches, and a large-scale understanding of geomorphological conditions and topography.

Water-sensitive ecosystem-based approaches are crucial for enhancing climate resilience in riverine and coastal ecosystems, as they help manage flood risks, protect biodiversity, and support sustainable livelihoods for communities dependent on these water-rich areas. By aligning human

activities with natural water cycles and geomorphological features, these approaches reduce vulnerabilities to climate impacts like flooding, erosion, and sea-level rise, while fostering ecosystem health and resilience.

CSL01 – Flood responsive Riverine and Deltaic (Including Dry River) Landscapes

CSL02 – Adaptative Sandy Shorelines

CSL03 – Adaptative Coastal Mangroves

Group 02: Intensive Land Use Systems – Anthromes

The second group of landscape categories refers to human-altered landscapes where intensive activities, such as agriculture, urbanisation, and industrial development, significantly shape the terrestrial and marine environments. These systems represent anthropogenic biomes (anthromes) with high-density human presence and infrastructure, leading to substantial ecological impacts, including habitat loss, biodiversity decline, and altered natural processes. This group of landscapes captures the extensive human footprint, highlighting the pressures exerted on ecosystems and the need for sustainable management to mitigate environmental degradation.

CSL04 – Climate-smart and Resilient Cities

CSL05 – Green & Blue Eco-Industrial Areas and Ports

CSL06 – Regenerative Agriculture

Group 03: Terrestrial and Marine Ecosystems

The third group encompasses landscapes and seascapes that play a critical role in climate resilience, biodiversity conservation, and sustainable livelihoods. Terrestrial and marine ecosystems in Southeast Asia are diverse natural landscapes and seascapes, including forests, rivers, coral reefs, and mangroves, that support rich biodiversity, provide essential ecosystem services, and contribute to climate resilience and the livelihoods of local communities. Efforts in these landscapes focus on preserving and restoring natural systems to withstand climate impacts, promote ecological regeneration, and support local economies reliant on ecosystem services.

CSL07 – Healthy Forests and Natural Habitats

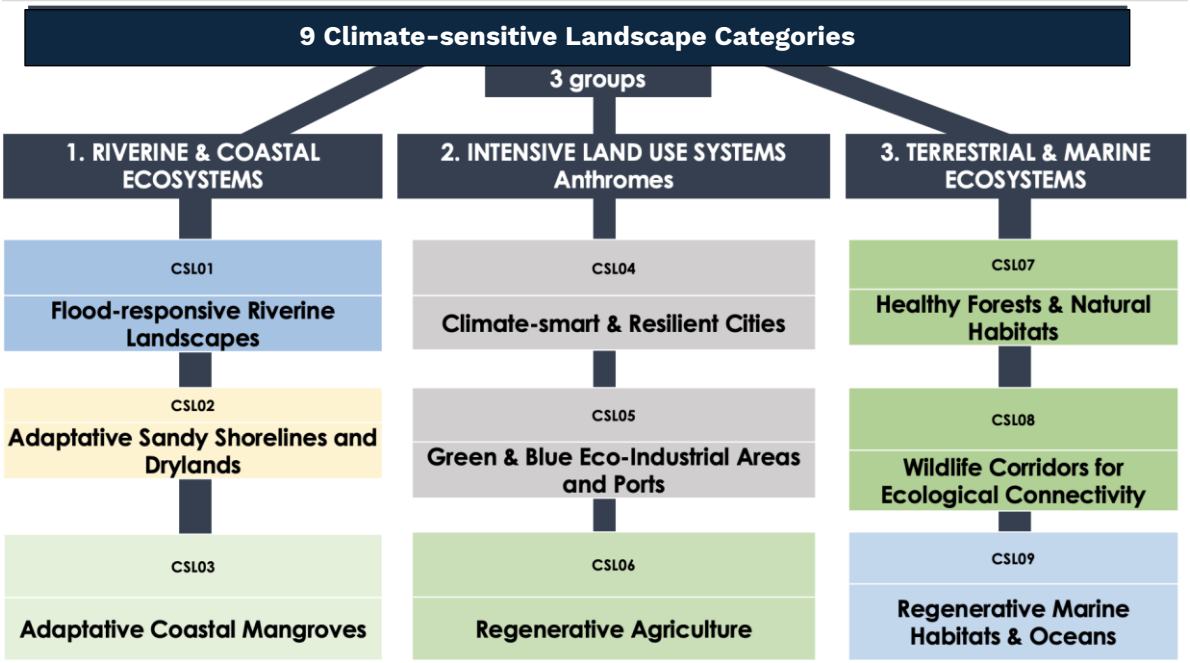
CSL08 – Wildlife Corridors for Ecological Connectivity

CSL09 – Regenerative Seascapes and Marine Habitats

Each landscape category can be identified in almost every ASEAN country and some of them require transboundary approaches, such as the ‘flood-responsive riverine landscapes’ which highlight the importance of planning climate resilience along river sheds and the opportunity to scale-up and synergise nature-based solutions for territorial resilience in the longer term.

The nine landscape categories are presented hereafter with 135 locations, case studies and project references in Southeast Asia which apply to the characteristics of those climate-sensitive landscapes.

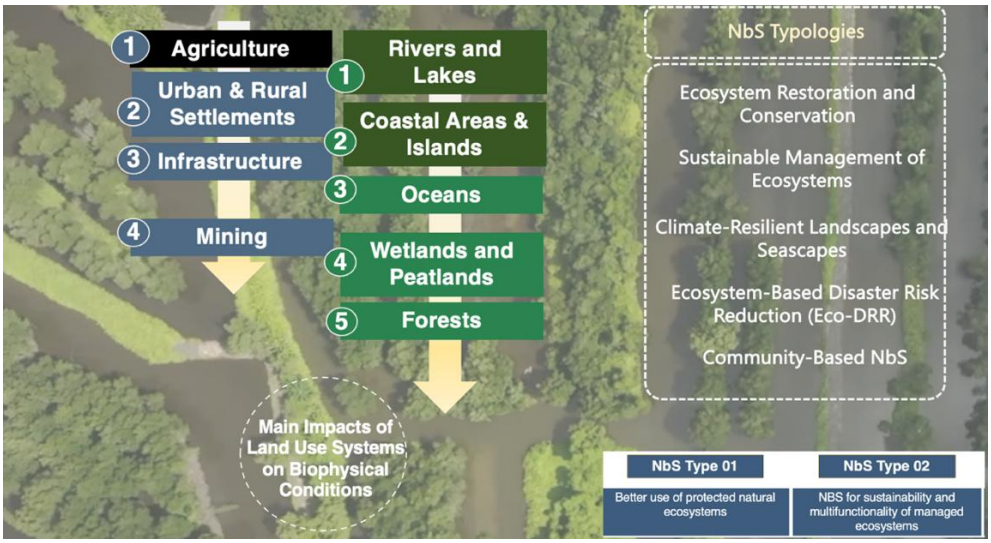
Figure 5. Nine Climate-Sensitive Landscape Categories



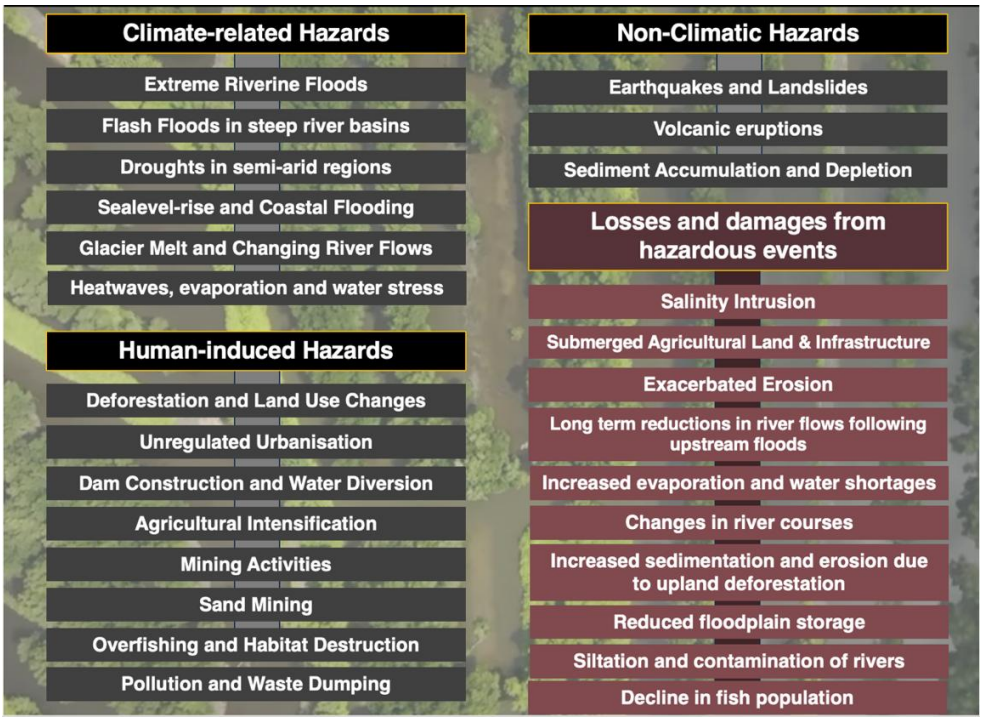
CSL01 – Flood responsive Riverine and Deltaic (Including Dry River) Landscapes

"Flood-responsive Riverine Landscapes" can be defined as interconnected territories, ecosystems, and land use areas along rivers, deltas, and lakes where communities have adapted to life with water, relying on it for resources, agriculture, and livelihoods. As climate events like floods and droughts intensify, these landscapes demand resilient strategies that safeguard biodiversity, local economies, and human well-being. Ecosystem-based approaches and nature-based solutions (NbS), such as floodplain restoration, wetland conservation, and sustainable water management, are essential in these areas to enhance natural flood defences, maintain ecosystem services, and promote long-term resilience.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Riverine Landscapes

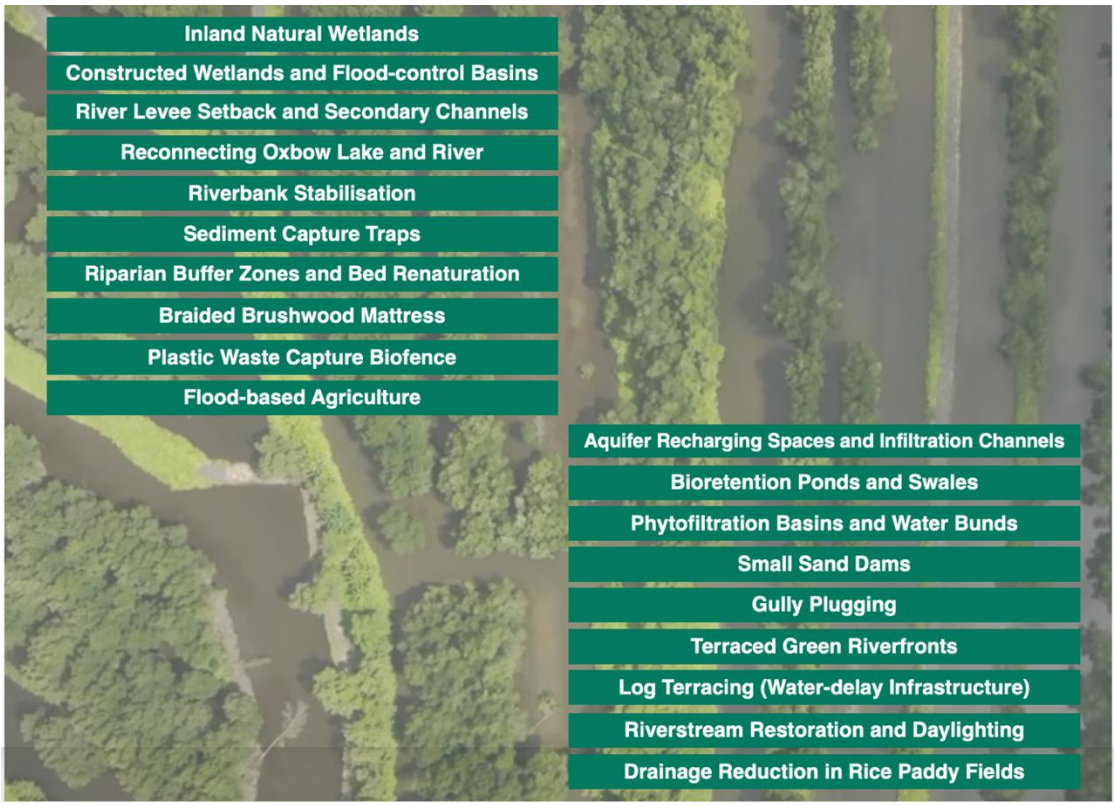


2 – Main Disaster Risks and Related Damages in Riverine Landscapes



3 – Ecosystem Services in Riverine Landscapes

4 – NbS Supporting Flood Responsive Riverine Landscapes



Flood-responsive riverine landscapes in Southeast Asia are a vital approach for maintaining ecological balance, supporting agriculture, mitigating the effects of climate change, and fostering resilience in flood-prone communities. The climatic, biophysical, and socio-economic characteristics of ASEAN countries — such as monsoonal rainfall, riverine flooding, saline intrusion in deltas, and high population densities in flood-prone areas require an integrated approach to landscape management along rivers and water bodies. A holistic analysis of flood frequencies, flow velocities, sediment and nutrient dynamics, and the changing salinity of water bodies that shape both natural ecosystems and human livelihoods promotes a scalable, synergetic approach of Nature-based Solutions in contexts shaped by complexity.

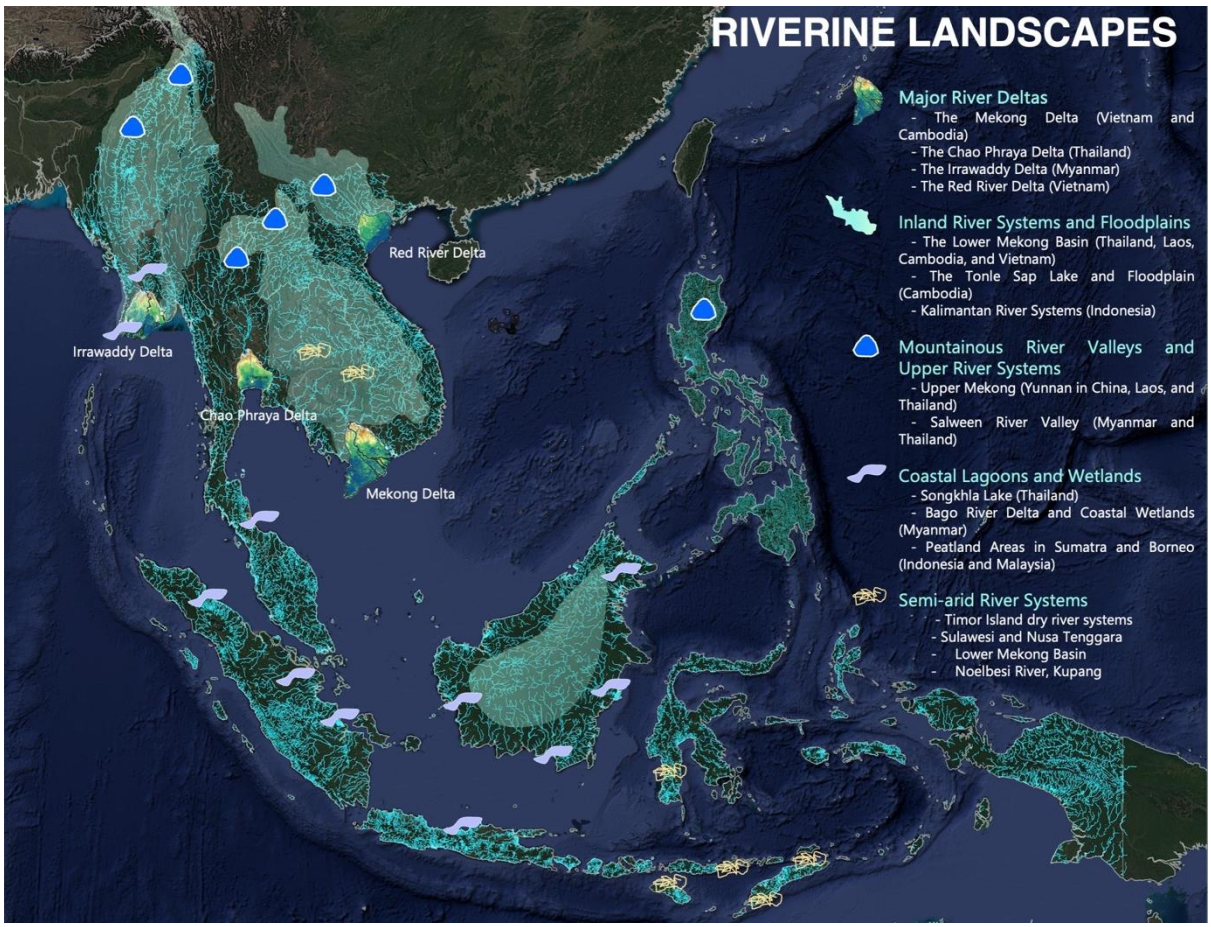
In Southeast Asia's humid riverine areas, restoring riparian forests and wetlands reduces erosion, stabilises riverbanks, and provides natural floodwater storage, protecting downstream communities during monsoon floods. Seasonal floodplains can be managed to retain water, replenishing aquifers while supporting local fisheries and agriculture. In drier riverine zones, check dams and re-vegetation efforts prevent sedimentation and enhance water retention in degraded riverbeds, ensuring water availability during droughts.

- In the Mekong Delta, where frequent flooding, saline intrusion, and land subsidence are major concerns, the restoration of inland natural wetlands and constructed wetlands can mitigate flood impacts while supporting biodiversity and fisheries. Similarly, river levee setbacks and reconnecting oxbow lakes with rivers can restore natural river dynamics, enhance sediment transport, and improve water quality. These measures reduce the pressure on riverbanks by preventing erosion and creating additional floodplain storage areas.
- In the context of flood-based agriculture, NbS such as floodplain farming techniques, riparian sylviculture (forest management along riverbanks), and small sand dams on dry rivers promote a more sustainable approach to farming. This regenerative agriculture enhances soil fertility, reduces erosion, and helps communities adapt to shifting flood patterns. The use of phytofiltration basins, water bunds, and sediment capture traps also ensures that excess nutrients and pollutants are filtered out before they reach critical water bodies, preventing downstream contamination.

- The implementation of riparian buffer zones, braided brushwood mattresses, and log terracing as water-delay infrastructure further protects vulnerable landscapes from erosion and sediment loss, improving water retention and mitigating the effects of extreme flooding. In regions where waste management is a challenge, solutions like plastic waste capture biofences can help reduce pollution while enhancing flood resilience by stabilising riverbanks.
- Aquifer recharging spaces and devices, bioretention ponds, and swales can help manage both floodwater and freshwater resources, ensuring the availability of water during dry periods. By incorporating both freshwater and saltwater flows into the landscape management strategy, we can create adaptive solutions for saline-prone areas and support the livelihoods of communities engaged in both agriculture and aquaculture.
- Agroforestry buffer zones along riverbanks reduce runoff, improve soil fertility, and blend sustainable agriculture with flood prevention. These NbS work in synergy to balance water retention, sediment transport, and flood mitigation, fostering regenerative landscapes and sustainable livelihoods.

Across Southeast Asia, riverine and delta landscapes are experiencing shifts in both natural processes and human-driven activities. The integration of these NbS along the Mekong, Chao Phraya, and Red River Deltas exemplifies the potential of using nature's own mechanisms to restore ecological balance while ensuring long-term sustainability.

5 – Mapping Riverine Landscapes in Southeast Asia



Flood responsive Dry Riverine Landscapes

In contrast, Dry River Landscapes, often found in interior and upland regions of Southeast Asia, are shaped by seasonal water scarcity, flash floods, and prolonged droughts. Communities in these semi-arid and drought-prone river basins, such as parts of northeastern Thailand and central Myanmar, have developed adaptive practices like rainwater harvesting, drought-resilient agroforestry, and rotational grazing. However, increasing climate variability is exacerbating water stress, land degradation, and biodiversity loss. To address these challenges, NbS approaches such as reforestation of degraded watersheds, restoration of seasonal wetlands, and sustainable soil and water conservation are vital. These interventions improve groundwater recharge, reduce erosion, and support climate-resilient agriculture and livelihoods, helping local communities withstand periods of both drought and intense rainfall.

We have identified and located four sub-categories of riverine and deltaic landscapes in Southeast Asia:

1. **Major River Deltas**
   - The Mekong Delta (Vietnam and Cambodia): A critical agricultural hub, especially for rice, the Mekong Delta faces seasonal flooding, land subsidence, and saltwater intrusion. Prolonged droughts also impact water availability, affecting farming and aquaculture.
   - The Chao Phraya Delta (Thailand): Located near Bangkok, this delta is prone to seasonal flooding and saltwater intrusion, especially in coastal areas. Urbanisation and upstream dam construction increase the area's vulnerability.
   - The Irrawaddy Delta (Myanmar): Known for rice production, this delta experiences seasonal flooding, periodic cyclones, and saltwater intrusion due to tidal changes and rising sea levels.
   - The Red River Delta (Vietnam): This highly populated region near Hanoi faces regular flooding from the Red River, exacerbated by increased urbanisation and industrialisation. Saltwater intrusion is also a concern, impacting agriculture.

2. **Inland River Systems and Floodplains**
   - The Lower Mekong Basin (Thailand, Laos, Cambodia, and Vietnam): This vast basin, essential for fisheries and agriculture, is prone to extreme seasonal flooding and occasional droughts, often tied to fluctuating monsoon patterns and dam regulation.
   - The Tonle Sap Lake and Floodplain (Cambodia): Tonle Sap, Southeast Asia’s largest freshwater lake, undergoes an annual flooding cycle that supports rich biodiversity. However, dam construction upstream and climate variability have disrupted its seasonal patterns, affecting fisheries and local livelihoods.
   - Kalimantan River Systems (Indonesia): Rivers like the Kapuas in West Kalimantan are affected by seasonal flooding, often aggravated by deforestation and land degradation, which also impacts the biodiversity-rich peatland ecosystems.

3. **Mountainous River Valleys and Upper River Systems**
   - Upper Mekong (Yunnan in China, Laos, and Thailand): These areas experience periodic floods and droughts due to both upstream water management and climate variability. The region’s hilly terrain increases the risk of landslides and flash floods during the rainy season.
   - Salween River Valley (Myanmar and Thailand): Known for its biodiversity, the Salween River faces fluctuating water levels due to seasonal rains, which can lead to floods and landslides in nearby communities.

4. Coastal Lagoons and Wetlands

- Songkhla Lake (Thailand): This coastal lagoon in Southern Thailand faces flooding and saltwater intrusion, affecting its fishing and agricultural communities.
- Bago River Delta and Coastal Wetlands (Myanmar): This area, near Yangon, includes vulnerable coastal wetlands and estuarine systems impacted by rising sea levels, storm surges, and seasonal flooding.
- Peatland Areas in Sumatra and Borneo (Indonesia and Malaysia): These peatlands are highly sensitive to droughts and can lead to severe flooding when degraded by human activity or fires, exacerbating soil erosion and saltwater intrusion in coastal areas.

5. Dry River Landscapes

- Mun–Chi River Basin (Northeastern Thailand): A semi-arid tributary of the Mekong, this basin faces long dry seasons, flash floods, and water stress due to upstream dams and land degradation. NbS like watershed reforestation and drought-resilient agroforestry help improve water retention and soil health.
- Dry Zone of Central Myanmar (Ayeyarwady Basin): One of Southeast Asia's most drought-prone areas, marked by erratic rainfall, deforestation, and soil erosion. Reforestation, rainwater harvesting, and climate-smart agriculture are key NbS strategies here.
- Sekong–Sesan–Srepok (3S) Basin (Cambodia, Laos, Vietnam): Increasingly seasonal flows and watershed degradation threaten water supply, fisheries, and livelihoods. Riparian restoration and wetland rehabilitation support ecological resilience and local economies.
- Barito River Basin (Kalimantan, Indonesia): A river system affected by peatland drainage and dry-season water shortages, with rising fire and subsidence risks. NbS include peatland rewetting, canal blocking, and community-based agroforestry

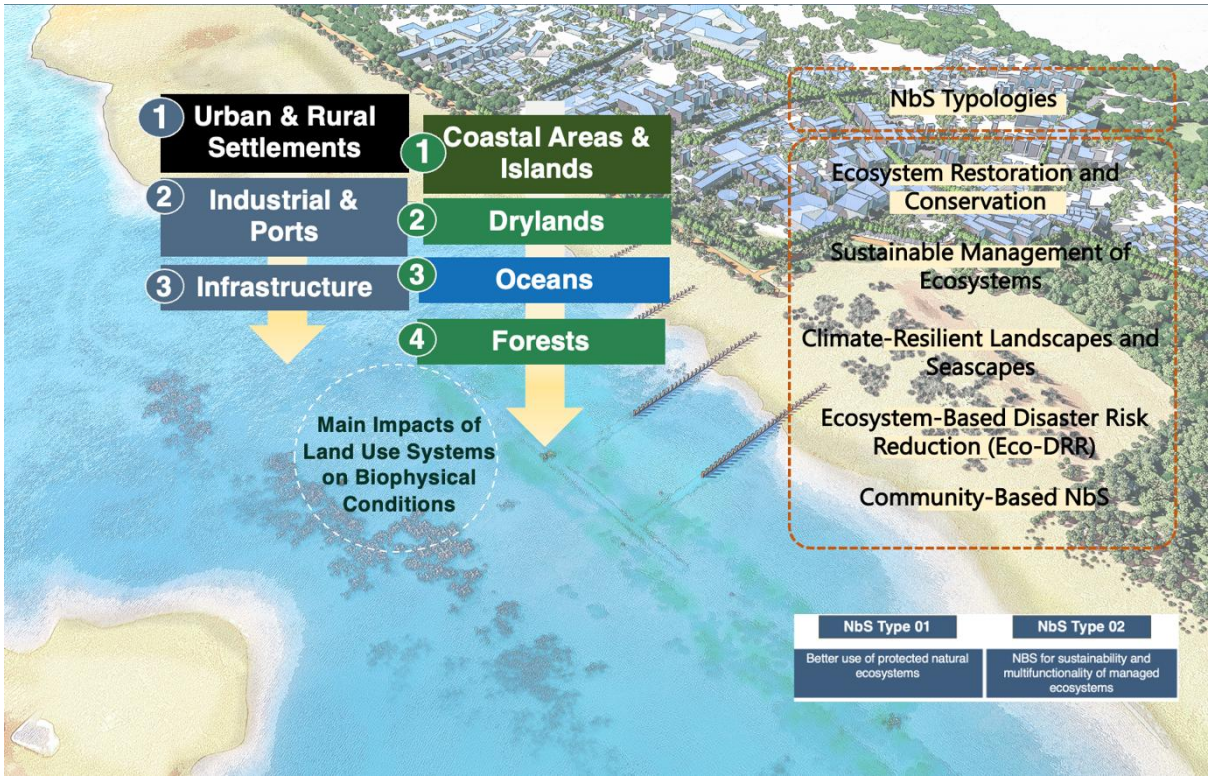
NbS practices in Flood-responsive Riverine Areas	
Technical Attributes	Establishes vegetated buffers along rivers to control erosion, filter pollutants, and provide wildlife habitat. It also reconnects rivers to natural floodplains where feasible to reduce flood risks.
Environmental Attributes	Enhances water quality, supports biodiversity, and provides natural flood management by slowing and storing floodwaters.
Project Management Attributes	Involves multisectoral management, including water, land use, and agriculture agencies, and requires long-term monitoring and community awareness programs.
Effectiveness for EbA and Eco-DRR	Highly effective in flood-prone areas, as buffer zones reduce flood intensity, protect communities from erosion, and improve water quality, which contributes to ecosystem health.
Risk Analysis	Risks include encroachment by agriculture, inconsistent maintenance, and lack of upstream-downstream coordination. Clear zoning and community stewardship can address these challenges.
Alignment with IUCN Criteria	Well-aligned with IUCN's principles by providing significant ecosystem services, reducing flood risks, and integrating community engagement.

CSL02 – Adaptative Sandy Shorelines

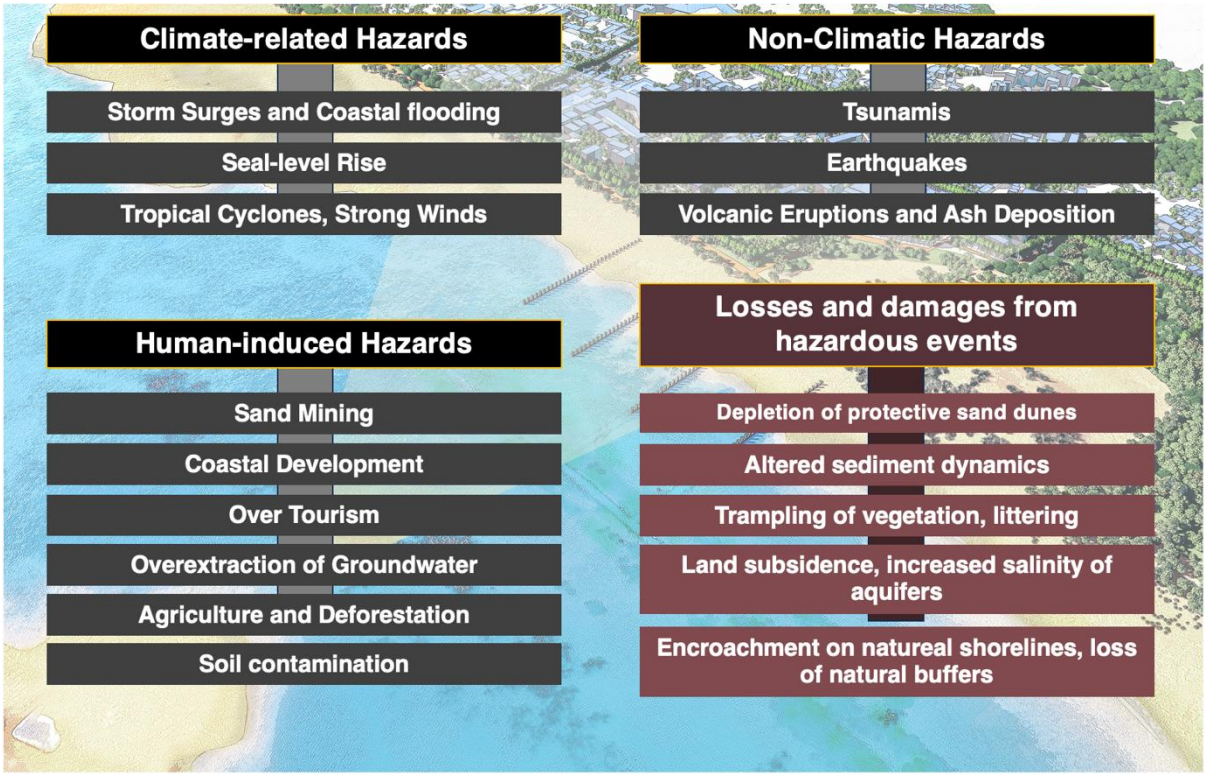
Sandy Shorelines and arid coastal territories and ecosystems, despite their high potential for tourism development, face increasing risks from climate impacts like drought, water scarcity, typhoons, strong winds, and coastal erosion. These areas are also threatened by human-induced pressures, including plastic pollution and loss of biodiversity in coastal and marine habitats.

Adaptative sandy shorelines refer to resilient dry coastlines such as the sandy shorelines of Ilocos Norte (The Philippines) where coastal resilience has been supported by dune restoration and coastal vegetation planting to combat erosion, enhance resilience to typhoons, and support eco-tourism. Similarly, Thailand's Koh Samet island and its waste management programs and coral restoration projects address plastic pollution and protect marine biodiversity, fostering sustainable tourism while preserving the natural coastline.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Sandy Shorelines and Drylands

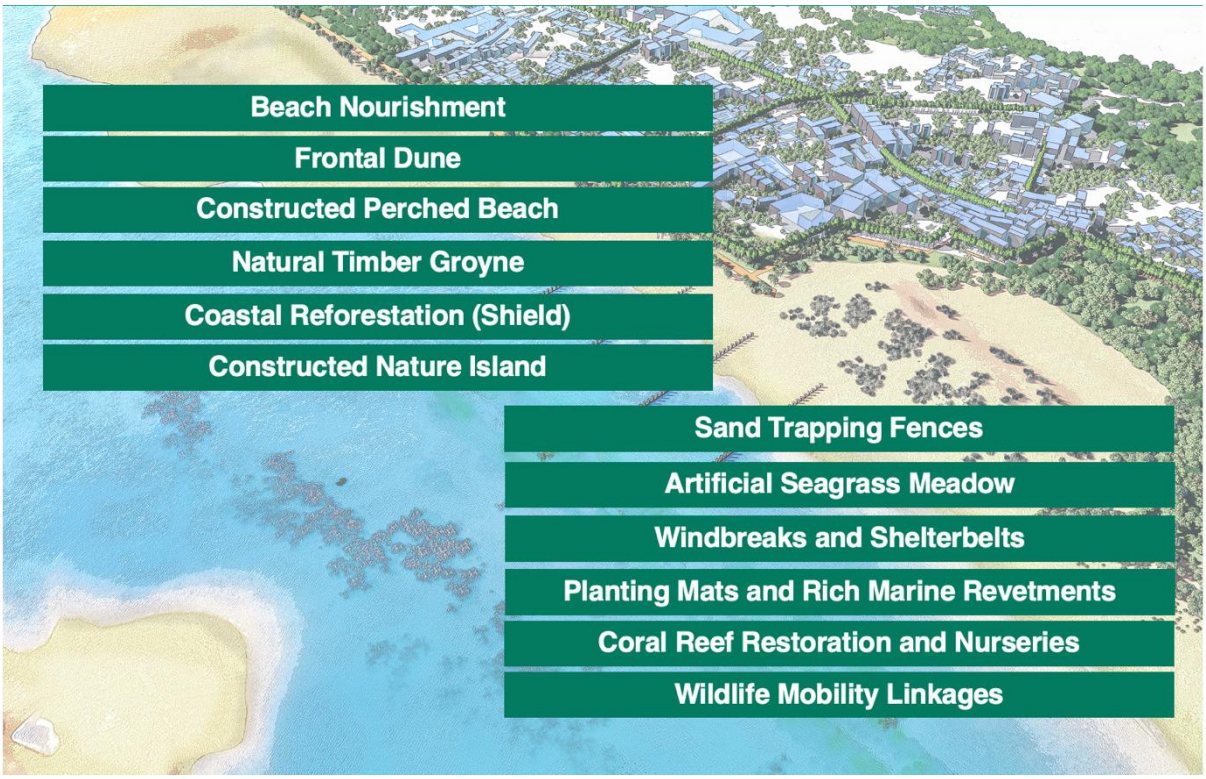


2 – Main Disaster Risks and Related Damages in Sandy Shorelines and Drylands



3 – Ecosystem Services in Sandy Shorelines and Drylands

4 – NbS Supporting Sandy Shorelines



Sandy coastlines face numerous challenges from coastal erosion, storm surges, and rising sea levels, all of which threaten local ecosystems, infrastructure, and livelihoods. A holistic approach to managing these landscapes is essential, integrating multiple Nature-Based Solutions (NbS) that address both the natural dynamics of sandy shores and the socio-economic needs of coastal communities.

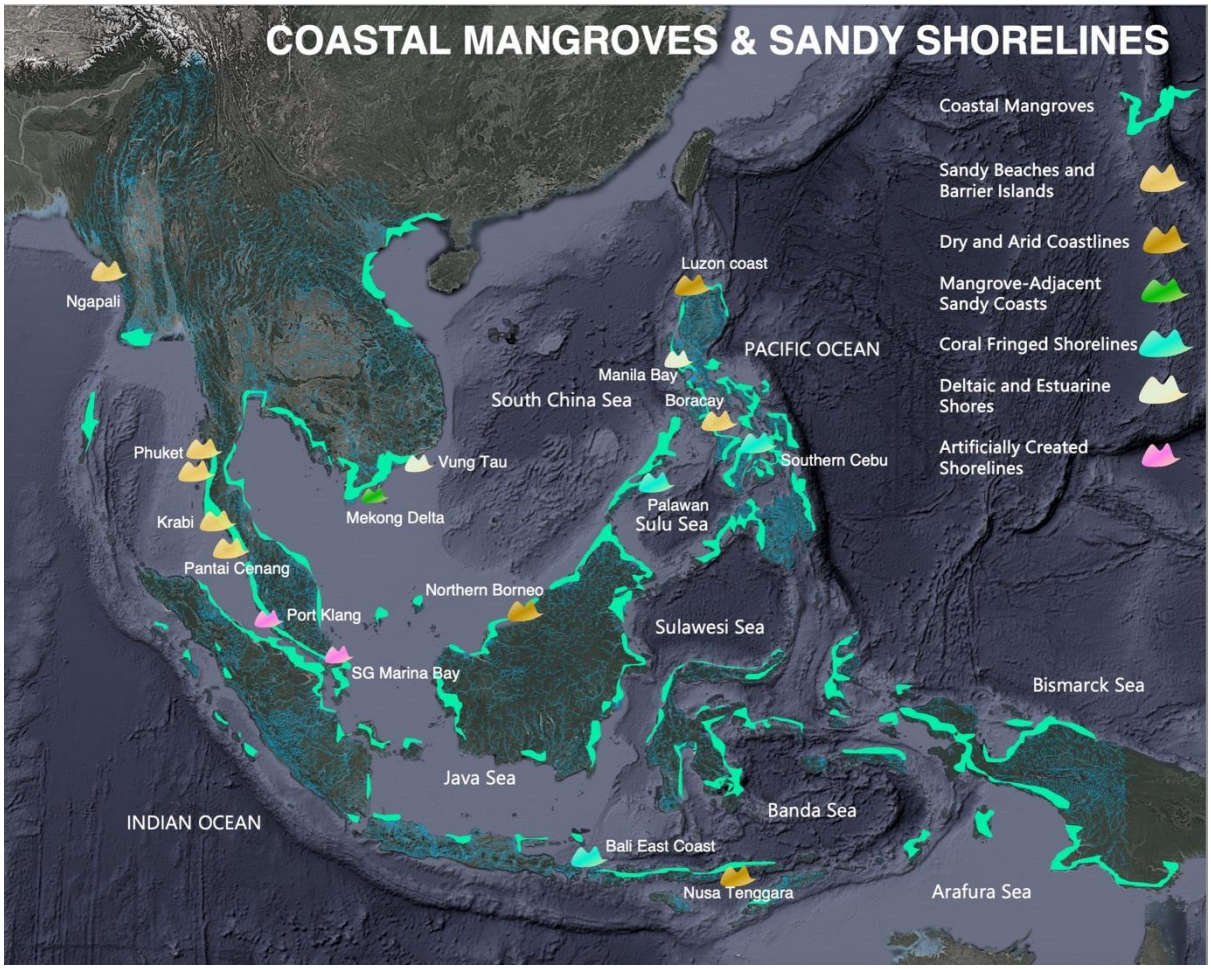
The approach presented in the NbS catalogue takes into account seasonal monsoons, tropical cyclones, and the delicate balance between marine and terrestrial ecosystems. By focusing on synergies between these NbS, the goal is to enhance coastal resilience, protect biodiversity, and support sustainable coastal livelihoods.

In Southeast Asia, sandy coastlines are protected and enhanced through a combination of natural and engineered solutions.

- Coral reef restoration and the establishment of coral nurseries help reduce wave energy before it reaches the shore, safeguarding beaches and infrastructure from storm surges and erosion. This is complemented by the restoration of seagrass meadows, which stabilise sediments and enhance marine biodiversity.
- Coastal reforestation, particularly with species like casuarina and pandanus, provides additional windbreaks and stabilises dunes, mitigating the effects of coastal erosion. Windbreaks and shelterbelts, along with sand trapping fences, further protect dune dynamics and improve the resilience of coastal ecosystems.
- Beach nourishment and tidal flat nourishment are key strategies for replenishing eroded beaches and strengthening the shoreline.
- Constructed perched beaches and natural timber groynes help manage sediment flow and reduce wave energy, preventing further erosion.
- For more vulnerable areas, artificial floating reefs and nature islands serve as barriers to mitigate wave energy and support marine life. The integration of sustainable tourism practices ensures that these natural defences are respected and preserved, providing economic opportunities while maintaining the integrity of fragile sandy ecosystems.

These NbS, working in synergy, address not only the immediate needs of coastal protection and erosion control but also contribute to long-term biodiversity conservation and risk management, including the mitigation of tsunami impacts. The collective effort of restoring and protecting sandy coastlines is crucial to maintaining the ecological and economic functions of these coastal zones, enhancing the resilience of Southeast Asia's coastal communities and ecosystems.
Examples from coastal areas such as the beaches of Phu Quoc and the Mekong Delta in Vietnam, the coastal regions of Palawan and Bohol in the Philippines, and the sandy shores of Bali and Lombok in Indonesia highlight the need for such Nature-Based Solutions. These locations are particularly vulnerable to coastal erosion and the impacts of climate change, where the implementation of NbS can strengthen coastal resilience, protect biodiversity, and safeguard local communities from the growing threats of storm surges, rising sea levels, and erosion.

5 – Mapping Sandy Shorelines (and Coastal Mangroves) in Southeast Asia



We have identified and located six sub-categories and 14 locations of sandy shorelines and arid coasts in Southeast Asia:

1. **Sandy Beaches and Barrier Islands**
   - Phuket and Krabi (Thailand): Both coastal areas face erosion and pollution pressures from development, as well as potential storm surges from typhoons in the Andaman Sea.
   - Ngapali Beach (Myanmar): This sandy beach is increasingly threatened by seasonal storms and erosion, alongside pollution and construction pressures.
   - Boracay Island (Philippines): Boracay faces erosion exacerbated by over-tourism, coastal developments, and typhoons, which can bring heavy winds and storm surges.

- Pantai Cenang (Langkawi, Malaysia): The sandy shoreline of Langkawi is prone to erosion due to natural forces and tourism-driven development.

2. Dry and Arid Coastlines

- Northern Borneo Coasts (Malaysia and Indonesia): Coastal regions in Sabah and East Kalimantan are arid and prone to erosion, worsened by mangrove deforestation, sand mining, and, in some areas, oil extraction, leading to ecological degradation.
- Coasts of Nusa Tenggara (Indonesia): Dry and rocky coasts of Nusa Tenggara experience strong winds, limited vegetation, and are susceptible to coastal erosion, worsened by climate change and human activities.
- Northern Luzon Coast (Philippines): The semi-arid coast of Northern Luzon, including areas like Pagudpud, faces significant erosion from seasonal typhoons, strong winds, and land-use changes.

3. Mangrove-Adjacent Sandy Coasts

- Mekong Delta Coastal Area (Vietnam): This coastline is a dynamic mix of sandy beaches and mangrove forests. It experiences severe erosion due to upstream sediment reduction and development pressures, as well as storm surges and salinisation.
- Sundarbans Coastline (Indonesia and Malaysia): Coastal regions in Sumatra and Borneo with sand and mangrove combinations are highly vulnerable to erosion from waves, typhoons, and pollution from aquaculture.

4. Coral Fringed Shorelines

- Southern Cebu and Palawan (Philippines): Coral reefs here help protect the sandy shores, but degradation from bleaching and pollution increases vulnerability to erosion and storm surges.
- Bali's East Coast (Indonesia): A mixture of sandy and coral-protected shores, this coastline is increasingly impacted by erosion as reefs degrade due to overfishing, tourism pressures, and warming waters.

5. Deltaic and Estuarine Shores

- Ho Tram and Vung Tau (Vietnam): Known for sandy beaches near estuarine systems, these areas are impacted by coastal erosion and typhoon-driven storm surges, especially as tourism increases.
- Manila Bay (Philippines): This heavily populated estuarine area suffers from severe pollution, coastal erosion, and occasional typhoon impacts, exacerbated by extensive urbanisation.

6. Artificially Created Shorelines and Reclaimed Areas

- Marina Bay (Singapore): Although heavily engineered, this reclaimed shoreline is exposed to strong winds and sea-level rise threats, managed with advanced sea walls and stormwater systems.
- Port Klang Area (Malaysia): Malaysia's largest port faces ongoing erosion and pollution from industrial activities, with reclamation projects altering the coastline's natural stability.

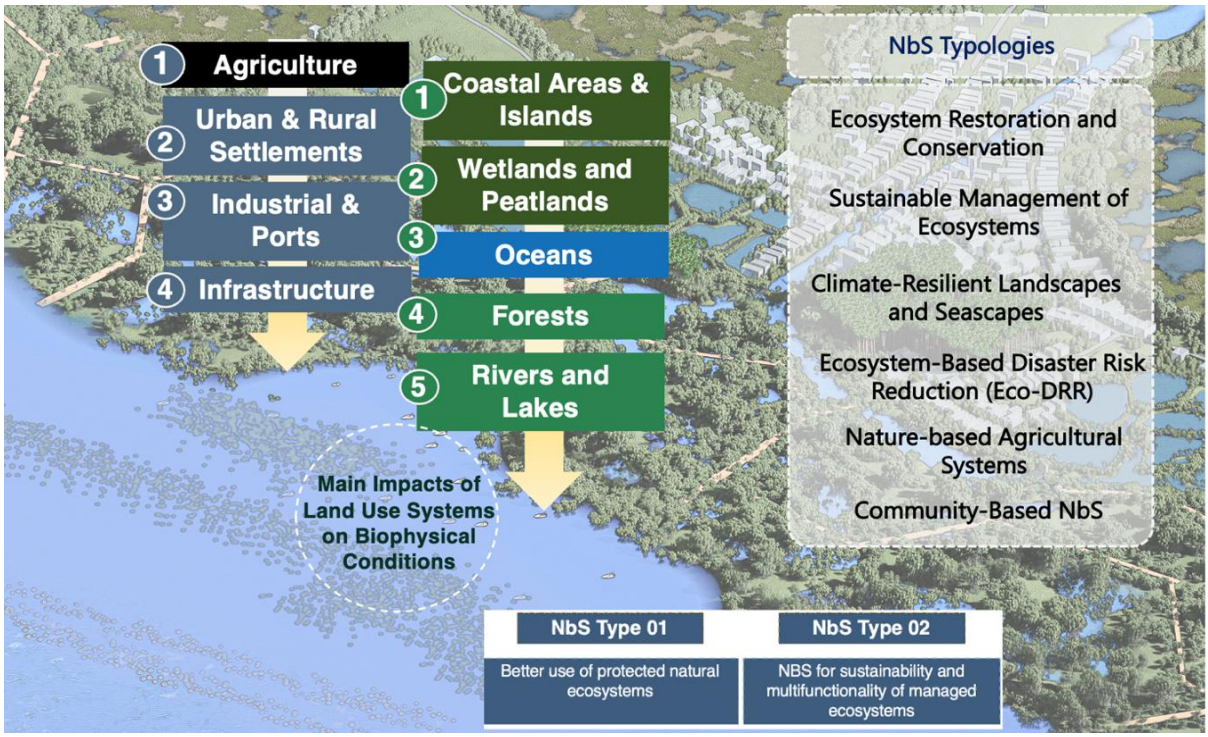
NbS practices in Sandy Coastlines	
Technical Attributes	Utilises drought-resistant native plants, rainwater harvesting, and soil conservation methods to stabilise degraded drylands and prevent desertification.
Environmental Attributes	Improves soil health, retains moisture, and supports biodiversity in arid and semi-arid areas.
Project Management Attributes	Involves community participation for planting and managing vegetation, along with training in sustainable grazing practices to avoid overexploitation.
Effectiveness for EbA and Eco-DRR	Effective in reducing soil erosion, enhancing drought resilience, and providing vegetation cover, which supports livestock and agricultural productivity.
Risk Analysis	Risks include overgrazing, insufficient funding, and loss of interest if benefits are not quickly realised. Long-term planning, incentives, and community-led management can address these issues.
Alignment with IUCN Criteria	Dryland restoration aligns well with IUCN's NbS framework, particularly in its focus on ecosystem services, community engagement, and drought resilience.

CSL03 – Adaptative Coastal Mangroves

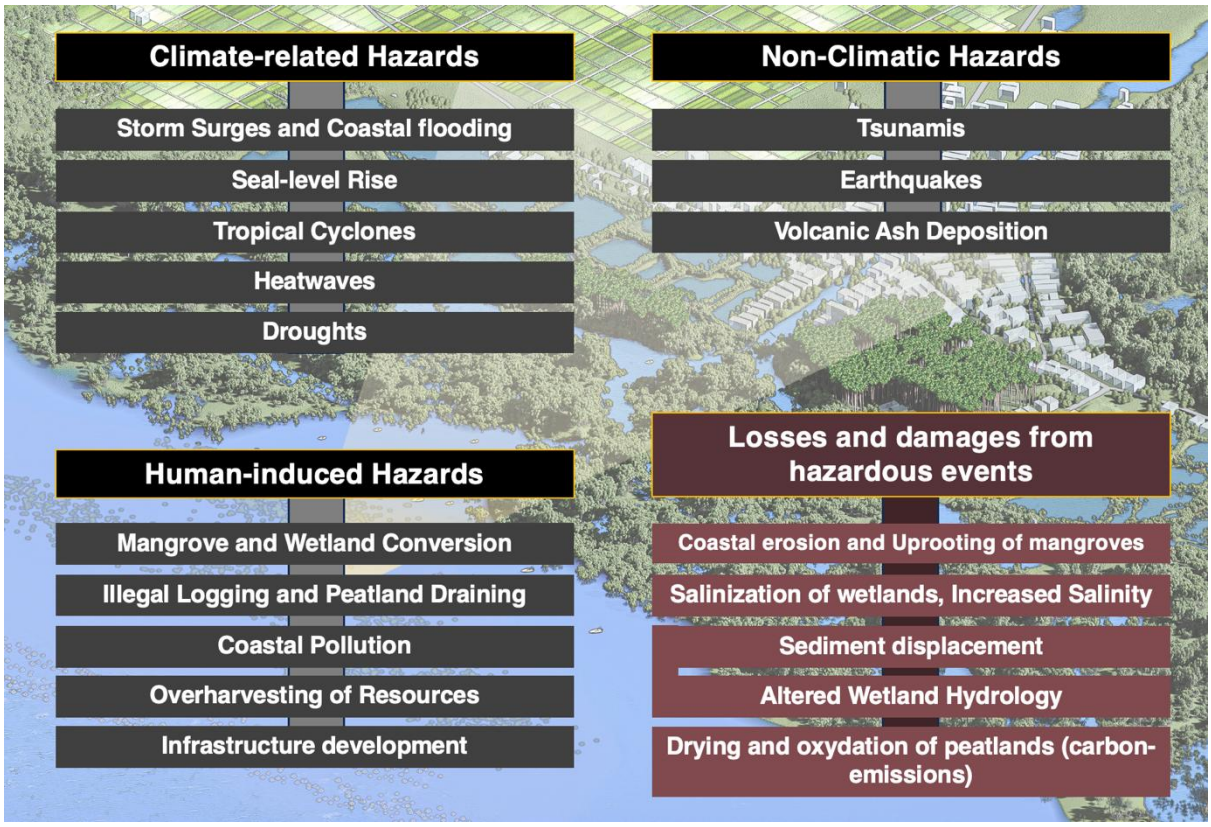
Coastal Mangroves in Southeast Asia refer to humid coastal ecosystems characterised by the presence of mangroves, wetlands, and peatlands, which play a vital role in maintaining biodiversity and supporting local communities. These landscapes are increasingly threatened by coastal erosion, tidal waves, plastic pollution, and the loss of marine and coastal biodiversity, exacerbated by climate change and human activities.

The coastal mangrove forests of Southeast Asia constitute muddy coastlines where dense mangrove ecosystems provide critical protection against storm surges and support rich biodiversity, yet face threats from coastal erosion and plastic pollution. The Peatlands of Central Kalimantan in Indonesia serve as vital carbon sinks and biodiversity hotspots but are increasingly vulnerable to land conversion and fire, necessitating restoration efforts to enhance resilience against climate impacts and preserve these crucial ecosystems.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Coastal Mangroves

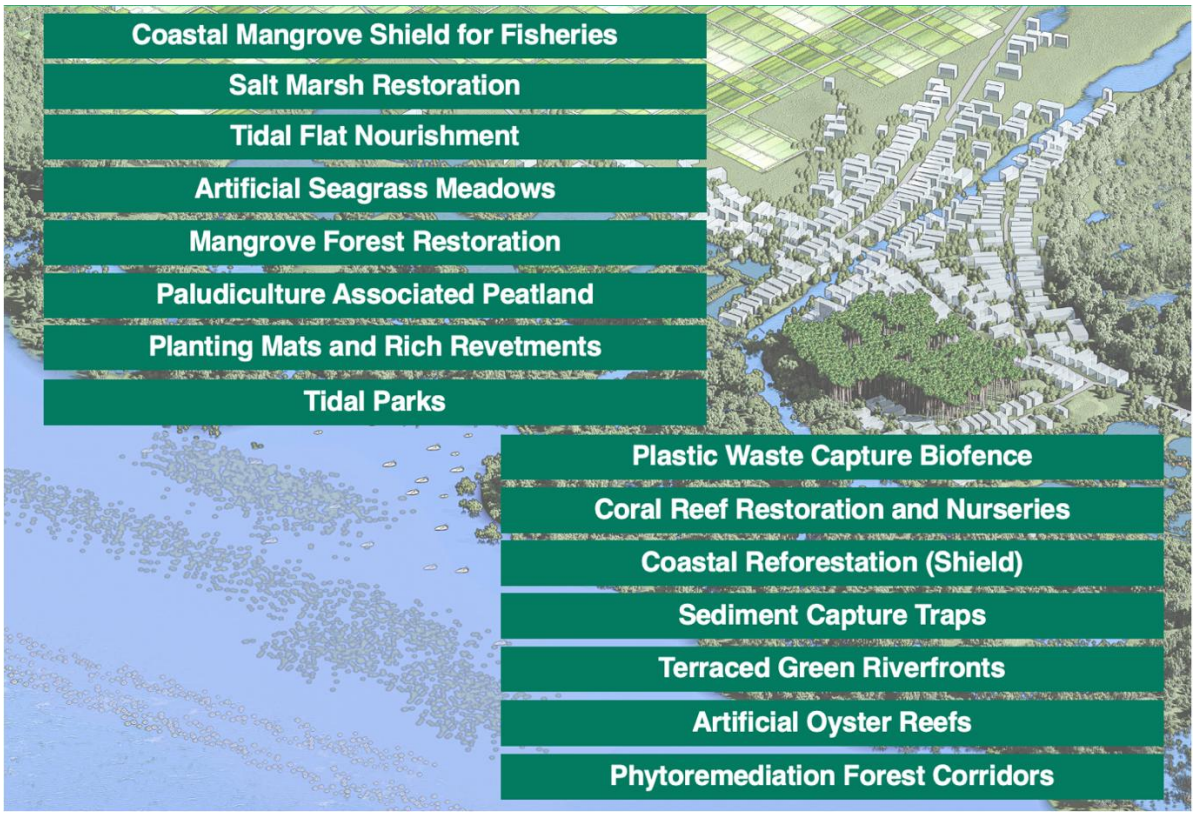


2 – Main Disaster Risks and Related Damages in Coastal Mangroves



3 – Ecosystem Services in Coastal Mangroves

4 – List of NbS Supporting Adaptative Coastal Mangroves

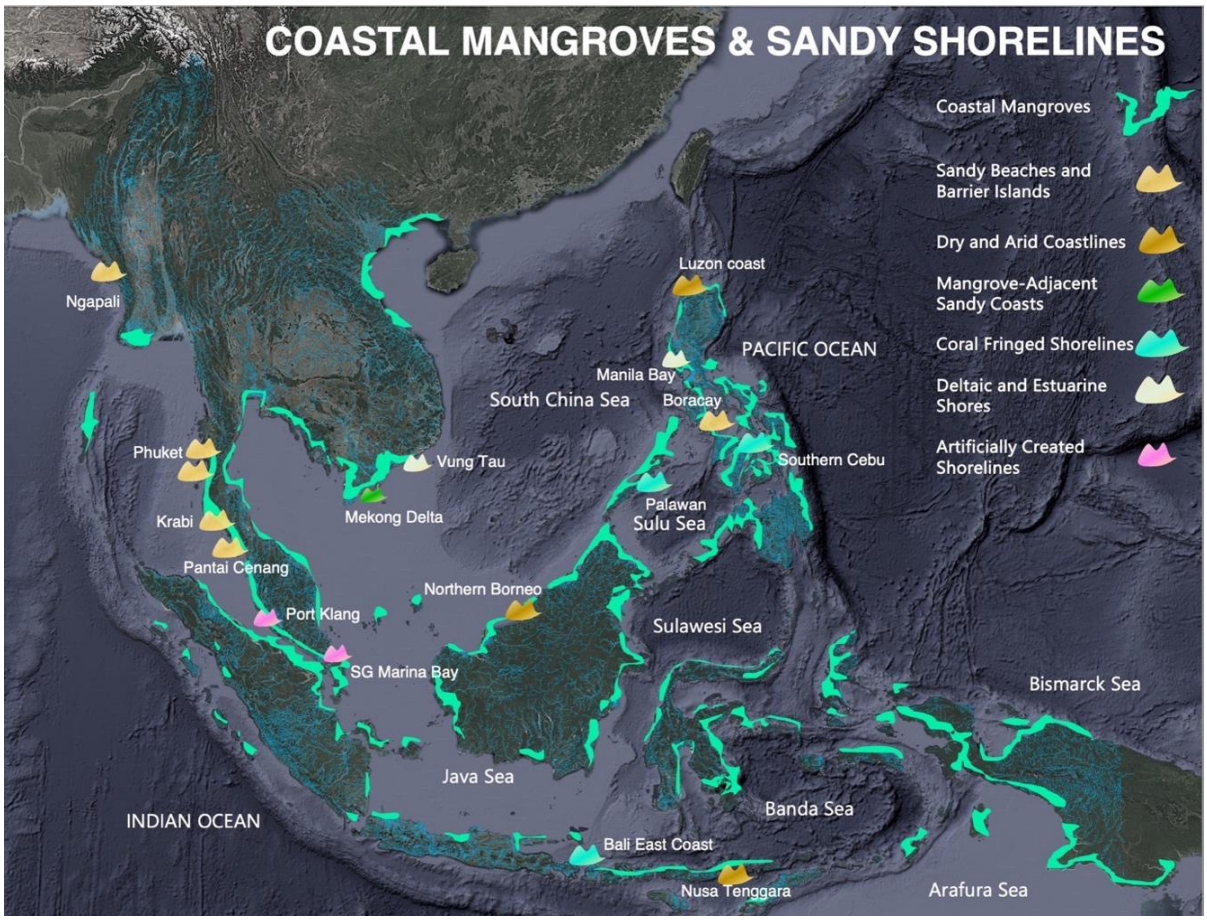


In Southeast Asia's muddy coastal zones, regenerating coastal mangroves is essential for building climate resilience and safeguarding vulnerable communities from the increasing risks of tidal surges, erosion, and rising sea levels. Mangroves offer critical ecosystem services, such as protecting coastlines from storm surges, stabilising sediments, and enhancing biodiversity. Landscape-based and scaled-up coastal Nature-Based Solutions (NbS) in synergy have the potential to create layered defences that protect both natural habitats and local economies.

For example, in areas like the Mekong Delta in Vietnam and the coastal regions of the Philippines, mangrove restoration can be complemented by salt marsh restoration and tidal flat nourishment, which work together to restore and stabilise the coast. The creation of artificial seagrass meadows and the use of hybrid structures like permeable brushwood, combined with mangrove planting, enhances sediment trapping, accelerates shoreline recovery, and reduces erosion. In Indonesia, where mangrove forests are rapidly declining, targeted projects focus on coastal reforestation and sustainable aquaculture practices, such as community-based shrimp farming integrated with mangrove ecosystems, ensuring economic resilience while protecting the environment.

These NbS strategies, including coastal mangrove shields, paludiculture, and planting mats, foster carbon sequestration, restore ecosystem services, and provide sustainable resources, such as nipa palm and firewood. Collectively, these approaches aim to create a resilient buffer against coastal disasters, supporting both the environment and the livelihoods of coastal communities across Southeast Asia.

5 – Mapping Coastal Mangroves in Southeast Asia



We have identified and located six sub-categories and 15 locations of muddy coasts in Southeast Asia:

1. Mangrove-Dominated Mudflats

- Mekong Delta Mangroves (Vietnam): Extensive mangrove forests in the Mekong Delta are critical for coastal resilience, protecting against tidal waves and erosion. However, they are impacted by saltwater intrusion, sediment loss from upstream dams, and land conversion for aquaculture and agriculture.
- Sundarbans Mangrove Ecosystem (Indonesia and Malaysia): These mangrove mudflats are rich in biodiversity but face threats from palm oil plantations, logging, and erosion exacerbated by mangrove degradation.
- Mahakam Delta (Indonesia): The Mahakam Delta has extensive mangrove mudflats threatened by aquaculture expansion, which causes coastal erosion, saltwater intrusion, and habitat loss.

2. Tidal Mudflats and Estuarine Wetlands

- Tonle Sap Lake Delta and Mekong-Tonle Sap Confluence (Cambodia): Tidal mudflats here are highly productive for fish nurseries and are seasonally flooded, but face biodiversity loss from pollution and upstream dam impacts, which alter water and sediment flow.
- Yangon Delta and Bago River Estuary (Myanmar): These tidal mudflats provide critical habitats for birds and fish but are increasingly threatened by saltwater intrusion, erosion, and the expansion of rice paddies and aquaculture, which degrade natural habitats.
- Johor River Delta (Malaysia): This area's muddy tidal flats are essential for local fisheries but face degradation from industrial activities, causing pollution, saltwater intrusion, and biodiversity loss.

3. Agricultural Wetlands on Muddy Coastlines

- Cilacap Coast (Central Java, Indonesia): Known for its muddy coastal plains, this area has significant paddy fields but is increasingly affected by saltwater intrusion, storm surges, and coastal erosion due to deforestation and aquaculture activities.
- Northern Coast of Java (Indonesia): Extensive agricultural wetlands along Java's northern coast are impacted by saltwater intrusion, soil subsidence, and coastal erosion. Industrial expansion also contributes to water pollution and biodiversity decline.
- Ayeyarwady Delta (Myanmar): This vast delta supports both rice farming and fisheries but suffers from tidal erosion, saltwater intrusion, and habitat fragmentation, driven by agricultural expansion and deforestation.

4. Peatland Muddy Coasts

- West Kalimantan Peat Coasts (Indonesia): Coastal peatlands in West Kalimantan are sensitive to erosion and saltwater intrusion. These peat soils are degraded by drainage for agriculture and palm oil plantations, increasing the risk of coastal erosion and loss of biodiversity.
- Southwest Sarawak Peat Coast (Malaysia): Sarawak's coastal peatlands support diverse species but face serious threats from land clearing, drainage, and erosion. Saltwater intrusion is also a growing issue, affecting coastal farming practices.

5. Sediment-Rich Coastal Lagoons

- Bac Lieu and Ca Mau Muddy Lagoons (Vietnam): These muddy lagoons in the southern Mekong Delta are rich in sediment and support extensive shrimp farming. However, they are prone to erosion, saltwater intrusion, and pollution from aquaculture, impacting local biodiversity.

- Tanjung Karang Coastal Lagoons (Malaysia): In Selangor, these sediment-rich lagoons are vital for fisheries but are degraded by pollution, sedimentation changes from upstream construction, and saltwater intrusion due to sea-level rise.

6. Urbanised Muddy Coastlines and Reclaimed Areas

- Jakarta Bay (Indonesia): This heavily urbanised muddy coastline faces severe erosion, land subsidence, and saltwater intrusion, worsened by the city's high extraction of groundwater. The bay's coastal ecosystems have been degraded by pollution and reclamation.
- Manila Bay (Philippines): Manila Bay's mudflats are impacted by heavy pollution, land reclamation, and erosion. Tidal waves and storm surges also contribute to saltwater intrusion, affecting fisheries and coastal communities.

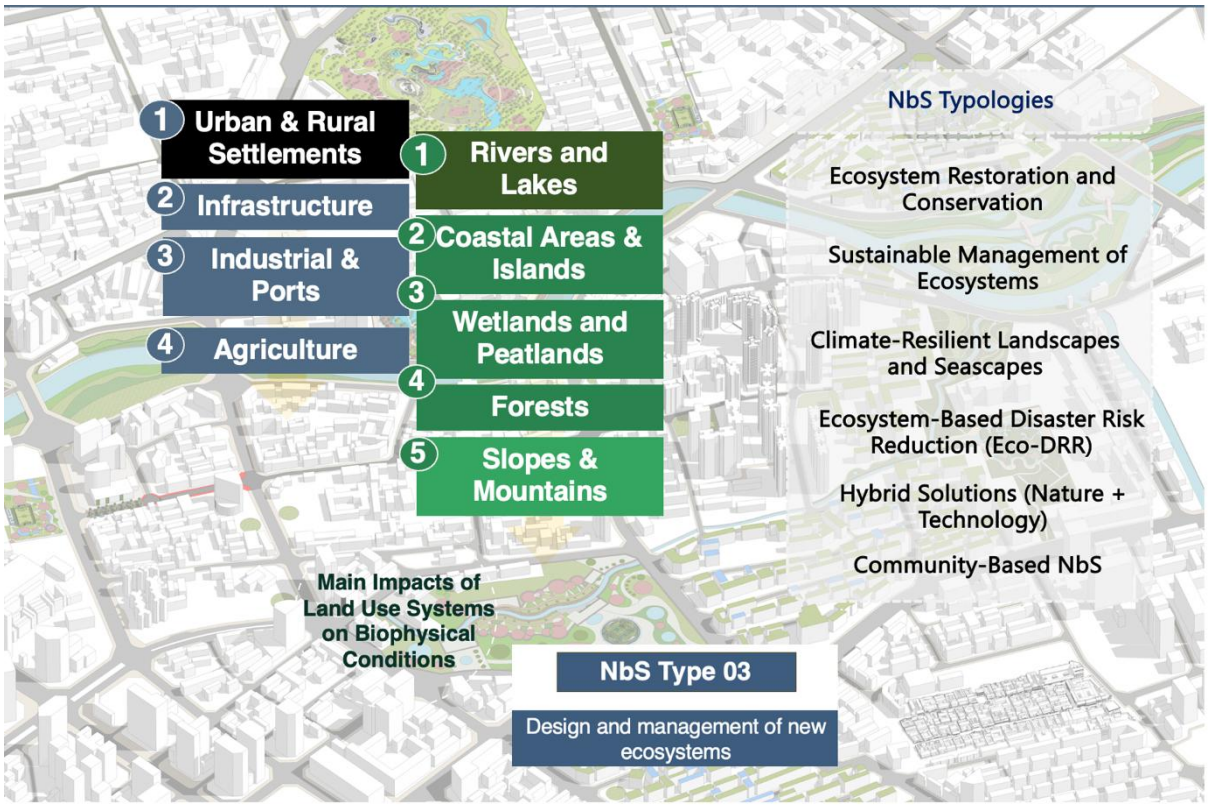
NbS practices in Adaptative Coastal Mangroves	
Technical Attributes	Planting suitable mangrove species, protecting existing mangrove forests, and constructing artificial reefs to support growth. Requires appropriate site selection considering hydrological and salinity conditions.
Environmental Attributes	Mangroves provide critical coastal protection, serve as carbon sinks, and support rich biodiversity, including fish nurseries.
Project Management Attributes	Community engagement is crucial for long-term success, along with clear land tenure, continuous monitoring, and support from local governments.
Effectiveness for EbA and Eco-DRR	Highly effective, as mangroves reduce wave energy, mitigate coastal erosion, and buffer against storm surges and sea-level rise, enhancing resilience for coastal communities.
Risk Analysis	Risks include improper species selection, lack of hydrological suitability, and inadequate community involvement, which can lead to project failure. Monitoring systems and community co-management can help mitigate these risks.
Alignment with IUCN Criteria	Mangrove restoration aligns well with IUCN's NbS criteria by providing measurable biodiversity and ecosystem services, supporting community livelihoods, and being adaptive in management.

CSL04 – Climate-Smart and Resilient Cities

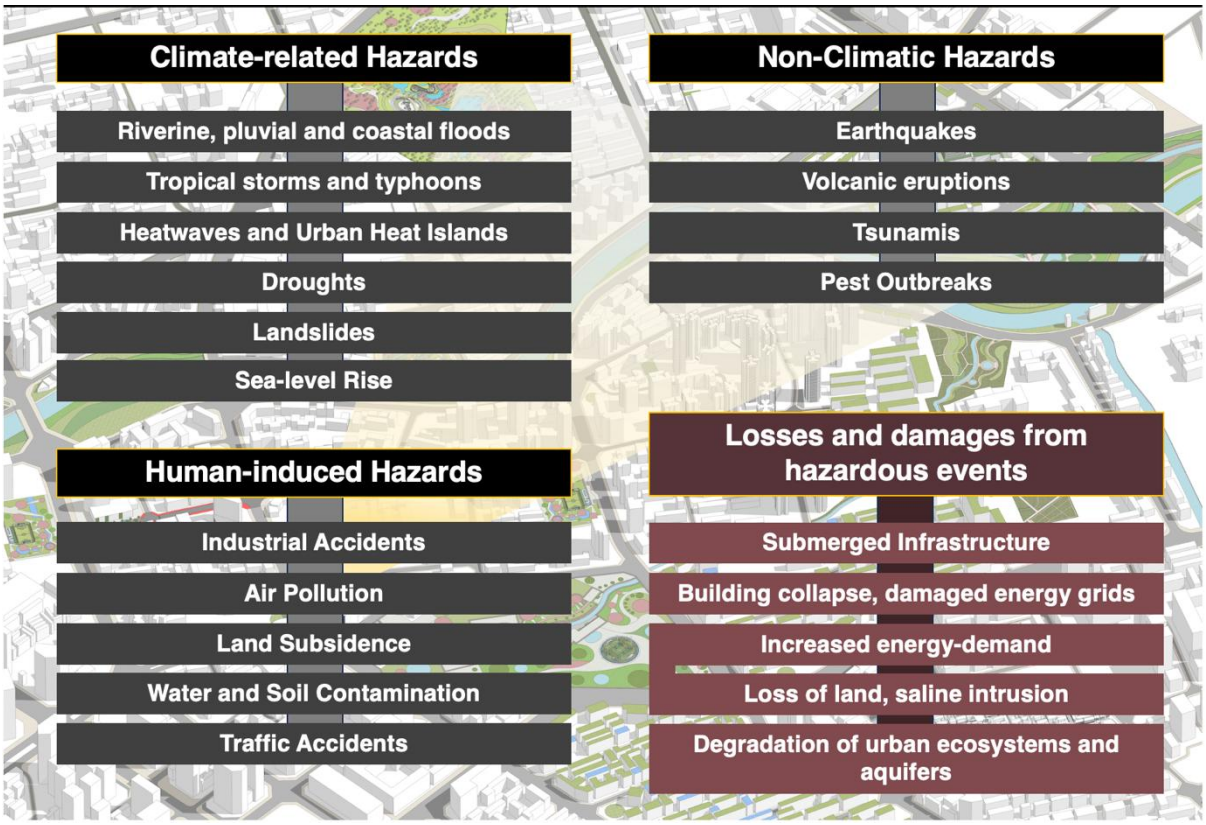
The landscape category and concept of “Climate-smart and Resilient Cities" targets urban agglomerations heading to adapt to climate adaptation through resilient urban planning that incorporates water-sensitive approaches and integrates green and blue infrastructure. These cities focus on effective water management practices, such as rainwater harvesting and flood mitigation, alongside the renaturation of urban spaces to enhance biodiversity and create green areas that alleviate urban heat island effects.

Singapore serves as a prime example of a Climate-smart and Resilient City, implementing innovative water management systems like the Marina Barrage, which integrates green spaces and effective flood control measures while enhancing urban biodiversity. Similarly, the city of Surabaya in Indonesia has adopted a comprehensive green infrastructure plan that includes the development of parks, urban forests, and permeable surfaces to manage stormwater effectively and reduce urban heat, showcasing resilience in the face of climate challenges.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Climate-smart and Resilient Cities

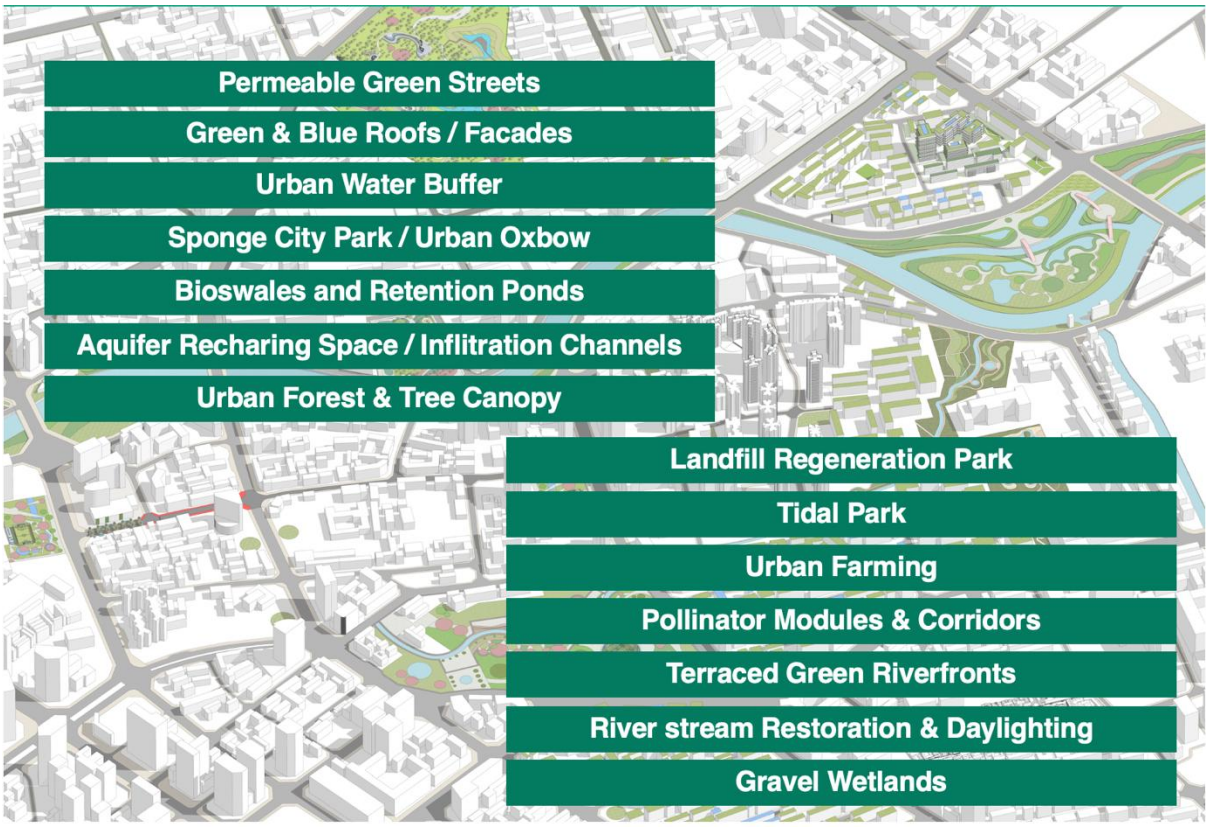


2 – Main Disaster Risks and Related Damages in Climate-smart and Resilient Cities



3 – Ecosystem Services in Climate-smart and Resilient Cities

4 – List of NbS Supporting Climate-smart and Resilient Cities



In the face of rapid urbanisation, Southeast Asia's cities are increasingly vulnerable to the effects of climate change, including flooding, heat islands, and water scarcity. To build climate-smart and resilient cities, integrating Nature-Based Solutions (NbS) is key and enable local authorities and communities to address multiple challenges simultaneously. These solutions leverage the natural environment to manage water resources, reduce heat, increase biodiversity, and improve the overall quality of urban life.

- One key approach is the integration of green infrastructure, such as permeable green streets, bioretention ponds, and sponge-city concepts, which enhance stormwater management and reduce the risk of flooding from heavy rainfall and riverine floods.

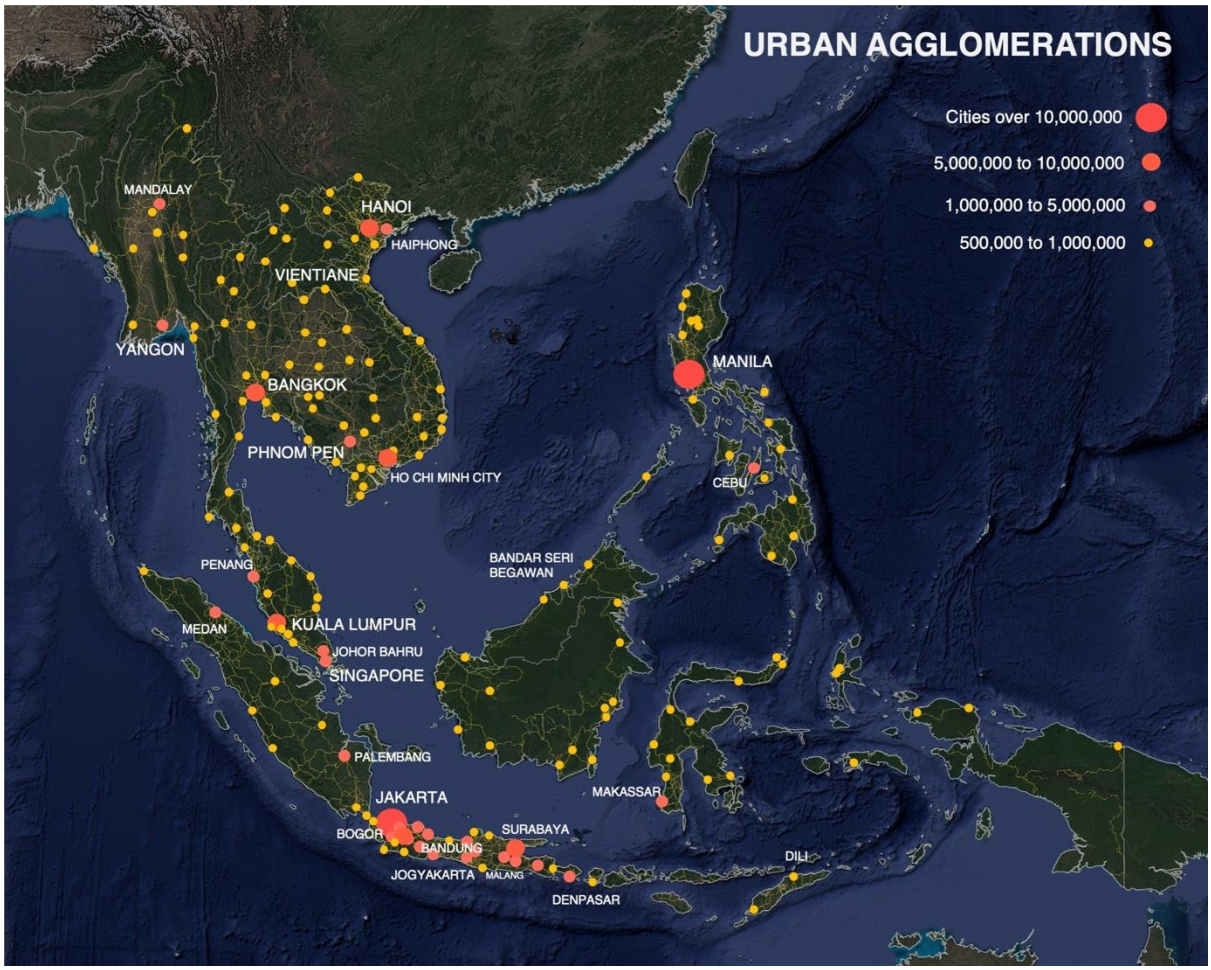
  For example, cities like Jakarta and Bangkok are adequate contexts to implement urban water buffers and terraced green riverfronts and to manage floodwaters and protect against land subsidence. In these contexts, aquifer recharging spaces and infiltration channels ensure that water is stored and reused sustainably, addressing both drought risks and water quality issues.

- To mitigate urban heat islands, urban forests, green belts, and green roofs are being introduced to provide shade, cooling, and carbon sequestration. In dense areas like Ho Chi Minh City, vertical gardens and green façades have the potential to transform the built environment, creating liveable, cooler spaces.

- Community-driven initiatives such as urban farming and pollinator corridors are helping to turn neglected urban spaces into hubs of local food security and biodiversity, while landfill regeneration parks in cities like Manila could offer opportunities to revitalise degraded lands into productive green spaces.

These strategies foster multi-functional urban landscapes that adapt to climate extremes, improve resilience, and create greener and more sustainable urban environments. Through NbS, Southeast Asian cities are transforming into climate-smart, green cities that balance the needs of their growing populations with the imperatives of climate resilience and environmental sustainability.

5 – Mapping Urban Agglomerations in Southeast Asia



We have identified six sub-categories and 18 examples of urban agglomerations and rural settlements in Southeast Asia which require contextualised approach to urban resilience and climate adaptation:

1. Dense Metropolitan Areas

- Bangkok (Thailand): Bangkok faces frequent floods, severe land subsidence, and a strong urban heat island effect due to high-density development, extensive pavement, and minimal green space. Sponge city measures like green roofs, permeable pavement, and expanded green spaces could improve climate resilience.
- Jakarta (Indonesia): Suffering from severe flooding, land subsidence, and UHI effects, Jakarta is a priority for resilient urban design. Its flood resilience could be enhanced through water-sensitive urban design, blue-green infrastructure, and managed aquifer recharge to mitigate subsidence.
- Manila (Philippines): Manila faces intense floods and droughts, UHI effects, and pollution. Green infrastructure, river restoration, and rainwater harvesting could support a transition to a sponge city model in its dense urban areas.

2. Secondary Cities and Medium-Sized Urban Centres

- Hai Phong (Vietnam): This port city on the Red River Delta is prone to floods and saltwater intrusion. Climate resilience in Hai Phong could focus on flood-adaptive infrastructure, riverbank reinforcement, and mangrove restoration to buffer coastal flooding.
- Da Nang (Vietnam): Known for its seasonal flooding and rising UHI effects, Da Nang could implement green corridors, urban wetlands, and rainwater harvesting as sponge city solutions, especially to support its growing population.
- Surabaya (Indonesia): Surabaya faces heat stress, water scarcity, and occasional floods. Green infrastructure projects, such as street tree planting, urban ponds, and permeable surfaces, could reduce these risks.

3. Small Cities and Emerging Urban Areas

- Battambang (Cambodia): A smaller city near the Tonle Sap, Battambang is vulnerable to seasonal floods and drought. Nature-based solutions like wetland preservation, urban green spaces, and rainwater capture systems could enhance resilience.
- Nakhon Ratchasima (Thailand): This small urban center in northeastern Thailand experiences both droughts and seasonal floods. Sponge city initiatives here could include rain gardens, retention basins, and permeable pavements to manage water more effectively.
- Pakse (Laos): Located near the Mekong River, Pakse faces periodic flooding and heat. Resilience measures could include riverine parks, sustainable drainage systems, and green infrastructure to absorb floodwaters.

4. Peri-Urban and Suburban Areas

- Metro Cebu (Philippines): Peri-urban areas around Cebu City suffer from UHI, flooding, and water scarcity. Integrating urban agriculture, reforestation, and improved drainage in peri-urban spaces could help mitigate these issues.
- Penang Island's Suburbs (Malaysia): Expanding urban development on Penang Island has led to flash floods and higher temperatures. Measures such as rainwater harvesting, permeable roads, and reforestation could improve water retention and reduce UHI.
- Iskandar Region (Malaysia): Near Johor Bahru, this rapidly growing suburban area faces issues with flooding and pollution. Nature-based drainage solutions, urban wetlands, and green roofs could provide resilience in new developments.

5. Rural Agricultural Landscapes

- Mekong Delta Rural Areas (Vietnam): Agricultural communities in the Mekong Delta face seasonal floods, saltwater intrusion, and droughts. Sponge community approaches, like agroforestry, rainwater harvesting, and mangrove reforestation, could protect farmlands and water resources.
- Central Plain Rural Villages (Thailand): Subject to seasonal flooding and drought, rural areas in the Central Plain could adopt resilient techniques such as rice terraces, canal restoration, and retention ponds to capture excess water for dry periods.
- Tonle Sap Floodplain (Cambodia): The rural areas around Tonle Sap Lake are prone to seasonal flooding and water shortages. Resilience measures could include wetland preservation, water storage systems, and flood-adaptive infrastructure.

6. Riverfront and Coastal Settlements

- Makati and Pasig River Areas (Metro Manila, Philippines): Dense settlements along the Pasig River experience urban flooding and pollution. Riverbank greening, river restoration, and community-managed flood control could make these areas more resilient.

- Can Tho and Other Mekong River Settlements (Vietnam): Riverfront settlements in Can Tho face annual floods and saltwater intrusion. Climate resilience here could be enhanced through floodplain zoning, resilient housing designs, and rain gardens.
- Palembang Riverfront (Indonesia): Located along the Musi River, Palembang experiences seasonal floods and heat. Riverbank restoration, urban wetlands, and flood-resistant infrastructure could benefit these riverside communities.

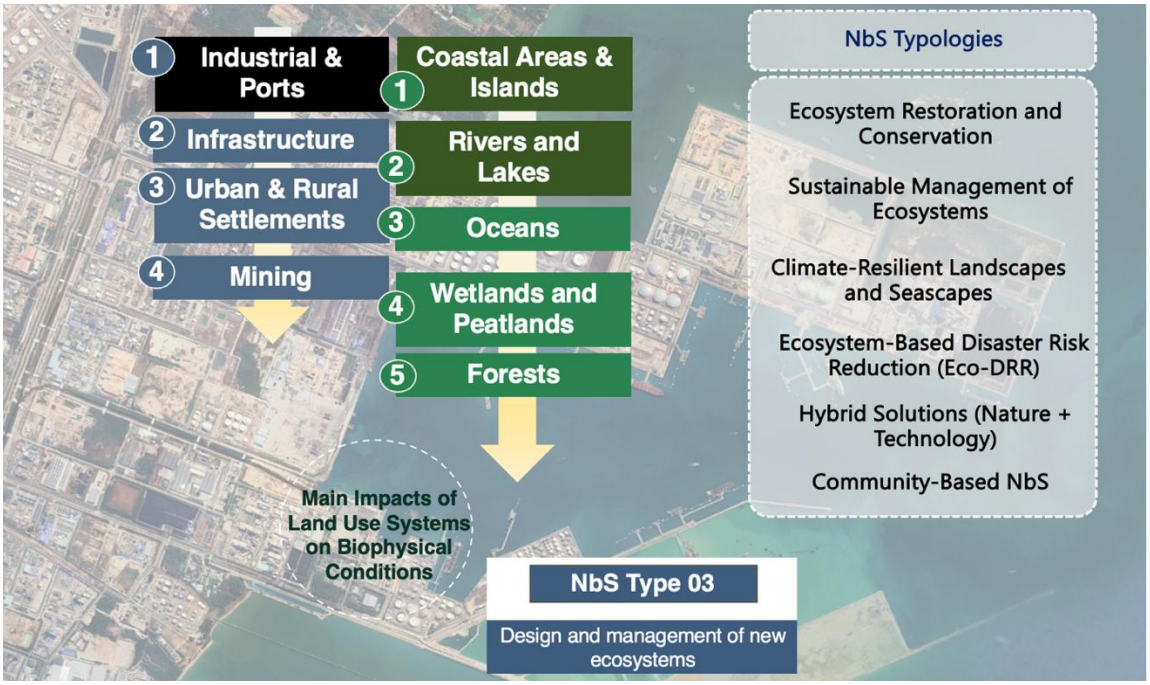
NbS practices in Climate-smart and Resilient Cities	
Technical Attributes	Includes green roofs, urban parks, bioswales, and permeable pavements to manage stormwater and reduce heat in urban areas.
Environmental Attributes	Reduces urban heat islands, absorbs excess rainfall, improves air quality, and supports urban biodiversity.
Project Management Attributes	Requires collaborative planning among urban planners, landscape architects, and water management agencies. Long-term maintenance and community participation are also essential.
Effectiveness for EbA and Eco-DRR	Effective in urban areas prone to heatwaves and flash floods by reducing surface runoff, mitigating urban heat, and providing green spaces.
Risk Analysis	Risks include high upfront costs, insufficient maintenance, and lack of public awareness. Securing funding for long-term maintenance and integrating green infrastructure into urban planning can help mitigate these risks.
Alignment with IUCN Criteria	Green infrastructure for cities is compatible with IUCN criteria, offering measurable ecosystem services and community benefits, and it can be scaled adaptively based on urban needs.

CSL05 – Green & Blue Eco-Industrial Areas and Ports

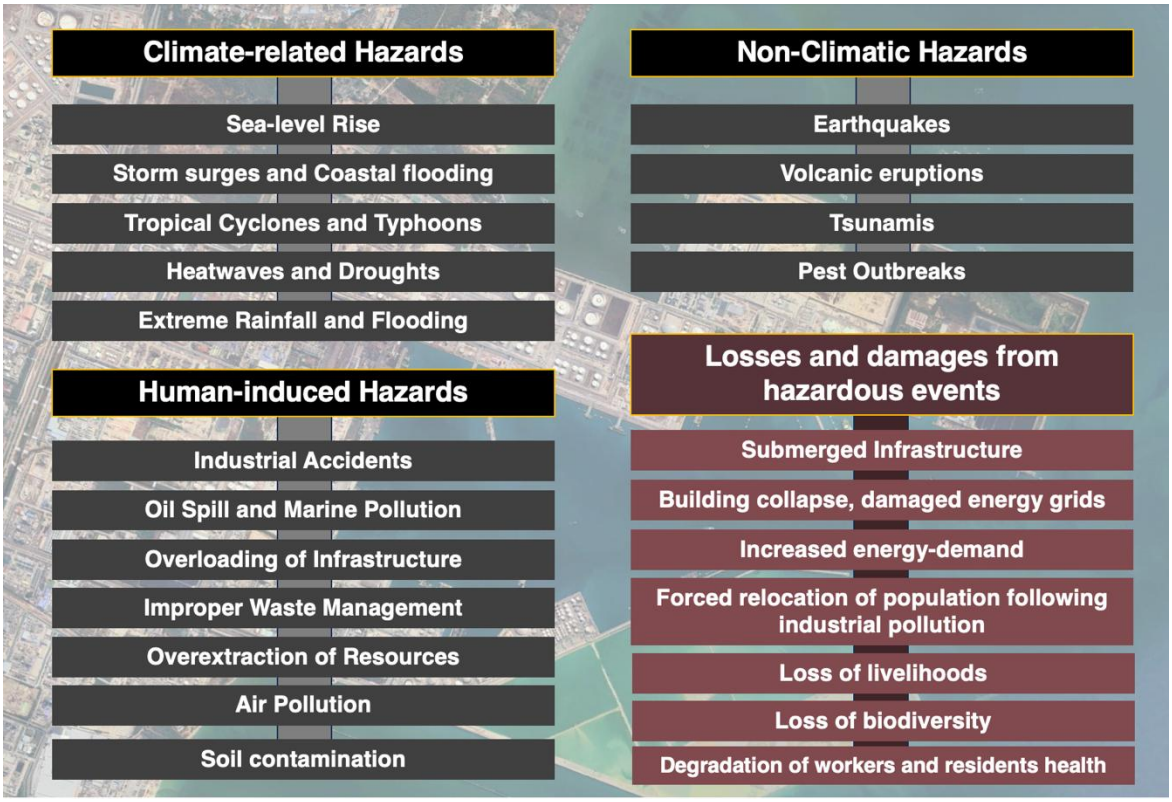
'Green & Blue Eco-Industrial Areas and Ports' in Southeast Asia encompass coastal and industrial regions designed to minimise environmental impact through the integration of low-impact industries, industrial symbiosis, and circular economy principles. These areas focus on sustainable practices such as efficient wastewater management, resource recovery from post-mining sites, and the utilisation of green infrastructure to enhance ecosystem resilience while promoting economic growth. activities and environmental stewardship.

Some industrial areas like Banyan Tree Group's Eco-Industrial Park in Vietnam are integrating sustainable practices like wastewater recycling, renewable energy usage, and industrial symbiosis among its tenants to minimise environmental impacts and enhance resource efficiency.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Green & Blue Eco-Industrial Areas and Ports

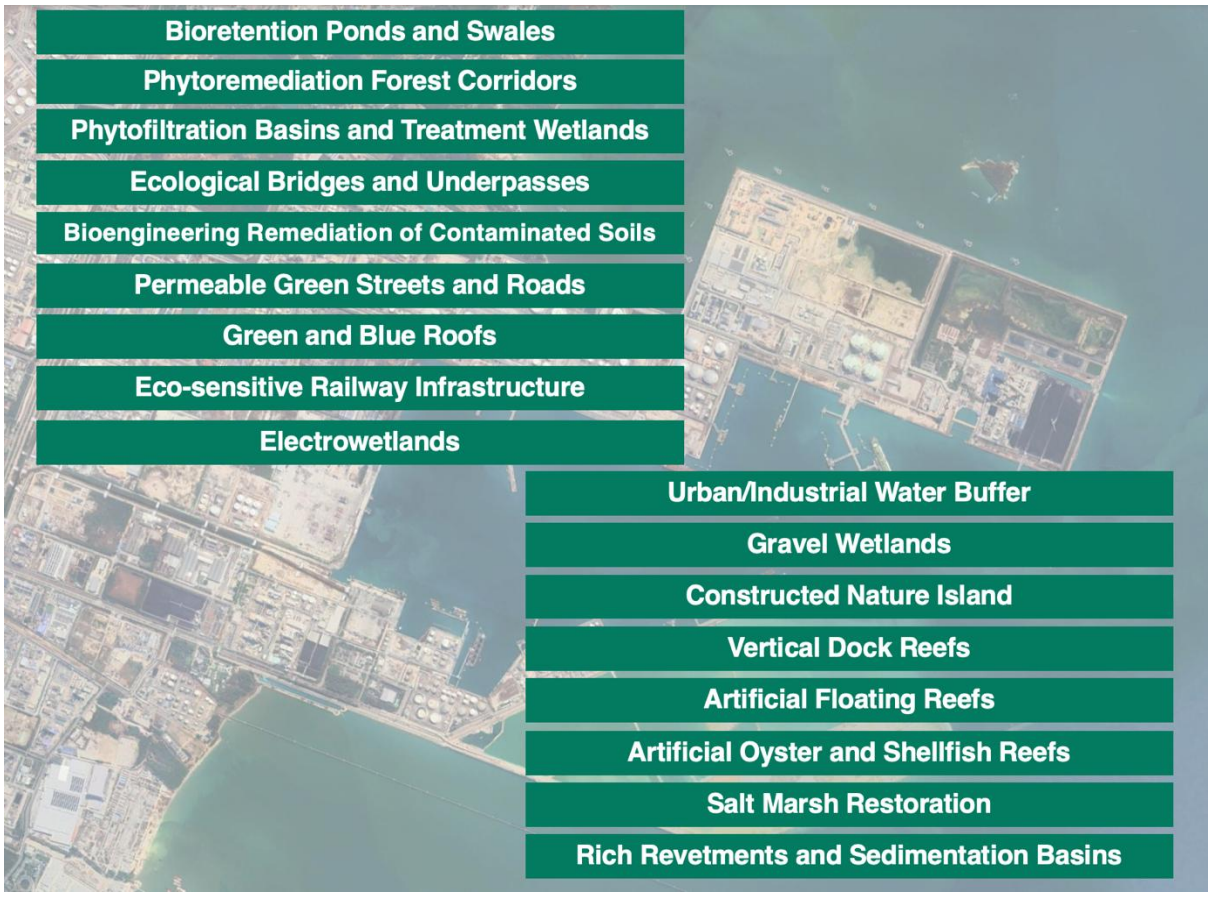


2 – Main Disaster Risks and Related Damages in Green & Blue Eco-Industrial Areas and Ports



3 – Ecosystem Services in Green & Blue Eco-Industrial Areas and Ports

4 – List of NbS Supporting Green & Blue Eco-Industrial Areas and Ports



Industrial areas and ports in Southeast Asia need a better integration of green and blue infrastructure, as it's essential for building resilient, sustainable environments that balance economic growth with environmental protection. With the region's rapid industrialisation, effective management of industrial pollution, waste, and climate impacts is critical. By combining Nature-Based Solutions (NbS) that leverage the region's rich ecosystems, we can transform industrial zones and ports into climate-resilient spaces that support both industrial productivity and ecological health.

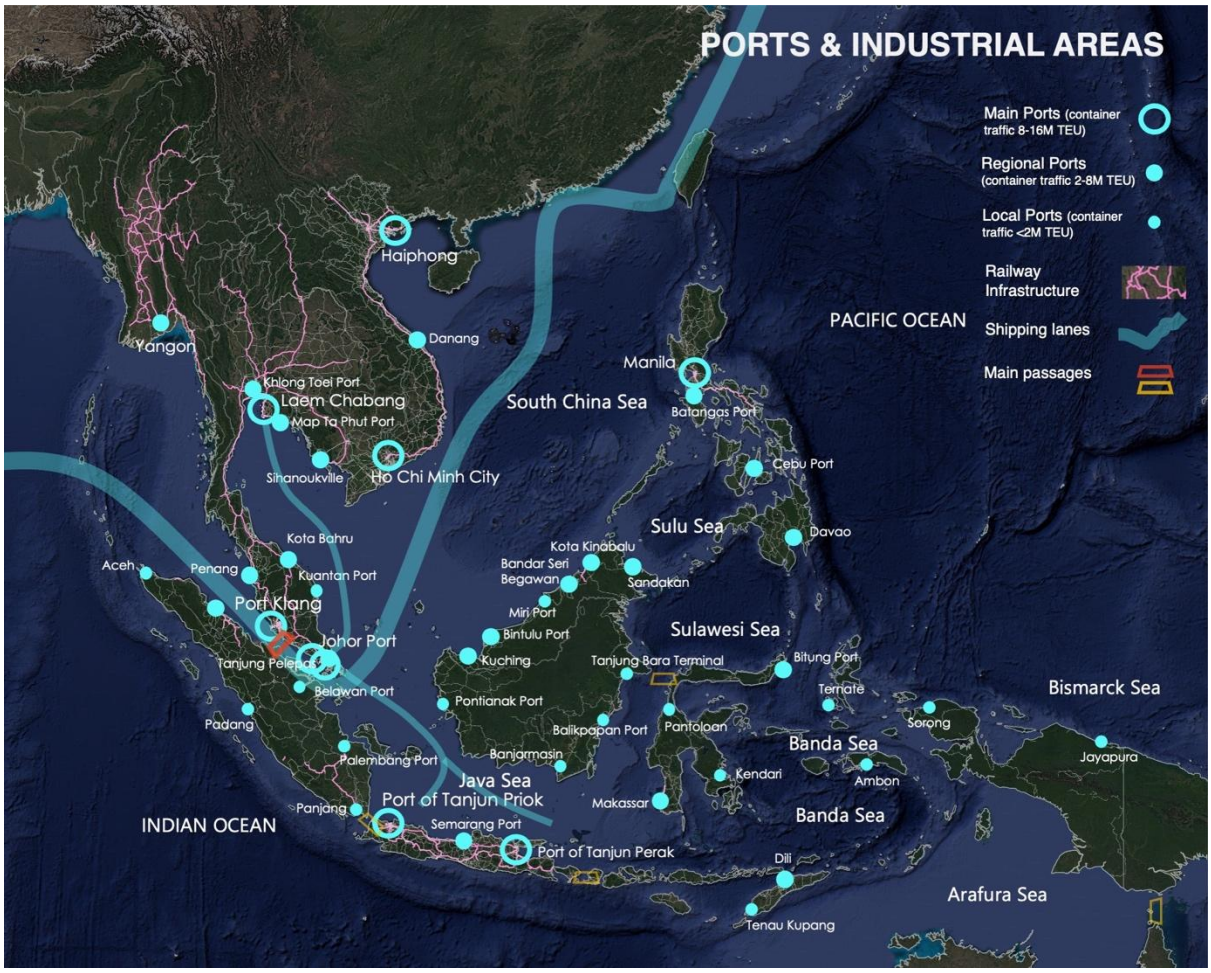
Eco-industrial parks and ports in Southeast Asia are adopting NbS such as mangrove forest restoration and salt marsh restoration to buffer against storm surges, protect infrastructure, and restore coastal ecosystems.

- For example, the restoration of mangroves and the establishment of artificial seagrass meadows in countries like Vietnam and Indonesia help stabilise sediments, support biodiversity, and mitigate coastal erosion. In addition, these ecosystems act as carbon sinks, contributing to the reduction of greenhouse gases while enhancing local livelihoods through sustainable fisheries and aquaculture systems.
- Constructed wetlands and bioengineering solutions, including electrowetlands and gravel wetlands, play a vital role in treating industrial wastewater, reducing pollutants entering nearby seas, and supporting healthy aquatic environments. Ports and industrial zones such as in Thailand and Malaysia are increasingly adopting green roofs and facades to cool the environment, reduce urban heat island effects, and mitigate the impacts of high temperatures on workers and surrounding communities. Vegetated noise barriers and buffer zones offer further protection to populations living near industrial areas, reducing noise pollution and improving air quality.

- In the mining sector, post-mining recovery strategies such as bioengineering remediation of contaminated soils and landfill regeneration parks contribute to restoring ecological health and revitalising degraded landscapes. The use of artificial oyster reefs and coral restoration projects near ports, such as those underway in the Philippines, is enhancing marine biodiversity while improving water quality and creating natural habitats for marine life.

By implementing these NbS in synergy, Southeast Asia's industrial areas and ports can be transformed into green and blue zones that support economic activities, protect natural ecosystems, and adapt to the impacts of climate change, offering a sustainable model for future development across the region.

5 – Mapping Ports and Industrial Areas in Southeast Asia



Six sub-categories of industrial areas have been analysed across Southeast Asia, including 18 examples of industrial and mining sites that have taken initiatives and actions to enhance climate mitigation, contain and reduce pollutants, and restore degraded environments. These 18 examples provide locations for potential opportunities to implement eco-industrial NbS in synergies.

1. Large-Scale Industrial and Export Processing Zones

- Map Ta Phut Industrial Estate (Thailand): Located on the eastern seaboard, this major industrial hub for petrochemicals, oil refining, and manufacturing is impacted by air and water pollution. Projects by Thailand's Industrial Estate Authority (IEAT) aim to transform Map Ta Phut into an eco-industrial park through air quality control, wastewater management, and green infrastructure.[4]
- Pasir Gudang Industrial Estate (Malaysia): An extensive industrial zone in Johor with chemical plants, manufacturing, and palm oil processing, Pasir Gudang faces water and air pollution challenges. Ongoing initiatives like Malaysia's Green Technology Master Plan* encourage eco-industrial transformation through waste reduction, green manufacturing, and bio-engineering solutions to manage pollution.[5]

[4] Green Design and Planning Resolutions for an Eco-Industrial Town: A Case Study of Polluted Industrial Estate in Rayong Province, Thailand, Ariya 'Narm Aruninta, Chulalongkorn University, Jan 2012

[5] Source: Department of Environment, Malaysia – Reports on industrial pollution in Johor; ASEAN Energy Reports

- Batam Industrial Zone (Indonesia): As a special economic zone (SEZ), Batam hosts electronics, shipbuilding, and oil industries. Soil and water pollution are pressing concerns. The Indonesian Ministry of Industry is piloting eco-industrial initiatives, with wastewater treatment, energy efficiency, and biodiversity preservation as central elements.[6]

2. Coastal Industrial Clusters and Seaport Areas

- Port of Tanjung Priok (Jakarta, Indonesia): This major seaport is heavily impacted by coastal pollution, artificialisation, and nearby urban waste. Efforts are underway to transition to a green port model with the Indonesia Port Corporation (Pelindo) focusing on reducing emissions, implementing waste management, and enhancing coastal vegetation to protect marine biodiversity.[7]
- Hai Phong Port Industrial Area (Vietnam): The Hai Phong port area, a major hub for logistics and heavy industry, faces pollution from industrial discharges and coastal degradation. The port development master plan aims to integrate wastewater management, mangrove reforestation, and pollution control systems to transition to an eco-friendly port.
- Port Klang Free Zone (Malaysia): Malaysia's largest port, Port Klang is impacted by both marine pollution and habitat loss from nearby development. The Eco-Port Project, supported by the Port Klang Authority, includes bioengineering measures, pollution monitoring, and green infrastructure initiatives aimed at reducing the port's environmental impact.

3. Mining-Related Industrial Zones

- Lao Cai Mineral Processing Zone (Vietnam): Known for mineral extraction and processing, this zone experiences significant soil, water, and biodiversity degradation. A push for green transformation by Vietnam's Ministry of Industry and Trade includes nature-based wastewater solutions, soil restoration, and pollution control systems as part of a larger eco-industrial strategy.[8]
- Samarinda Industrial Mining Zone (East Kalimantan, Indonesia): In a region affected by coal mining, this industrial area faces extensive land degradation and water pollution. Indonesia's Ministry of Energy and Mineral Resources is piloting the Rehabilitation of Mined Land Project, involving reforestation, soil remediation, and green infrastructure to restore degraded landscapes.[9]
- Phalaborwa Industrial Mining Complex (Laos): This complex, focused on copper and gold mining, impacts water resources and biodiversity. The Laos Ministry of Natural Resources and Environment works on land and water rehabilitation projects, including artificial wetlands and bioengineering for wastewater treatment.[10]

[6] Multiple sources of information: Batam Development Agency website, Jakarta Post articles
[7] UNEP's Clean Ports Program and freight news articles on Tanjung Priok's green port initiatives: https://www.unep.org/explore-topics/transport/what-we-do/global-clean-ports/port-tanjung-priok-jakarta-indonesia
[8] Vietnam's Ministry of Industry and Trade on green economic shifts in industrial zones like Lao Cai, emphasizing renewable energy and eco-industrial transformations: https://ven.congthuong.vn/lao-cai-moves-to-promote-mineral-processing-21167.html
[9] Rehabilitation of Mined Land Project: https://en.antaranews.com/news/218893/ministry-pupuk-kaltim-to-rehabilitate-former-mining-lands
[10] Hydrogeochemical assessment, water treatment and revalorization of dumps, tailings and drainages produced at Phalaborwa Industrial Complex, Arias Gomez, UFS, 2020: https://scholar.ufs.ac.za/items/365acf28-bc78-4780-a982-4d15988357ec

4. Logistics and Transport Hubs (Road, Rail, Air)

- Suvarnabhumi Airport Area (Thailand): As a major air transport hub, the Suvarnabhumi Airport area is a source of noise pollution and carbon emissions. In collaboration with Airports of Thailand (AOT), green initiatives aim to reduce emissions, enhance nearby green spaces, and implement rainwater capture to reduce stormwater runoff.
- Inland Container Depot, Tanjung Perak (Surabaya, Indonesia): Located near Surabaya, this transport hub is vital for road and rail logistics but contributes to air and noise pollution. Efforts by Indonesia Port Corporation include installing vegetated barriers, improving rail-to-port connectivity, and implementing noise reduction strategies.
- Iskandar Malaysia (Malaysia): The Iskandar development region has integrated industrial, commercial, and logistics zones. Environmental challenges include air pollution and urban sprawl. The Iskandar Malaysia Green Economy Program emphasises green logistics infrastructure, pollution control, and water-sensitive design, integrating urban greening with eco-industrial development.

5. Heavy Manufacturing and Chemical Clusters

- Rayong Chemical Complex (Thailand): This industrial area is heavily affected by chemical pollution and air quality issues. The Eastern Economic Corridor Development Project is working on eco-friendly practices, including chemical recycling, sustainable waste management, and installation of green buffers around industrial sites.
- West Port Industrial Zone (Penang, Malaysia): This area, focused on electronics manufacturing, produces a high volume of waste and emissions. With support from the Malaysia Green Technology Corporation, the project includes green buffer zones, pollution control, and partnerships with local governments to improve wastewater treatment.
- Chonburi Industrial Complex (Thailand): With automotive and electronics industries, this zone faces pollution challenges but is transitioning toward eco-industrial standards through cleaner production processes and green infrastructure, supported by the Thailand Board of Investment and Japanese International Cooperation Agency (JICA).

6. Special Economic and Free Trade Zones

- Eastern Seaboard Industrial Zone (Thailand): The Eastern Seaboard faces water and soil contamination. With the Eastern Economic Corridor Office and international support, eco-industrial park elements are being introduced, including water-sensitive urban design and the integration of nature-based green spaces.
- Subic Bay Freeport Zone (Philippines): Located on a former military base, this free trade area combines logistics with light manufacturing. Pollution from waste and runoff is a concern, and Subic Bay Metropolitan Authority (SBMA) works on eco-industrial initiatives, such as improved wastewater treatment, forest preservation, and coastal buffer zones.
- Batangas Special Economic Zone (Philippines): This SEZ includes oil refineries and other industries contributing to water and air pollution. Supported by the Philippine Economic Zone Authority (PEZA), projects aim to improve wastewater recycling, restore mangrove areas, and implement emissions control.

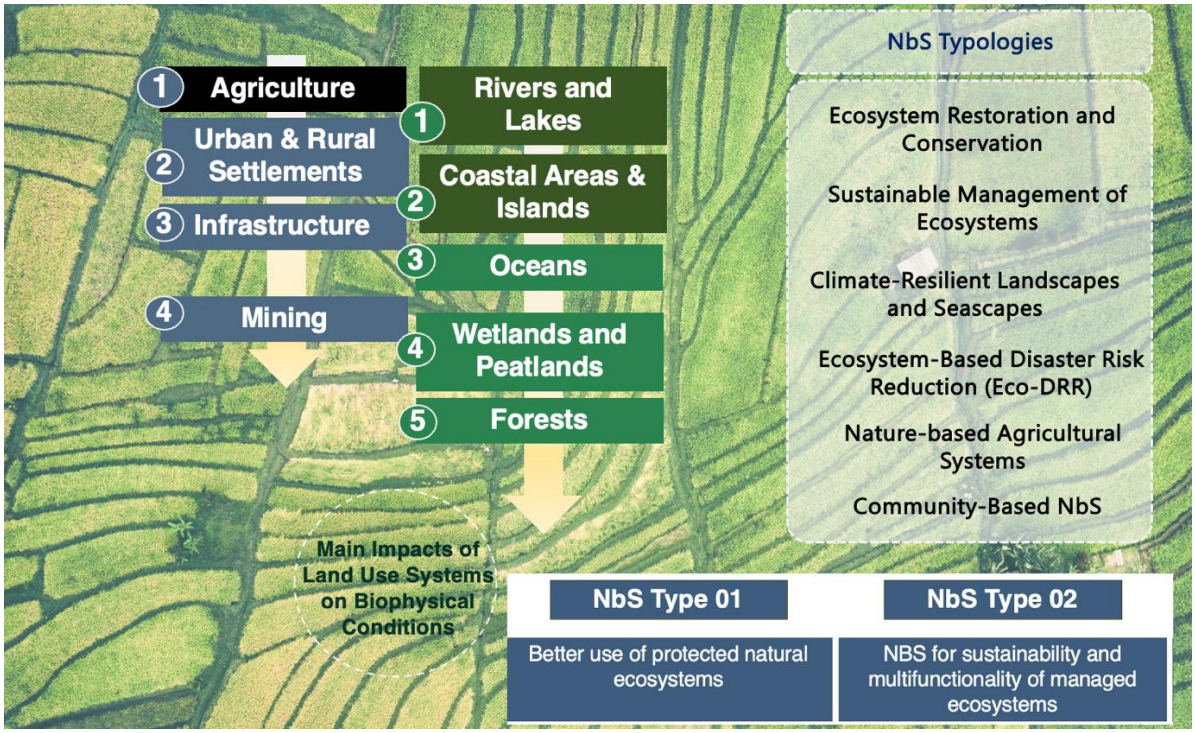
NbS practices in eco-Industrial Areas and Ports	
Technical Attributes	Uses plants (phytoremediation), fungi (mycoremediation), or bacteria to break down contaminants and absorb heavy metals or hydrocarbons from soils and water bodies around industrial, mining, and port sites. Techniques include planting hyperaccumulator plants in contaminated areas or applying microbial treatments to polluted waters.
Environmental Attributes	Reduces toxic substances in soil and water, enhances soil health, and supports gradual ecosystem restoration in degraded landscapes. Can create more habitable environments for native vegetation and wildlife over time.
Project Management Attributes	Requires thorough initial site assessments, ongoing monitoring, and controlled introduction of bioremediation species. Effective implementation relies on environmental engineers, scientists, and local stakeholders to manage contamination levels and support long-term ecosystem recovery.
Effectiveness for EbA and Eco-DRR	Effective for long-term restoration of ecosystems degraded by industrial activities, enhancing resilience by gradually restoring ecosystem services such as soil fertility, water filtration, and habitat provision.
Risk Analysis	Risks include the time needed for contaminants to be fully absorbed or broken down, which can be lengthy. Misapplication (e.g., introducing non-native species for bioremediation) can disrupt local ecosystems. Selecting site-appropriate bioremediators and conducting periodic soil/water testing can reduce these risks.
Alignment with IUCN Criteria	Strong alignment with IUCN's NbS criteria as bioremediation offers measurable improvements to ecosystem health, supports biodiversity recovery, and is adaptable to varied contamination levels and site-specific needs.

CSL06 – Regenerative Agriculture

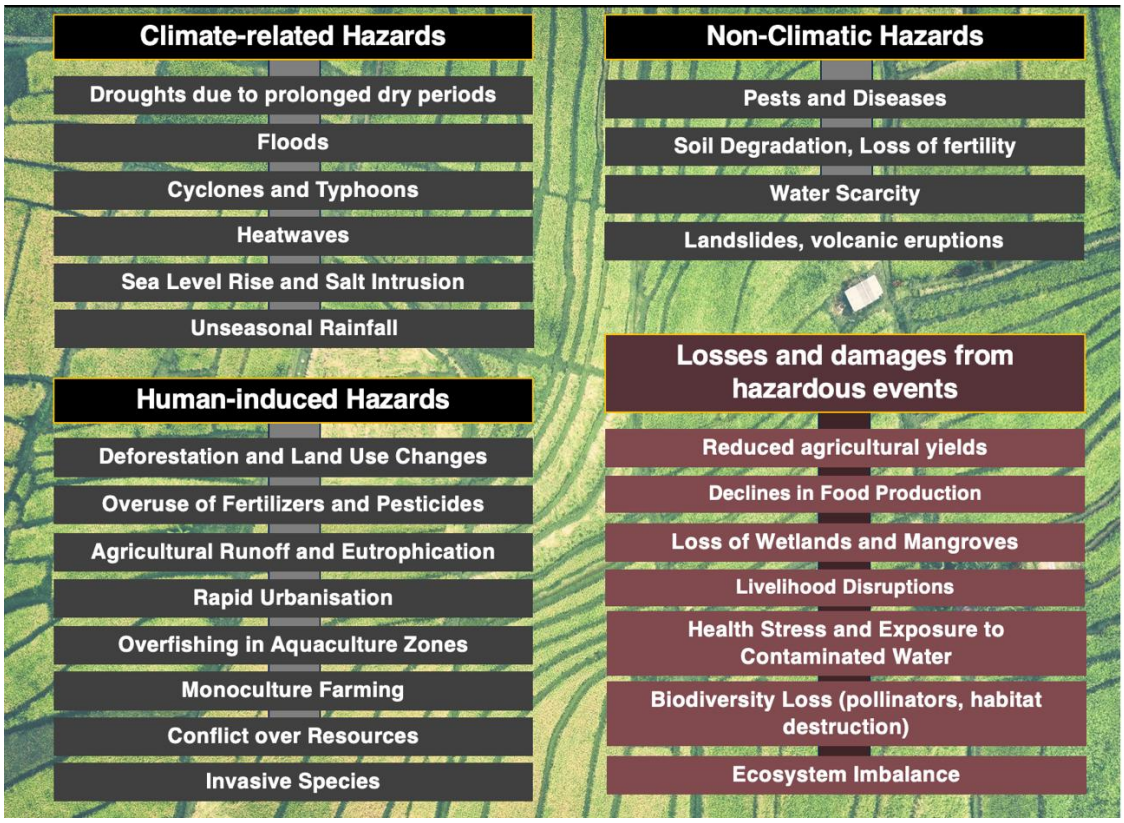
Developing Regenerative Agriculture as a 'climate-sensitive eco-landscape' in Southeast Asia covers diverse, climate-smart farming practices, including terrestrial agriculture, forestry, aquaculture, floating farms, and paludiculture (wetland or peatland cultivation), that aim to enhance food security while protecting biodiversity and ecosystem health. This landscape category prioritises sustainable, diversified practices that restore soil health, promote water conservation, and prevent risks like pollution, saltwater intrusion, and land degradation. Implementing nature-based solutions (NbS) within these systems - such as agroforestry, integrated aquaculture, and wetland management - supports resilient agriculture that mitigates climate impacts, counters the negative effects of monocultures, and enhances productivity without compromising environmental integrity.

In Indonesia, rice-fish farming systems in West Java integrate aquaculture with rice paddies, promoting biodiversity, reducing pesticide use, and improving food security by producing both fish and rice. Vietnam's Mekong Delta has adopted floating rice cultivation and mangrove-aquaculture integration to manage saltwater intrusion, increase resilience to flooding, and enhance local livelihoods while protecting coastal ecosystems.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Regenerative Agriculture

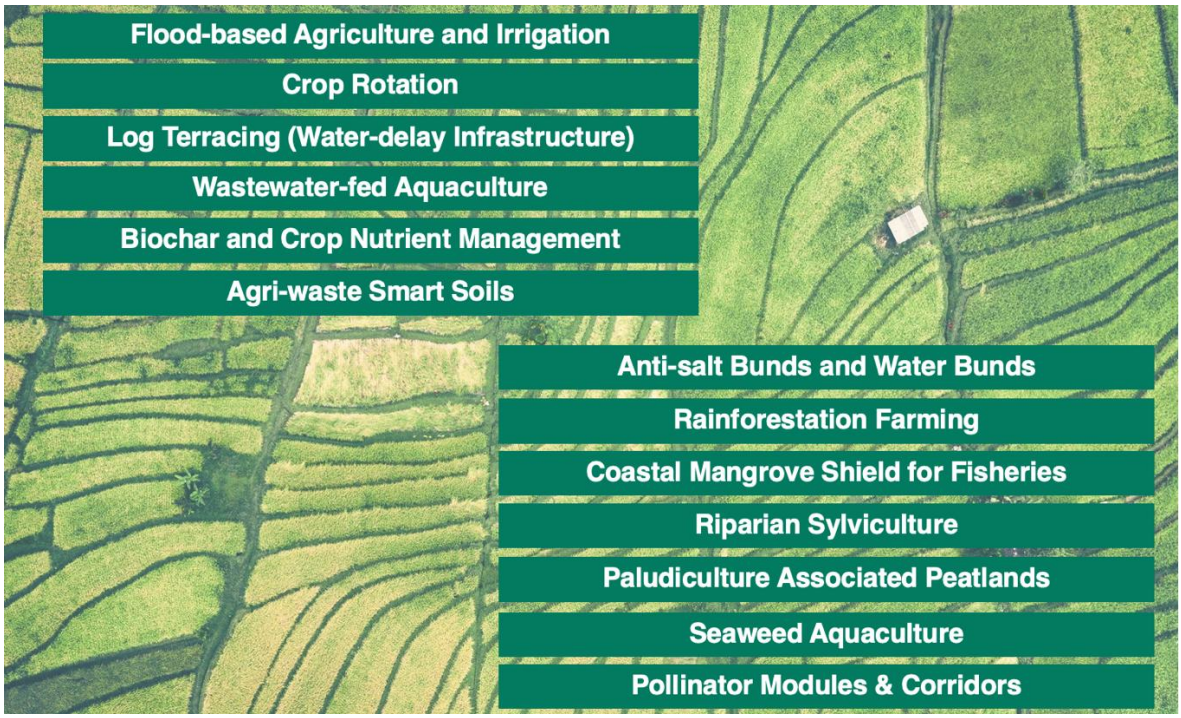


2 – Main Disaster Risks and Related Damages in Regenerative Agriculture



3 – Ecosystem Services in Regenerative Agriculture

4 – List of NbS Supporting Regenerative Agriculture

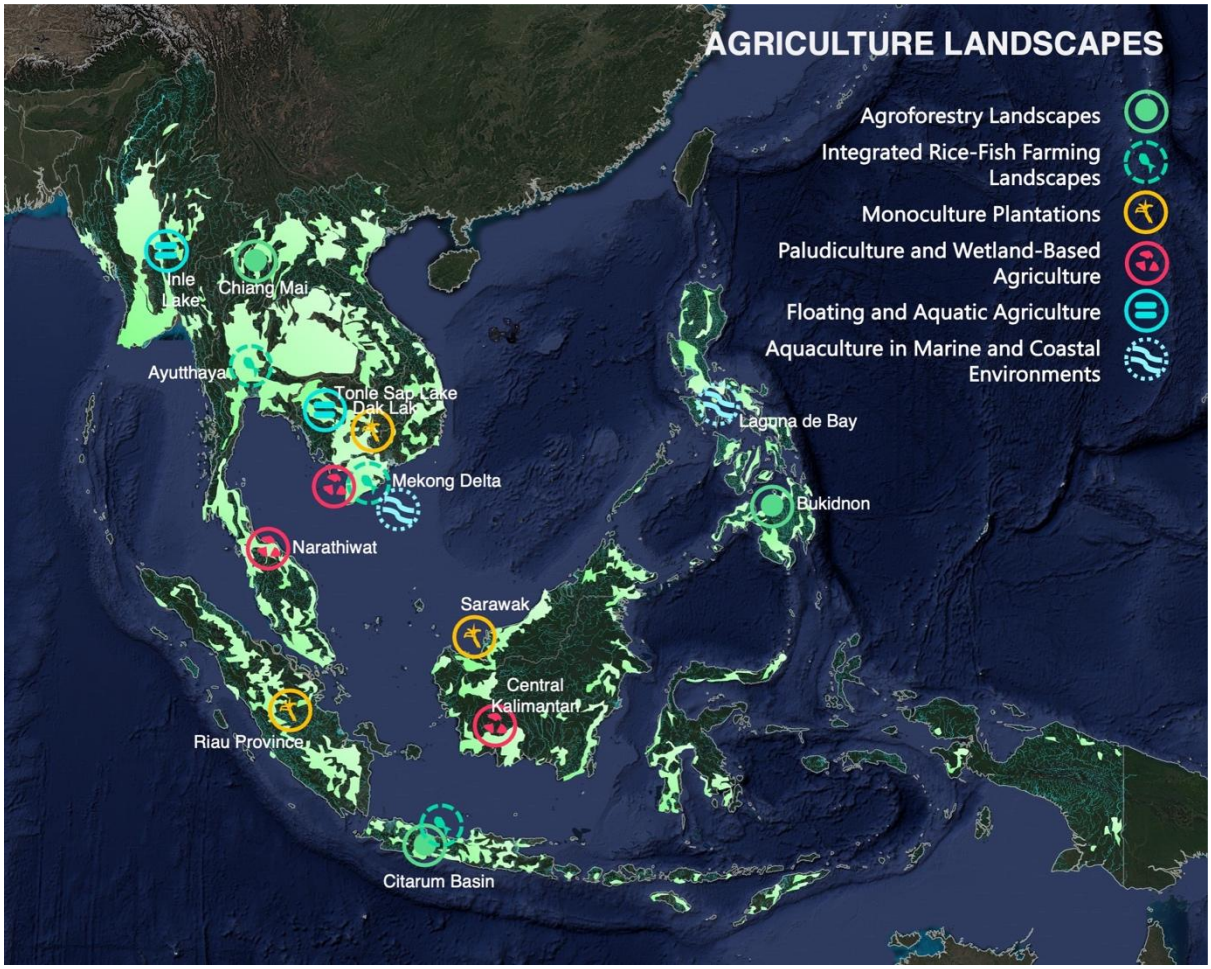


Agriculture is central to both the economy and food security in Southeast Asia. Regenerative practices that integrate Nature-Based Solutions (NbS) offer a powerful approach to creating resilient and sustainable farming systems. These landscapes, rich in biodiversity and tradition, face challenges such as soil degradation, water scarcity, shifting rainfall patterns, and the pressures of intensive farming. By leveraging NbS, agricultural systems can regenerate soil health, enhance water management, and mitigate the impacts of climate change, ensuring long-term agricultural productivity and ecosystem restoration.

- Agroforestry systems that combine native trees with traditional crops, such as those practiced in Indonesia and the Philippines, improve soil fertility, increase water retention, and support biodiversity. This approach is particularly effective in upland farming, where terraced farming and agroforestry work together to reduce erosion and capture rainfall. In the fertile rice paddies of Vietnam and Thailand, techniques like drainage reduction and flood-based agriculture help optimise water use and prevent runoff, ensuring that water resources are managed efficiently and that rice production remains stable despite climate variability.
- Paludiculture, a practice focused on the restoration of peatlands through sustainable land use, is gaining traction in Indonesia and Malaysia. By restoring peatlands, these areas can sequester significant amounts of carbon, prevent subsidence, and maintain water levels in surrounding areas.
- Similarly, riparian buffer zones, managed by local communities in places like Cambodia and Laos, help protect watercourses from agricultural pollution and ensure reliable irrigation for crops.
- Polyculture and crop rotation, practices long embraced by local farmers, are being enhanced by the integration of organic farming methods that reduce dependency on chemical fertilisers and pesticides. This approach builds resilience to pests and extreme weather events, contributing to both environmental and economic sustainability.
- Innovative solutions such as biochar for crop nutrient management, agri-waste smart soils, and seaweed aquaculture are improving nutrient cycles, reducing waste, and supporting alternative income streams for coastal communities.

- In areas prone to strong winds and extreme weather, windbreaks and shelterbelts offer critical protection to crops and farming communities, while reforestation techniques, including rainforestation farming and riparian sylviculture, help restore landscapes and strengthen the resilience of rural areas to climate impacts.

5 – Mapping Agriculture Landscapes in Southeast Asia



This first phase of analysis provides a non-exhaustive list of six sub-categories and 14 cases of agricultural practices in Southeast Asia which are taking initiatives and actions to enhance climate mitigation, contain and reduce pollutants, restore degraded environments. These 18 examples provide locations for potential opportunities to implement eco-industrial NbS in synergies.

1. Agroforestry Landscapes

- Bukidnon, Philippines: In Mindanao's Bukidnon region, indigenous communities practice agroforestry with coffee, cacao, and native trees, reducing soil erosion and enhancing biodiversity. Despite challenges of initial setup and training needs, local cooperatives and NGOs provide support.[11]
- Chiang Mai, Thailand: In the mountains around Chiang Mai, hill tribes like the Karen and Hmong cultivate forest gardens with native plants and medicinal herbs, preserving biodiversity and traditional agricultural knowledge. Expansion of commercial farming, however, poses risks to these systems.[12]

[11] Restoring the Heart of Mindanao Through Reforestation: https://www.terraformation.com/blog/restoring-the-heart-of-mindanao-through-reforestation

[12] Hta: How Karen Farming Saved a Forest in Thailand and Its Poetry Changed International Policy : https://terralingua.org/langscape_articles/hta-how-karen-farming-saved-a-forest-in-thailand-and-its-poetry-changed-international-policy/

- In the Citarum Basin (West Java), coffee is grown under native and fruit trees, stabilising soil and conserving water. Supported by cooperatives, this system is climate-resilient but requires pest management and training.[13]

2. Integrated Rice-Fish Farming Landscapes

- Mekong Delta, Vietnam: Farmers here practice rice-fish farming, where fish help control pests and fertilise rice, enhancing food security and reducing chemical use. However, the method depends on stable water quality and careful management by local authorities.
- In the Citarum Basin of West Java, Indonesian farmers grow rice with carp and tilapia, improving water quality and offering an extra income.
- Ayutthaya, Thailand: In central Thailand, farmers rotate rice with shrimp, minimising pests and optimising land use, though it requires seasonal planning and is sensitive to saltwater intrusion. Cooperatives support the adaptive management of this method.[14]

3. Monoculture Plantations

- Sumatra's Riau province has extensive palm oil plantations, which, while economically valuable, lead to deforestation and biodiversity loss. Managed by large companies, these plantations face increasing pressure to adopt sustainable practices.[15]
- Rubber monocultures in Sarawak, Borneo provide jobs but degrade soil and biodiversity. Multinational companies and local owners benefit economically, though conservationists advocate for sustainable changes.
- Dak Lak, Vietnam: Vietnam's Central Highlands feature coffee monocultures that drive exports but lead to soil exhaustion and high-water demands. Smallholders benefit economically, but environmental challenges remain, particularly as climate patterns shift.[16]

4. Paludiculture and Wetland-Based Agriculture

- Central Kalimantan, Indonesia: In the peatlands of Borneo, indigenous communities cultivate sago palms without draining peat, preserving carbon stores and reducing fire risks. Conservation groups support these sustainable practices.
- Mekong Delta, Vietnam: Farmers grow floating rice in flooded fields, adapting to natural water cycles and boosting food security. Cooperatives support this method, which requires skilled water management to remain effective.
- In Narathiwat's peat swamp forests (Thailand), wetland-compatible agriculture helps maintain carbon-rich soils and reduce flood risks. Peatland conservation organisations help manage these efforts to avoid fire risks.[17]

5. Floating and Aquatic Agriculture

- Tonle Sap Lake, Cambodia: On Tonle Sap Lake, farmers grow vegetables on bamboo rafts during wet season floods, ensuring year-round food production. Local NGOs provide support, though water pollution remains a risk.

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[13] Source: https://explorer.land/x/project/weforest_citarum/about

[14] Source: Socio-economic and environmental implications of inland shrimp farming in the Chao Phraya Delta, Brian W. Szuster; Rice-shrimps farming: a nature-based solution in Mekong River Delta, Phu le Dac, AgriTerra: https://www.agriterra.org/rice-shrimps-farming/

[15] Destruction of Sumatra forests driving global climate change and species extinction: WWF: https://wwf.panda.org/wwf_news/?125741/Destruction-of-Sumatra-forests-driving-global-climate-change-and-species-extinction-WWF

[16] Impact of climate change on irrigation water requirements for coffee plants in the fruit development stage: a case study of Dak Lak and Gia Lai provinces in the Central Highlands of Vietnam, Lap Quoc Tran, Jan 2024, IWA Publishing; IUCN: New study on coffee transition for multiple benefits in the Central Highlands : https://iucn.org/news/viet-nam/202203/new-study-coffee-transition-multiple-benefits-central-highlands

[17] Peat Swamp forests for adaptation: potentials and vulnerability, Matthew Warren; https://www.cifor-icraf.org/swamp/ecosystems/peatlands/

- Inle Lake, Myanmar: The Intha community cultivates floating gardens on lake weeds, growing tomatoes and other crops, which provide income while adapting to fluctuating water levels. Conservation groups aid in managing lake eutrophication risks.

6. Aquaculture in Marine and Coastal Environments

- Mekong Delta, Vietnam: In the Mekong Delta's brackish zones, shrimp farming is a dominant industry, often managed by smallholders and larger companies. Although it provides substantial economic returns, it leads to issues like water salinisation and mangrove loss. Government initiatives are promoting more sustainable practices, such as integrated mangrove-shrimp systems.
- Laguna de Bay, Philippines: In Laguna de Bay, fish pens for tilapia and milkfish are a vital source of income for local communities, with management support from the Laguna Lake Development Authority. While this aquaculture sustains livelihoods, it is vulnerable to pollution and overstocking, which necessitates balanced management to preserve water quality.[18]

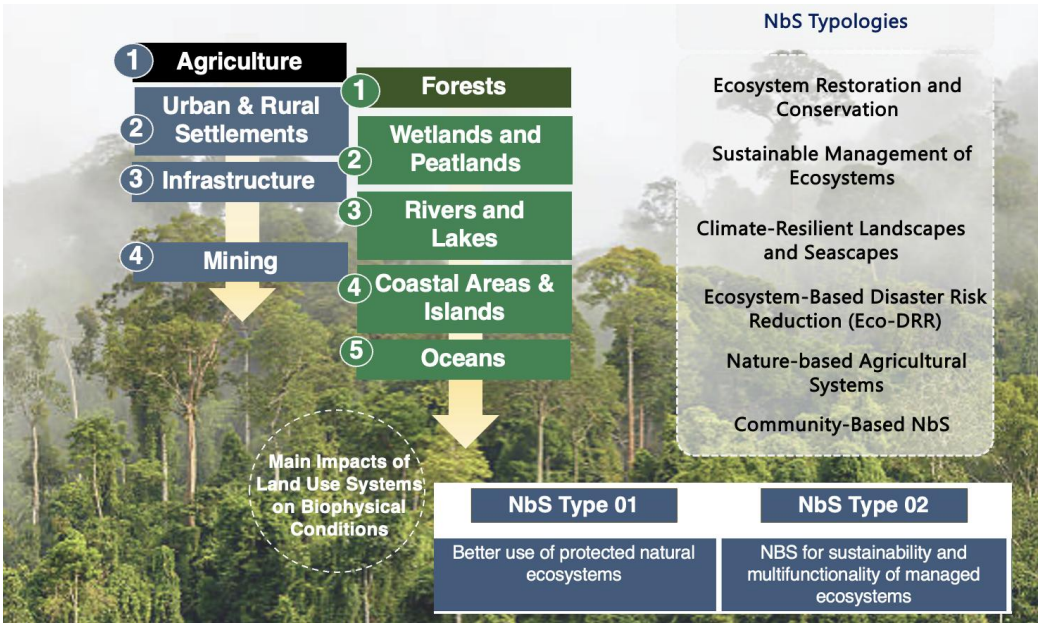
[18] UNEP article: Battling pollution in the Philippines' largest lake: https://www.unep.org/news-and-stories/story/battling-pollution-philippines-largest-lake
Fishpen and Fishcage Culture in Laguna de Bay: Status, Economic Importance, and the Relative Severity of Problems Affecting its Practice, Danilo C.Israel, Philippines Journal of Development, 2008

NbS practices in Regenerative Agriculture	
Technical Attributes	Employs soil health-focused farming techniques such as cover cropping, agroforestry, crop rotation, and minimal tillage. In aquaculture, regenerative practices include polyculture (raising multiple species), use of natural feed, and water recycling. Paludiculture (wet agriculture) involves cultivating crops like reeds, sedges, and rice in wetlands and peatlands, allowing productive use of land without draining peat, thereby preserving carbon stores and maintaining hydrological cycles.
Environmental Attributes	Enhances soil fertility, increases carbon sequestration, reduces chemical inputs, and promotes biodiversity. Aquaculture and paludiculture support water retention, reduce soil degradation, and help rehabilitate degraded or waterlogged lands, which are abundant in Southeast Asia. These practices also support fish stocks, biodiversity, and water quality in coastal and inland aquaculture systems.
Project Management Attributes	Requires training for local farmers and fishery operators, initial investment in regenerative practices, and policy support to shift away from intensive, resource-depleting agriculture. Management involves continuous monitoring of soil and water quality, alongside community-led efforts to adapt these practices locally.
Effectiveness for EbA and Eco-DRR	Highly effective in enhancing resilience of agricultural landscapes, reducing soil erosion, improving water management, and increasing productivity under changing climate conditions. Reduces the need for artificial inputs and preserves natural soil and water functions, making landscapes more resilient to drought, flooding, and extreme weather.
Risk Analysis	Risks include initial low yields as soil health builds over time, limited access to regenerative resources (e.g., seeds for cover crops), and potential market instability for unconventional crops. Investment in training, government support for regenerative practices, and creation of local cooperatives can help manage these challenges.
Alignment with IUCN Criteria	Strong alignment with IUCN NbS criteria, as regenerative agriculture actively restores ecosystem functions, supports livelihoods, reduces greenhouse gas emissions, and is adaptable to local contexts. It also promotes long-term food security by improving soil and water resources.

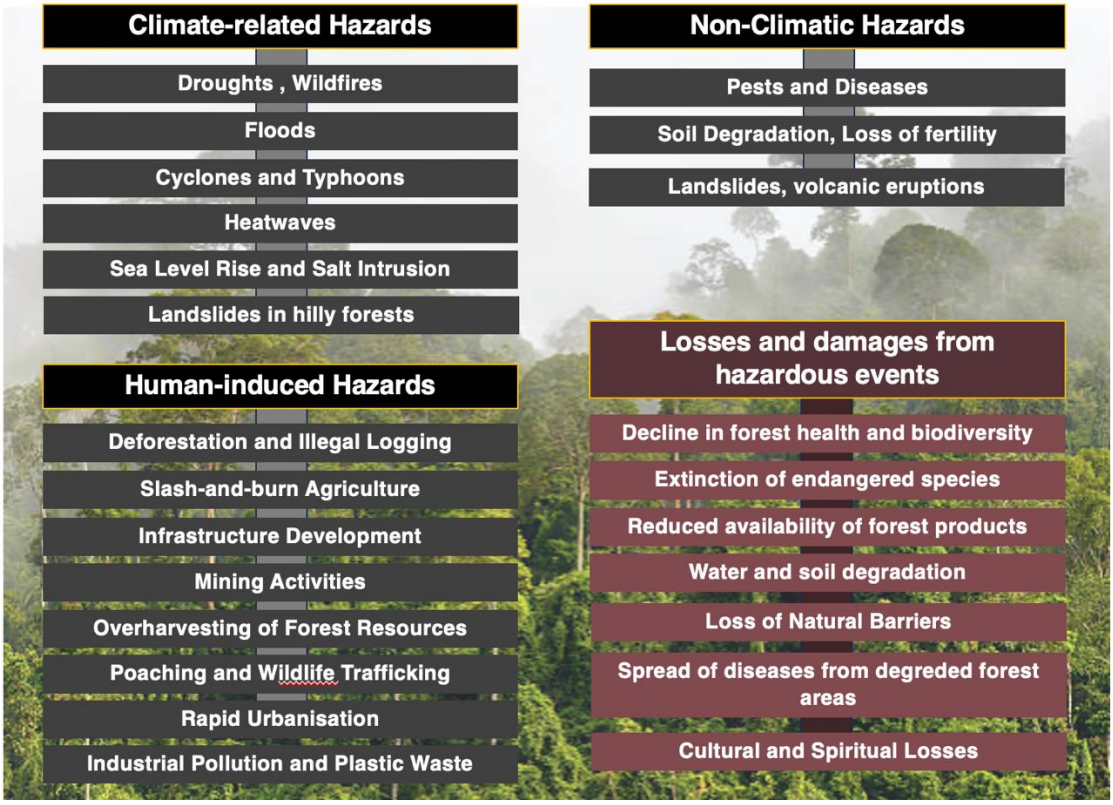
CSL07 – Healthy Forests and Natural Habitats

The wide variety of forest types in Southeast Asia have in common numerous threats such as deforestation, biodiversity loss, landslides, floods, droughts, and forest fires. These threats have led to numerous reforestation, afforestation, and conservation projects that involve communities and aim to bolster local economies. This climate-sensitive landscape category has a different approach as it covers all forest types in relation with their potential to recover biodiversity, improve agricultural practices, develop innovative solutions to protect forests from urbanisation, industrialisation, mining, infrastructure and related pollution risks.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Healthy Forests and Natural Habitats



2 – Main Disaster Risks and Related Damages in Healthy Forests and Natural Habitats



3 – Ecosystem Services in Healthy Forests and Natural Habitats

4 – List of NbS Supporting Healthy Forests and Natural Habitats

Southeast Asia is rich in biodiversity and hosts crucial forest ecosystems. Maintaining healthy forests and natural habitats is essential for climate resilience, sustainable livelihoods, and biodiversity conservation. The region faces significant challenges, including deforestation, land degradation due to agriculture and urbanisation, and the increasing risks posed by climate extremes such as floods, droughts, and fires.

To address these, a comprehensive approach using Nature-Based Solutions (NbS) is critical. These solutions are designed to restore and protect forests, mitigate the impacts of human activities, and create landscapes that are resilient to future climate and disaster risks.

Restoring degraded forests with native species, particularly in the upland areas of the Philippines (the Cordillera Mountains) and Vietnam (the Annamite Range), helps stabilise soils, reduce landslide risks, and improve water cycles. Upland reforestation and agroforestry, combined with sustainable practices such as rainforestation farming in the Philippines' Sierra Madre mountains, promote biodiversity and enhance carbon sequestration.

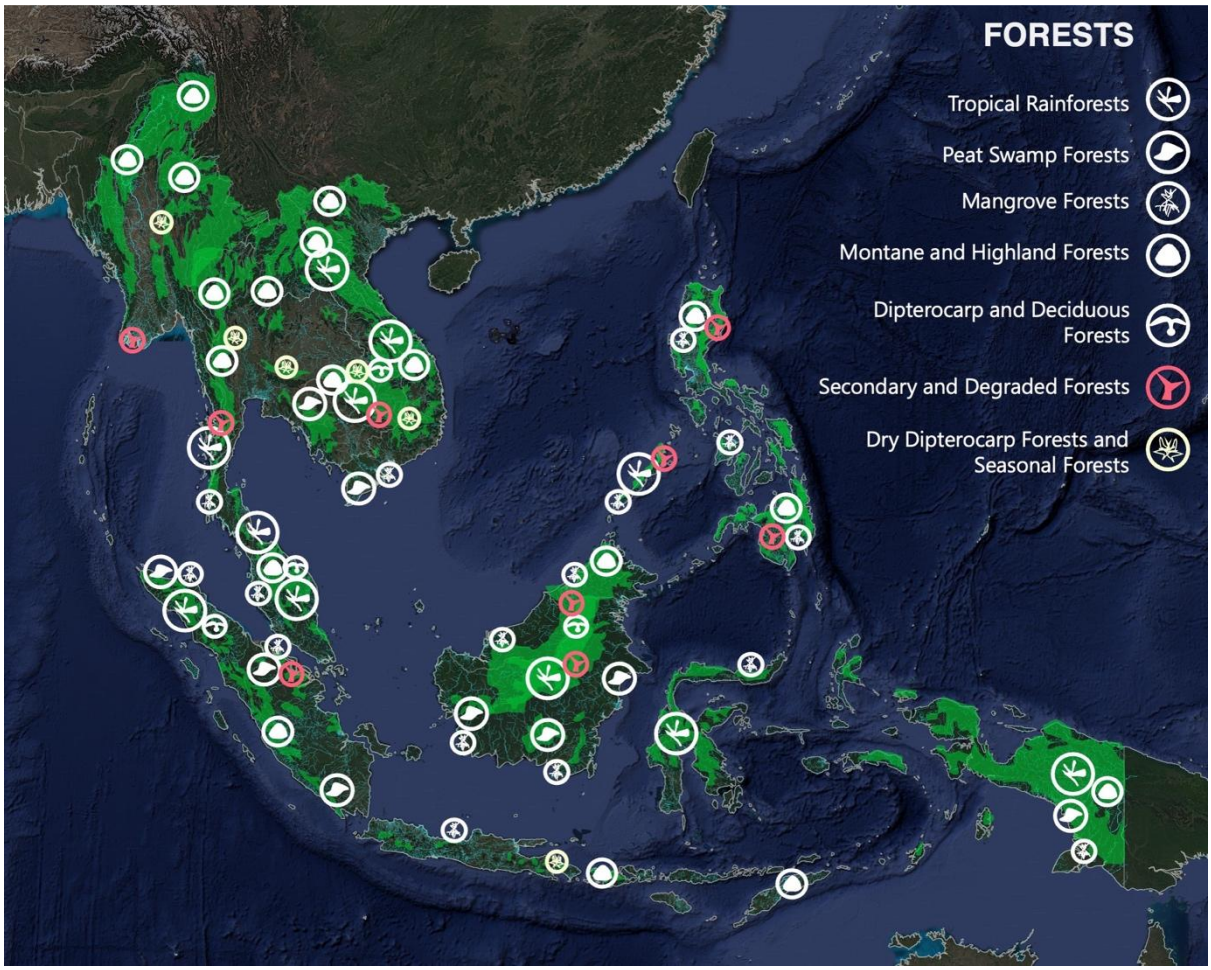
In Indonesia, peat swamp forest restoration in areas like Central Kalimantan plays a vital role in reducing carbon emissions, preventing fires, and safeguarding unique ecosystems. Similarly, riparian forest buffers along waterways, especially in regions like the Tonle Sap Lake basin in Cambodia and the Mekong Delta in Vietnam, protect water quality, reduce soil erosion, and mitigate flooding risks while providing critical habitats for wildlife.

To restore balance in areas affected by mining, urbanisation, and infrastructure development, techniques like bioengineering remediation of contaminated soils, phytoremediation forest corridors, and gully plugging have been identified as essential NbS. These strategies ensure that degraded landscapes, such as those impacted by illegal logging in Malaysia's Taman Negara National Park or urban expansion in Indonesia’s Java island, can recover, support biodiversity, and become functional ecosystems once again. Moreover, community-based initiatives such as community forestry in Thailand's northern forests and assisted natural regeneration in Laos' Xieng Khouang region foster local stewardship and ensure that forests are managed sustainably, benefiting both the environment and local communities.

In coastal areas, mangrove forest restoration in places like the Sundarbans in Indonesia, the coastlines of Thailand, and Vietnam's Mekong Delta enhances coastal protection against storm surges and sea-level rise while also providing important ecosystem services such as carbon sequestration and biodiversity support.

This is particularly relevant for countries where mangrove ecosystems are critical to both the environment and the livelihoods of coastal communities. Similarly, the integration of riparian sylviculture and vetiver grass systems along watercourses in Cambodia's Cardamom Mountains helps protect against erosion and improves water quality, providing further resilience in flood-prone regions.

5 – Mapping Forest Landscapes in Southeast Asia



Type 01: Tropical Rainforests

Found in lowland areas with high humidity, tropical rainforests are among the world's most biodiverse ecosystems. They are rich in plant and animal species but are highly susceptible to deforestation and biodiversity loss due to logging, agriculture, and urban expansion.
We find them in Borneo (Indonesia and Malaysia), the Cardamom Mountains (Cambodia), and the Philippine Island of Palawan.

Threats targeting tropical forests: Deforestation, biodiversity loss, land conversion for agriculture, and forest fires.

Identified projects and initiatives:

- Heart of Borneo Initiative (Indonesia, Malaysia, and Brunei): This tri-nation initiative aims to conserve 220,000 km2 of rainforest. It includes community forestry, eco-tourism, and sustainable agriculture projects to support local livelihoods while preserving biodiversity.[19]
- Cardamom Mountain Protection Program (Cambodia): Led by Wildlife Alliance, this program involves communities in reforestation and sustainable forest management to protect habitats from logging and land conversion.[20]
- Philippine Rainforestation Initiative (Philippines): This community-based reforestation initiative promotes the use of native species for forest recovery and integrates sustainable agroforestry to support local farmers.[21]

Type 02: Peat Swamp Forests

Found in low-lying coastal areas, peat swamp forests store vast amounts of carbon but are prone to fires and drainage, which release greenhouse gases. These forests are also crucial for flood prevention and water regulation. We find them in Riau and Kalimantan (Indonesia), Selangor (Malaysia), and the Mekong Delta (Vietnam). Threats targeting peat swamp forests: Deforestation, peatland drainage for palm oil plantations, fires, and greenhouse gas emissions.

Identified projects and initiatives:

- Indonesia's Peatland Restoration Agency (BRG): Working to restore over 2 million hectares of degraded peatlands by involving local communities in reforestation and sustainable peatland management.[22]
- Selangor State Peatland Conservation Program (Malaysia): Aims to restore degraded peatlands and prevent fires by re-wetting dried-out areas and involving communities in fire prevention and eco-friendly agriculture.
- Coastal Wetlands Conservation Program (Vietnam): Protects and restores peat and mangrove forests, integrating sustainable fishing and agroforestry practices to support local communities while maintaining carbon-rich ecosystems.

Type 03: Mangrove Forests

Mangrove forests are located along coastlines and river deltas, mangrove forests act as natural barriers against erosion, storm surges, and saltwater intrusion. They are important nurseries for marine life and protect coastal communities. They are located in Mekong Delta (Vietnam), Gulf of Thailand (Thailand), and along coastlines in the Philippines and Myanmar. Threats targeting mangrove forests include coastal development, aquaculture, pollution, and climate change impacts like sea-level rise.

Identified projects and initiatives:

- Mangroves for the Future (Regional): Supported by the IUCN and UNDP, this program promotes mangrove restoration through community-led planting initiatives, ecotourism, and sustainable fishing to support local economies.[23]

[19] See Declaration of the Heart of Borneo Initiative, WWF website: https://wwf.panda.org/discover/knowledge_hub/where_we_work/borneo_forests/about_borneo_forests/declaration/
[20] Guardians of the Cardamons, Wildlife Alliance: https://www.wildlifealliance.org/guardians-cardamoms/
[21] https://rainforestation.ph/
[22] https://www.mongabay.co.id/
[23] IUCN Report - Mangroves for the Future: A Strategy for Promoting Investment in Coastal Ecosystem Conservation, 2007-2012: https://portals.iucn.org/library/sites/library/files/documents/2007-040.pdf

- Philippines' National Greening Program: A large-scale reforestation project that includes mangrove reforestation to protect coastlines from erosion and provide habitats for marine life, with a focus on local employment and sustainable fishing.[24]
- Myanmar Coastal Conservation Program: Led by Fauna & Flora International (FFI), this project works with local communities to restore mangroves for coastal protection, carbon sequestration, and sustainable livelihoods.

Type 04: Montane and Highland Forests

Montane forests are found in mountainous regions, often with cooler climates and unique flora and fauna adapted to high altitudes. These forests play a crucial role in regulating water flow and preventing landslides. We located them in Annamite Range (Vietnam and Laos), Tenasserim Hills (Thailand and Myanmar), and northern Luzon (Philippines). These ecosystems are threatened by deforestation, agriculture expansion, landslides, and climate-related events.

Identified projects and initiatives:

- Green Annamites Project (Vietnam): A USAID-funded initiative that includes reforestation, sustainable agroforestry, and eco-tourism to support local livelihoods in the Annamite Mountains while conserving forest cover and biodiversity.[25]
- Northern Luzon Conservation Initiative (Philippines): Focuses on preserving the highland forests by integrating agroforestry and reforestation with native tree species, helping communities mitigate landslides and improve soil health.
- Highland Agroforestry Program (Thailand): Promotes sustainable farming practices, reforestation, and native tree planting with local hill tribes, enhancing soil stability and biodiversity conservation.[26]

Type 05: Dipterocarp and Deciduous Forests

These forests, dominated by hardwood Dipterocarp species, are known for rich biodiversity but are vulnerable to logging and fires. Deciduous forests are seasonally dry, with flora and fauna adapted to these conditions. We find them in Cambodia's Northern Plains, Isan region (Thailand), and Borneo (Indonesia and Malaysia). They are threatened by logging, agriculture, fires, and biodiversity loss.

Identified projects and initiatives:

- Cambodia Northern Plains Forest Conservation Project: Led by WCS, this project integrates sustainable land use, eco-tourism, and community-based forest management to protect Dipterocarp forests and associated wildlife, including endangered bird species.[27]
- Forest Restoration and Agroforestry Project (Isan, Thailand): A collaboration between local NGOs and government agencies, this project encourages sustainable farming, community forest management, and reforestation with native species.[28]
- Sabah Forest Restoration Initiative (Malaysia): Focuses on restoring Dipterocarp forests impacted by logging through community reforestation programs and eco-tourism development in collaboration with local indigenous communities.

[24] https://denr.gov.ph/
[25] https://www.snv.org/project/usaid-green-annamites-project
[26] Thailand's Community Forest Act: https://www.recoftc.org/sites/default/files/publications/resources/recoftc-0000392-0001-en.pdf
[27] USAID report, Case Study: Tmatboey Community-based Ecotourism Project, Cambodia, 2008
[28] https://www.fao.org/4/ac648e/ac648e0e.htm

Type 06: Secondary and Degraded Forests

Often arising from previously logged or cleared land, secondary forests are less diverse but play an important role in restoring ecological functions and sequestering carbon. We can find them across Southeast Asia, especially in areas that were previously logged or used for agriculture, such as parts of Sumatra (Indonesia) and Mindanao (Philippines). They usually are threatened by soil degradation, low biodiversity, invasive species, and vulnerability to re-clearing.

Identified projects and initiatives:

- Indonesia's National Peatland and Mangrove Restoration Project: Targets degraded secondary forests in peatland areas, engaging communities in reforestation, agroforestry, and sustainable land management practices.
- Mindanao Reforestation and Livelihood Project (Philippines): This project reforests degraded lands with a mix of native and agroforestry species, providing both ecological benefits and income opportunities through agroforestry and sustainable timber.[29]
- Forest and Farm Facility (Myanmar): A FAO-led initiative that supports reforestation and sustainable forest management by smallholders, helping to restore degraded areas while supporting local economies.[30]

Type 07: Dry Dipterocarp Forests and Seasonal Forests

We find these specific dry forests in areas with distinct dry seasons, as they are adapted to drought and occasional fires, with resilient species. However, they face challenges from land conversion and fire. They are located in Northern Thailand, Myanmar's central dry zone, and parts of Cambodia. Usual threats are logging, land clearing for agriculture, and seasonal fires.

Identified projects and initiatives:

- Thailand's Sustainable Agroforestry in Dry Dipterocarp Forests: Promotes sustainable land use by integrating agroforestry, reforestation, and fire management in northern Thailand to maintain biodiversity and support communities.
- Dry Zone Greening Project (Myanmar): In the central dry zone, this project works to restore degraded dry forests through community-led reforestation, fire management, and sustainable farming practices.

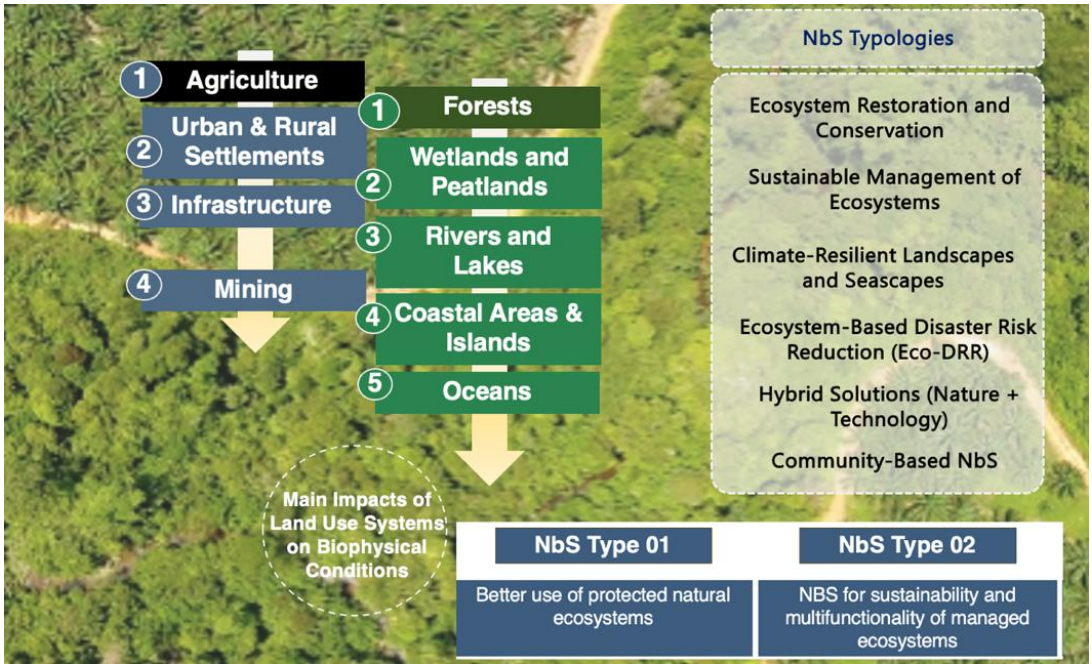
[29] Forest Restoration and Rehabilitation in the Philippines, Lucrecio L.Rebugio, 2009
[30] IUCN Workshop on Restoring Myanmar's Degraded and Deforested Landscapes; Thingaha Hotel, Nay Pyi Taw, Myanmar, 9-11 November 2016 (Workshop report: https://portals.iucn.org/library/sites/library/files/documents/Rep-2016-021.pdf)

NbS practices in Healthy Forests / Agroforestry / Slopes	
Technical Attributes	Integrates trees with crops or livestock to improve soil fertility, water retention, and crop yields. Techniques include contour planting, tree intercropping, and terracing for erosion control.
Environmental Attributes	Enhances biodiversity, improves soil health, and supports watershed stability, which is essential in regions prone to landslides and soil erosion.
Project Management Attributes	Requires training for farmers in agroforestry practices, and incentives for maintaining tree cover, often in partnership with local or regional agricultural organisations.
Effectiveness for EbA and Eco-DRR	Effective in stabilising slopes, reducing landslide risk, and increasing resilience to droughts. Agroforestry also provides diversified income sources, enhancing community adaptive capacity.
Risk Analysis	Risks include crop failure if there's insufficient training in agroforestry techniques or lack of market access for diverse products. Support systems, like extension services and farmer cooperatives, help manage these risks.
Alignment with IUCN Criteria	Strong alignment with IUCN criteria due to its provision of ecosystem services, livelihood benefits, and adaptability to local conditions, especially if community-managed.

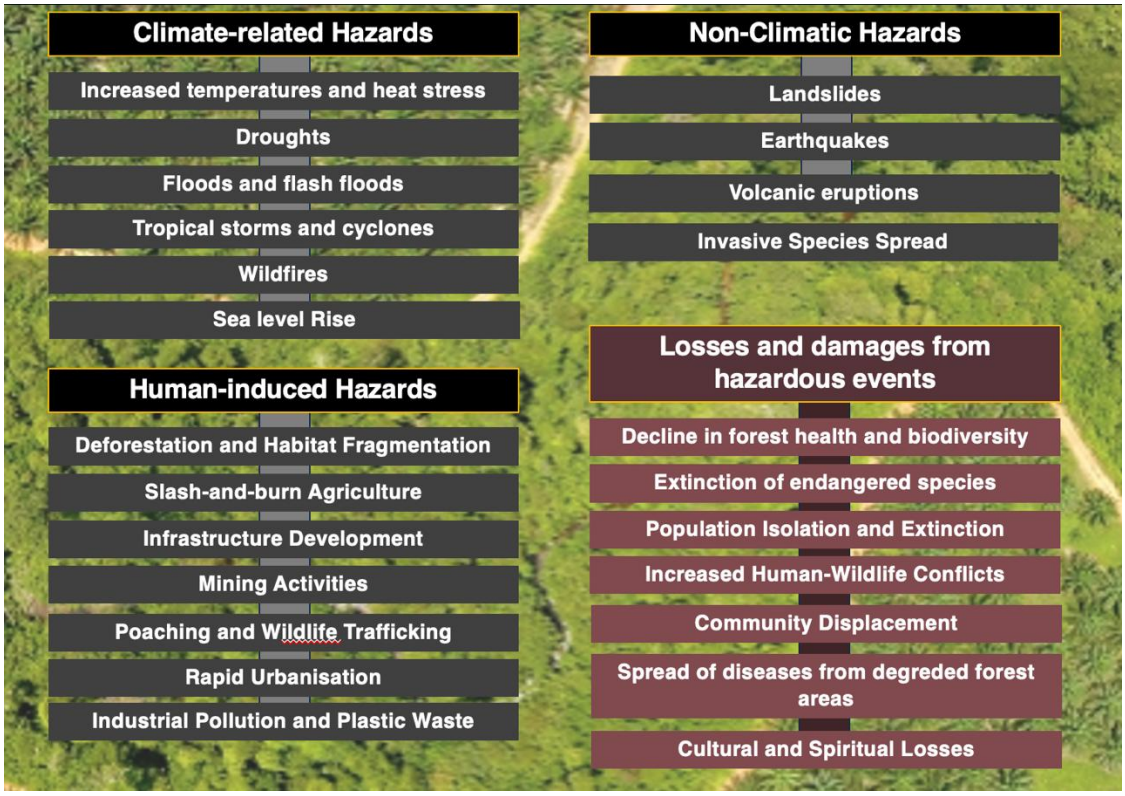
CSL08 – Wildlife Corridors for Ecological Connectivity

Wildlife corridors in Southeast Asia are crucial for maintaining biodiversity and supporting the movement of larger species across fragmented habitats. Many corridors face spatial interruptions and biodiversity loss due to monocultures, urbanisation, infrastructure development, and mining. We see a high potential for ecosystem-based approaches and nature-based solutions to contribute to the sustainability of those eco-corridors, as they play roles of linkages for fauna and flora, of buffer zones between conflictual land use systems and between nature and human activity. For this reason, wildlife corridors are identified as climate-sensitive landscapes and their principles can also be applied to seascapes. There are promising initiatives that aim at restoring connectivity for ecological resilience.

1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Wildlife Corridors for Ecological Connectivity

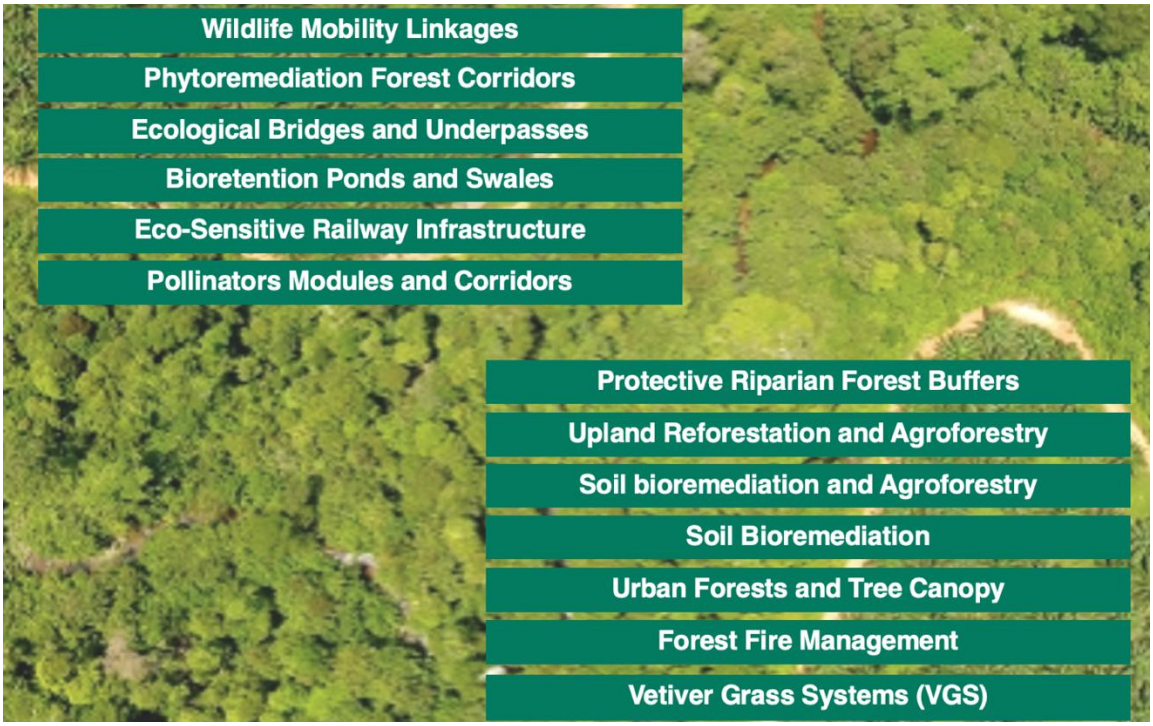


2 – Main Disaster Risks and Related Damages in Wildlife Corridors for Ecological Connectivity



3 – Ecosystem Services in Wildlife Corridors for Ecological Connectivity

4 – List of NbS Supporting Wildlife Corridors for Ecological Connectivity



Southeast Asia is shaped by rapidly expanding urbanisation, agriculture, and infrastructure development and its development model poses a growing threat to biodiversity and the integrity of ecosystems. Maintaining ecological connectivity is vital for the survival of many species. The fragmentation of natural habitats disrupts migratory paths, isolates populations, and intensifies the challenges species face in adapting to climate change. To address these pressing concerns, a strategic nature-based approach to Wildlife Corridors for Ecological Connectivity is being developed, incorporating a suite of Nature-Based Solutions (NbS) tailored to regional and local climatic, biophysical, and socio-economic characteristics.

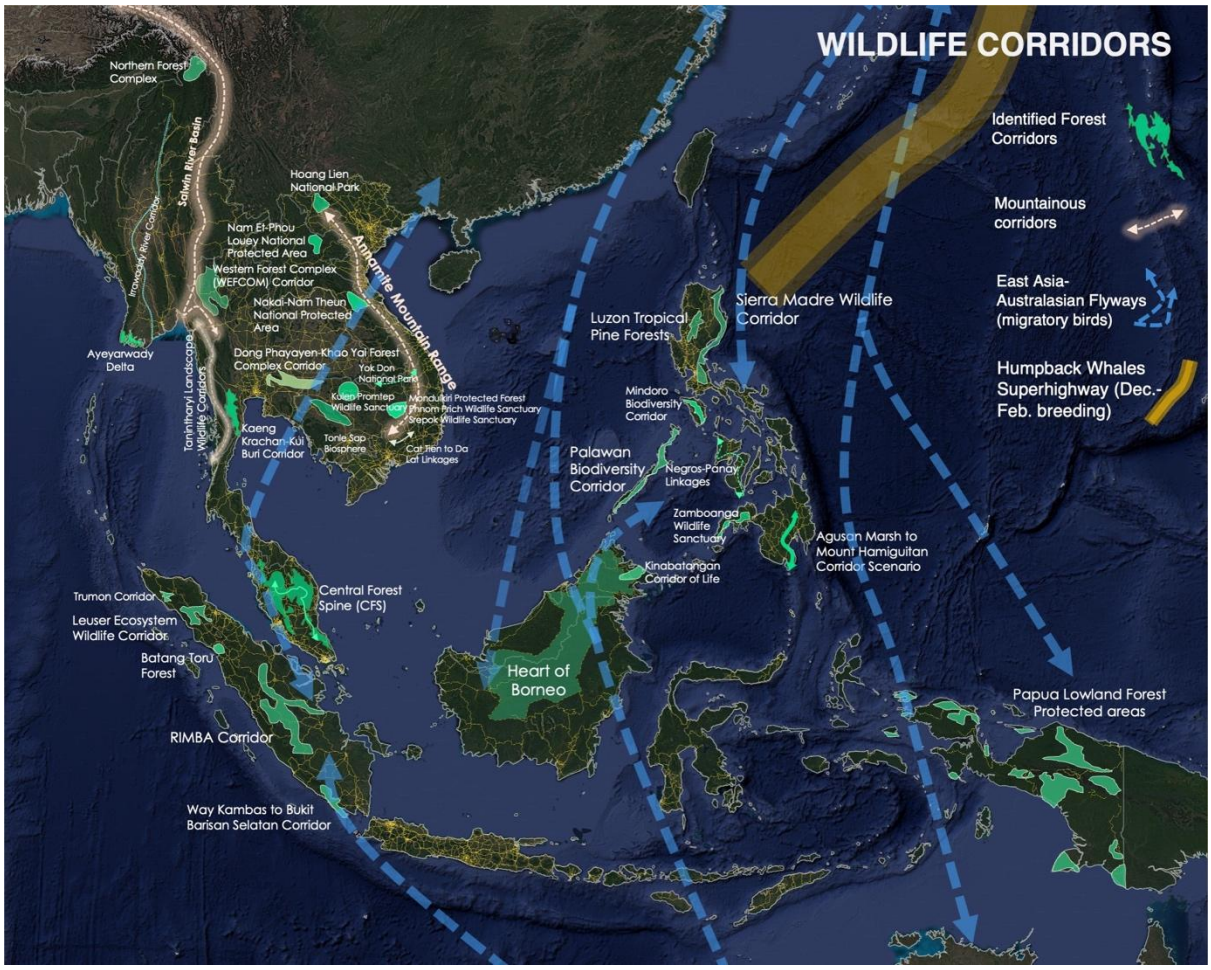
Key to this strategy is the restoration and establishment of wildlife mobility linkages across fragmented landscapes, connecting habitats that have been severed by agriculture, infrastructure, and urbanisation.

- For instance, in Malaysia's Borneo region, efforts to restore wildlife corridors are crucial for the conservation of endangered species like the Bornean orangutan and proboscis monkey, whose survival is threatened by deforestation and habitat fragmentation.
- In Thailand, the creation of ecological corridors through upland reforestation and agroforestry can maintain habitat continuity for species such as tigers, leopards, and elephants, enabling them to migrate freely between protected areas like the Huai Kha Khaeng Wildlife Sanctuary and the Thung Yai Naresuan Wildlife Sanctuary.
- Ecological bridges and underpasses are essential solutions in areas where infrastructure divides wildlife habitats. In Indonesia, where palm oil plantations and logging activities have heavily impacted orangutan populations in Sumatra and Borneo, the installation of wildlife corridors, such as overpasses and tunnels, could facilitate the safe passage of these critically endangered species across human-dominated landscapes.
- In Vietnam's Central Highlands, the creation of wildlife linkages over roads and railways is improving the movement of animals like sun bears and gibbons, which are increasingly affected by habitat loss and fragmentation.

Community involvement plays a key role in mitigating human-wildlife conflict, which is particularly common in regions like the forests of Cambodia and Laos, where agricultural expansion often encroaches on protected areas. By establishing community-managed buffer zones around parks and reserves, such as the Phnom Prich Wildlife Sanctuary in Cambodia, local populations can reduce conflicts with wildlife, while promoting sustainable livelihoods through eco-tourism and non-timber forest products. This approach helps to balance conservation goals with the needs of rural communities, fostering both ecological and social resilience.

Wetland connectivity is another critical aspect of wildlife corridors in Southeast Asia. The restoration of riparian and wetland habitats, particularly along important migratory routes, is vital for species such as migratory birds and amphibians. The Mekong Delta in Vietnam and Cambodia's Tonle Sap Lake provide important flyways for birds like the globally threatened Sarus crane and waterfowl species. Restoring wetlands and creating bioretention ponds in urban and rural areas enhances habitat quality and supports migratory movements, providing safe resting and feeding grounds.

5 – Mapping Wildlife Corridors in Southeast Asia



By restoring wildlife corridors, integrating ecological bridges, and creating connectivity between forests, wetlands, and marine ecosystems, Southeast Asia can protect its diverse species, maintain ecosystem services like pollination and seed dispersal, and increase resilience to climate and disaster risks.

1. Forest-Based Transboundary Corridors

- Greater Mekong Subregion (GMS): Spanning Thailand, Laos, Cambodia, Vietnam, and Myanmar, this region includes several cross-border corridors, such as the Indo-Burma Biodiversity Hotspot and areas connecting with China's Yunnan Province. Habitat fragmentation here is driven by monoculture plantations, road networks, and dams. Projects like the Biodiversity Conservation Corridors Initiated by the Asian Development Bank to reestablish connectivity through forest restoration and sustainable land management.[31]
- Leuser Ecosystem Corridor (Indonesia): This critical area in northern Sumatra is one of Southeast Asia's last refuges for endangered species like tigers, elephants, rhinos, and orangutans. It faces threats from palm oil plantations, mining, and illegal logging. Conservation organisations like the Leuser Conservation Forum and Aceh Government's Forest Restoration Program work to reconnect fragmented areas and protect this biodiversity hotspot.[32]
- Cardamom Mountains Rainforest Corridor (Cambodia): Home to many large mammals and endemic species, the Cardamoms are threatened by infrastructure projects, mining, and illegal logging. Efforts by Wildlife Alliance and Fauna & Flora International work to secure continuous forest corridors and promote sustainable livelihoods for local communities to limit further fragmentation.[33]

2. Mountainous and Highland Corridors

- Annamite Range Corridor (Vietnam and Laos): This biologically rich range is essential for the movement of species like the saola and Asian black bear. However, infrastructure projects, agricultural encroachment, and mining impact connectivity. WWF's Carbon and Biodiversity Project (CarBi) and the Green Annamites Project focus on creating protected corridor zones, forest restoration, and cross-border conservation agreements.[34]
- Tenasserim Hills Corridor (Thailand and Myanmar): This mountainous region provides vital connectivity for elephants, tigers, and gibbons, linking forests between western Thailand and eastern Myanmar. However, roads, dams, and logging disrupt these connections. Efforts led by the Wildlife Conservation Society (WCS) and WWF work on habitat restoration, establishing conservation zones, and mitigating the effects of roads on wildlife movement.[35]

3. Mangrove and Coastal Corridors

- Sundarbans Coastal Corridor (Indonesia and Malaysia): Mangrove corridors along Sumatra's coastlines are home to unique wildlife, including saltwater crocodiles, tigers, and migratory birds. These areas are threatened by shrimp farming, coastal urbanisation, and sea-level rise. Projects by Wetlands International and Mangrove Action Project work on restoring mangrove corridors, especially in degraded zones, to improve connectivity and support biodiversity.[36]
- Mekong Delta Coastal Zone (Vietnam): Mangrove restoration and conservation projects, like those implemented by IUCN, aim to restore connectivity between coastal mangroves and inland habitats, enhancing protection for migratory birds and marine species. Land-use changes and saltwater intrusion, however, remain significant challenges.

[31] Ecosystem Profile Report , Indo-Burma Biodiversity Hotspot , Indochina Region : https://www.cepf.net/sites/default/files/indo-burma-ecosystem-profile-2007.pdf
[32] https://globalconservation.org/projects/leuser-ecosystem-sumatra-indonesia
[33] https://www.conservation.org/cambodia/projects/central-cardamom-mountains-landscape
[34] https://www.wwf.mg/?362570/Central-Annamites-Rewilding-a-Transboundary-Landscape
[35] https://thailand.wcs.org/en-us/About-Us/Achieve-Project/Tenasserim-Corridor.aspx
[36] https://forestsnews.cifor.org/87675/crocodiles-tigers-rising-tides-fieldwork-in-the-largest-mangrove-forest-on-earth?fnl=

4. Agricultural and Agroforestry Corridors

- Eastern Plains Landscape (Cambodia): Rich in biodiversity, this region's connectivity is hindered by agriculture, rubber plantations, and mining. Initiatives led by WWF Cambodia promote sustainable land-use practices, agroforestry, and smallholder reforestation to maintain corridor areas for species like elephants and banteng.[37]
- Northern Luzon Agroforestry Corridor (Philippines): Agroforestry and reforestation efforts in Northern Luzon, supported by the Philippine Eagle Foundation, work to restore ecological connectivity in fragmented forests, allowing the movement of eagles and other wildlife. The primary challenges are road construction, monocultures, and logging.[38]

5. Corridors across Urban and Industrial Areas

- Singapore's Ecological Network: Singapore has developed an Eco-Link@BKE, a green corridor bridge that connects the Bukit Timah Nature Reserve with the Central Catchment Nature Reserve, aiding movement for native species like the Sunda pangolin and flying lemur. Urban fragmentation remains a challenge, but the *National Parks Board* is working to enhance green linkages within the urban matrix to further support connectivity.[39]
- Kinabatangan Wildlife Corridor (Sabah, Malaysia): The Lower Kinabatangan area is heavily fragmented by oil palm plantations and settlements, affecting connectivity for species like pygmy elephants and orangutans. HUTAN-Kinabatangan Orangutan Conservation Project and Sabah Wildlife Department focus on reforesting key areas and establishing riparian buffers to allow for movement through this semi-urban corridor.[40]

6. River and Floodplain Corridors

- Ayeyarwady River Corridor (Myanmar): The floodplains and seasonal forests along the Ayeyarwady River are critical habitats for migratory birds, freshwater species, and even some large mammals. Development pressures, damming, and mining threaten connectivity. Efforts by the Ayeyarwady Biodiversity and Conservation Project are focused on restoring riparian forests and establishing wildlife-friendly river management practices.[41]
- Chao Phraya River Corridor (Thailand): Supporting fish migration and bird habitats, the Chao Phraya floodplain experiences fragmentation from urbanisation and industrial activities. Restoration initiatives are led by local NGOs and the Royal Thai Government to protect seasonal wetlands and create flood-resilient buffer zones for biodiversity.[42]

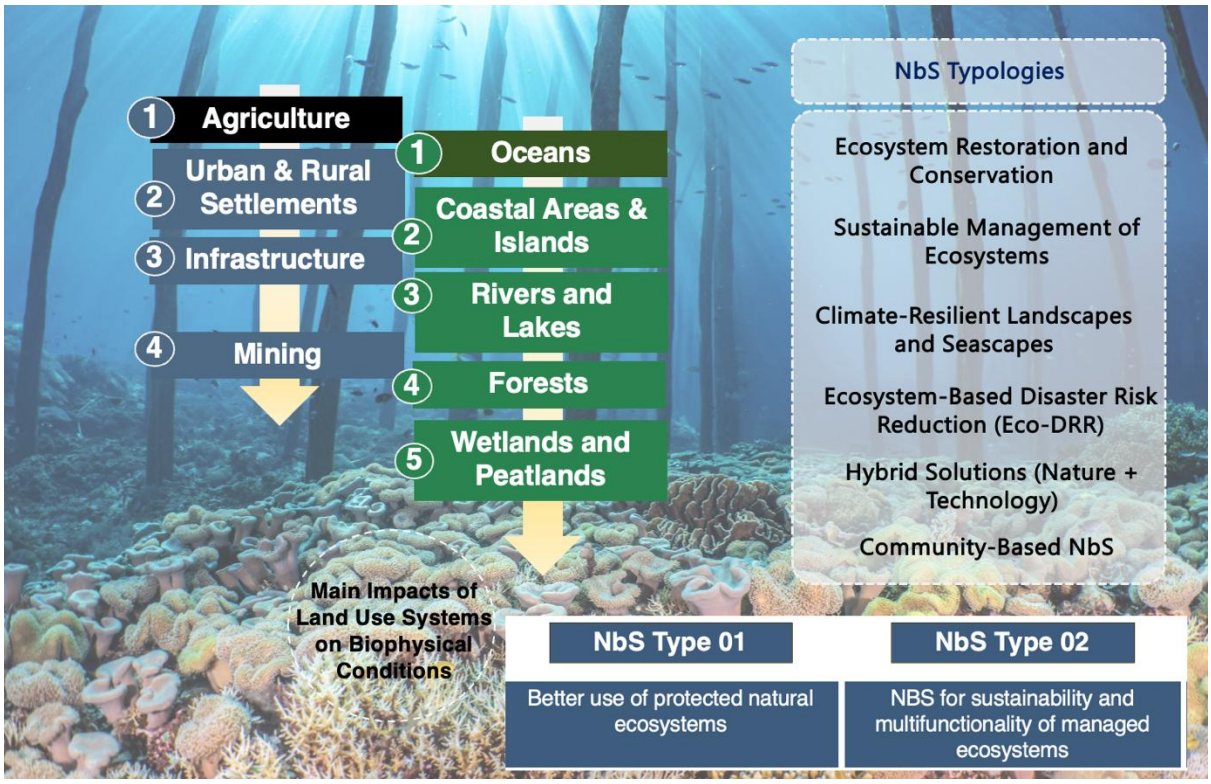
[37] https://origin-mekong.wwf-sites.org/challenges_in_the_greater_mekong/gold_mining_in_the_eastern_plains_landscape/
[38] Reforestation and Deforestation in Northern Luzon, Philippines: Critical Issues as Observed from Space, Gay Jane Perez, 2020
[39] https://www.nparks.gov.sg/nparksbuzz/issue-20-vol-1-2014/conservation/eco-link-bke--reconnecting-our-biodiversity
[40] Hutan 2021-2022 Report: https://www.hutan.org.my/wp-content/uploads/2024/04/Report_2021_2022SuperLight.pdf
EU Project : https://www.theorangutanproject.eu/project-summaries/hutan-kinabatangan-orangutan-conservation-programme/
[41] Ayeyawadi River Corridor Description: https://whc.unesco.org/en/tentativelists/5870/
[42] Flood and Drought Management Tools, Chao Phraya basin, GEF, UNEP and IWA Report: file:///Users/sebastiengoethals/Downloads/chao-phraya-basin-factsheet.pdf

NbS practices in Wildlife Corridors for Ecological Connectivity	
Technical Attributes	Establishes designated areas and linear corridors of native vegetation that connect fragmented habitats, allowing wildlife to move safely across industrial and developed landscapes. Techniques include land-use zoning, fencing modifications, and construction of wildlife overpasses or underpasses for safer crossings near roads or transport corridors.
Environmental Attributes	Maintains genetic diversity, reduces human-wildlife conflict, and supports the migration and breeding of species affected by habitat loss and fragmentation. Enhances ecosystem connectivity and resilience, particularly for species sensitive to changes in habitat continuity.
Project Management Attributes	Involves land-use planning in partnership with environmental agencies, NGOs, and local communities to identify, map, and protect critical wildlife paths. Requires ongoing monitoring of wildlife activity and habitat conditions, along with measures to prevent encroachment by industrial operations.
Effectiveness for EbA and Eco-DRR	Highly effective in supporting biodiversity resilience, especially for species vulnerable to industrial expansion and habitat loss. Corridors provide alternative pathways during extreme weather events or disasters, enhancing the adaptive capacity of both flora and fauna.
Risk Analysis	Risks include encroachment from industrial activities, inadequate corridor design, and potential for increased poaching in accessible areas. Regular monitoring, effective land-use zoning, and engagement with local communities for stewardship can mitigate these risks.
Alignment with IUCN Criteria	Strong alignment with IUCN's NbS criteria, as wildlife corridors provide measurable biodiversity benefits, improve ecosystem connectivity, and are adaptable to changing environmental and industrial conditions. They also foster community and stakeholder collaboration.

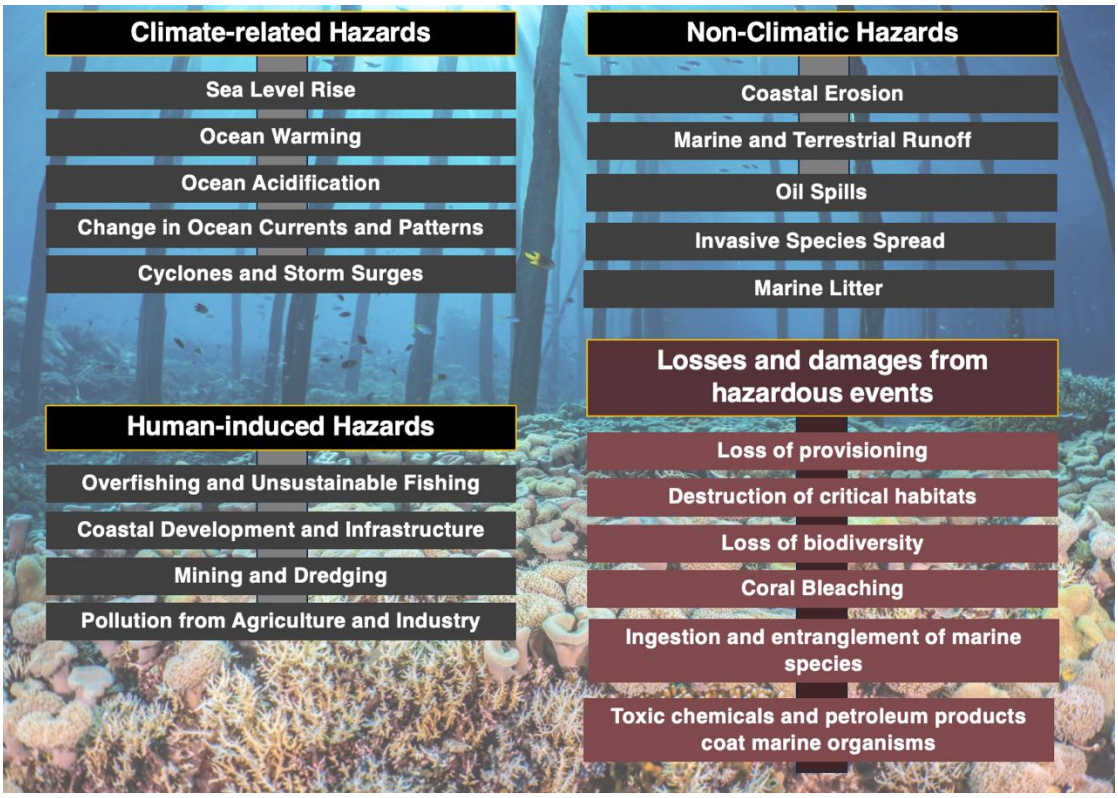
CSL09 – Regenerative Seascapes and Marine Habitats

Regenerative Marine Habitats and Oceans refer to coastal and marine ecosystems, including coral reefs, seagrass meadows, kelp forests, and oyster reefs, that not only support biodiversity but also provide essential ecosystem services to coastal communities in Southeast Asia. These habitats help buffer shorelines against storms, enhance fish stocks, sequester carbon, and improve water quality. However, they face significant threats from climate change, overfishing, and pollution. Ecosystem-based approaches and nature-based solutions (NbS), such as coral reef restoration, mangrove planting, and sustainable fisheries management, are critical to regenerating these habitats and restoring ecological balance, while also supporting sustainable livelihoods and food security for coastal populations.

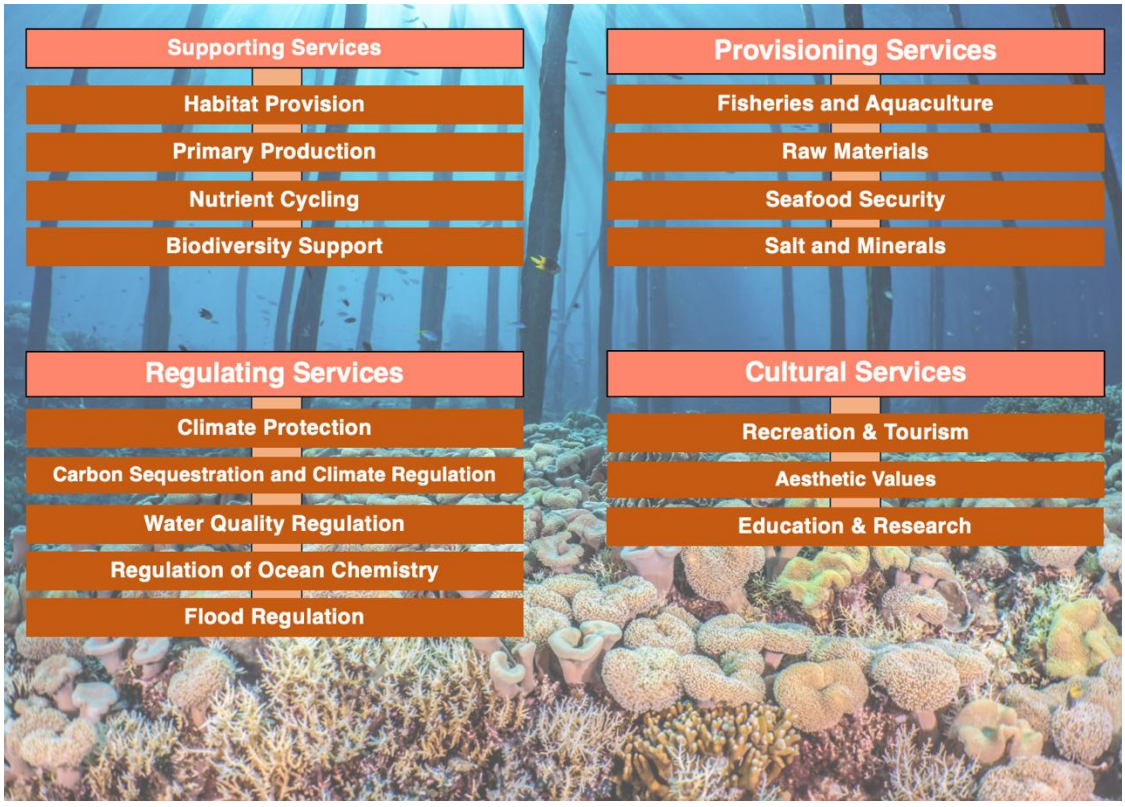
1 – Main Biophysical Conditions and Land Use Categories & Main NbS Typologies and Types addressing Regenerative Marine Habitats and Oceans



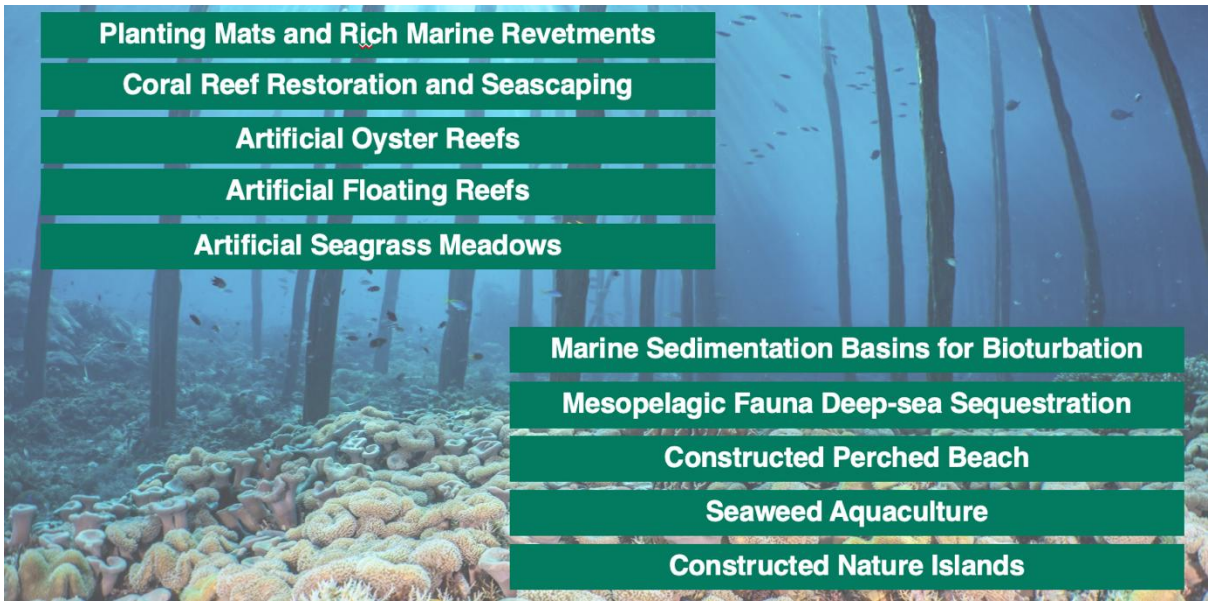
2 – Main Disaster Risks and Related Damages in Regenerative Marine Habitats and Oceans



3 – Ecosystem Services in Regenerative Marine Habitats and Oceans



4 – List of NbS Supporting Regenerative Marine Habitats and Oceans



Southeast Asia's marine ecosystems are not only among the most biologically rich in the world but also face significant pressures from climate change, overfishing, coastal development, and pollution. To address these challenges and create a more resilient and regenerative marine environment, a strategic approach involving Nature-Based Solutions (NbS) is essential. These solutions aim to restore and enhance marine habitats, increase biodiversity, support coastal protection, and strengthen the sustainability of local livelihoods, all while contributing to climate adaptation and mitigation efforts.

The regeneration of marine habitats begins with coral reef restoration, an urgent priority in the region, where reefs are being damaged by both natural and anthropogenic factors. Coral gardening and the establishment of coral nurseries play a critical role in rehabilitating these vital ecosystems. For instance, in the Philippines, coral nurseries and reef restoration programs along the coast of Palawan and Sulu are rebuilding degraded reefs, improving biodiversity, and reducing wave energy, which in turn protects coastal infrastructure from the impacts of storms and rising sea levels. Similarly, in Indonesia, the use of artificial reef structures not only provides habitats for marine species but also reduces the risk of coastal erosion and wave damage, creating a more stable coastline.

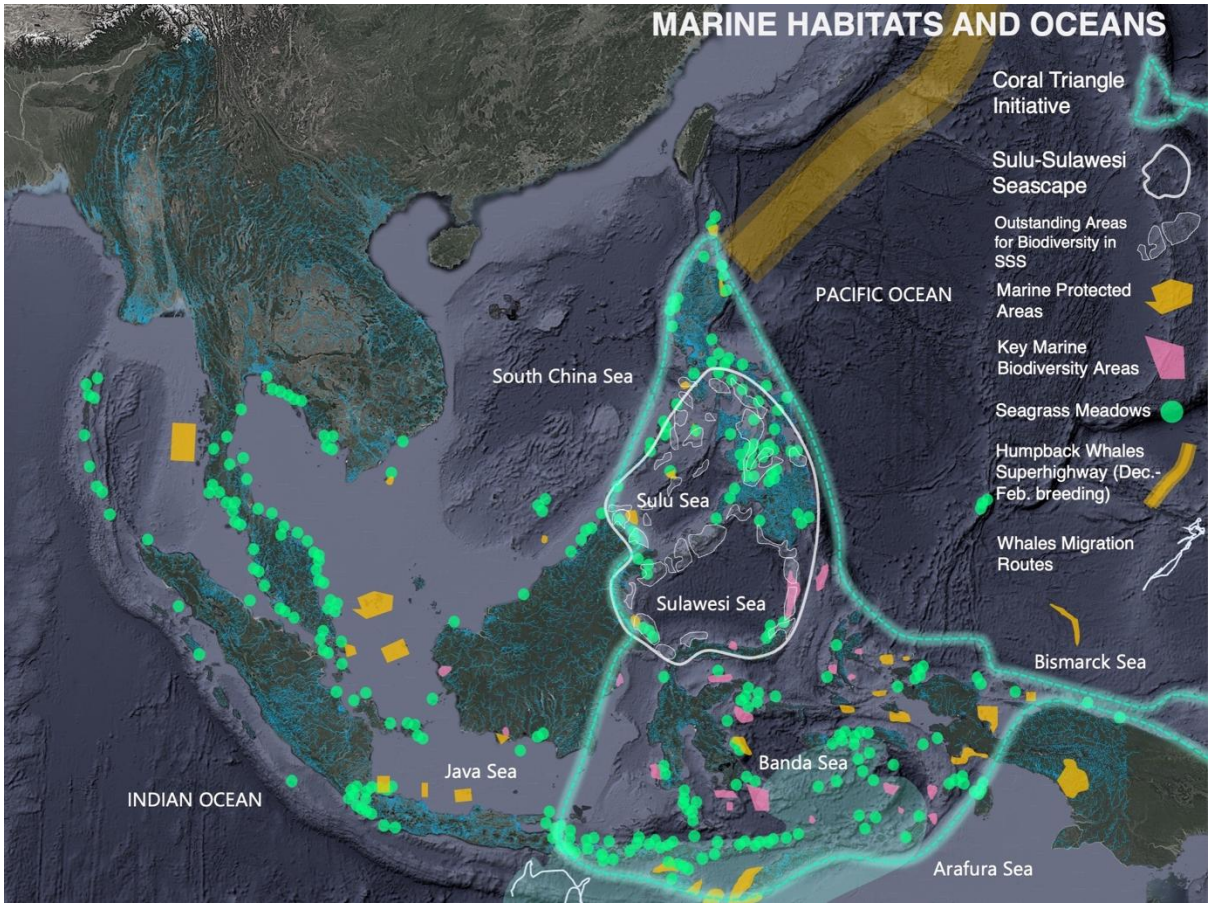
Mangrove-seagrass-coral ecosystems are another essential focus for restoration in Southeast Asia, particularly as they provide critical services such as water filtration, carbon sequestration, and habitat for fish stocks. In Malaysia's Sarawak region, efforts to restore degraded mangrove and seagrass beds have revived coastal ecosystems, promoting biodiversity, enhancing fisheries, and improving water quality. These systems also act as natural barriers, reducing the impact of storm surges and tsunamis while providing critical nursery grounds for marine life.

Beyond habitat restoration, integrating sustainable and healthy marine aquaculture systems is crucial for easing pressure on wild fish stocks. In Vietnam’s Mekong Delta, integrated aquaculture systems that combine fish farming with mangrove restoration are proving successful in maintaining ecological balance while supporting local communities. Similarly, in Thailand, seaweed aquaculture is being promoted not only as a source of income but also as an important contributor to ocean health, providing carbon sequestration and enhancing biodiversity in coastal waters.

Artificial reefs and rich marine revetments are an innovative solution to enhance biodiversity and provide protection to coastal areas. These structures, which can be made from natural materials like limestone or even artificial mats, serve as habitats for a variety of marine organisms, boosting local fisheries and improving the resilience of coastal ecosystems.

The deep-sea environment, often overlooked in marine conservation efforts, is also a focus for regenerative strategies. In particular, the creation of marine sedimentation basins and the sequestration of mesopelagic fauna—organisms that inhabit the deep sea—are emerging as important methods for enhancing deep-sea biodiversity and improving the health of ocean ecosystems. These methods are being explored in regions like the South China Sea and the Sulu Sea, where deep-sea habitats are home to a wealth of species that play a critical role in the global carbon cycle.

5 – Mapping Marine Habitats and Oceans in Southeast Asia



The creation of community-led marine-protected areas (MPAs) is central to ensuring the long-term health of Southeast Asia's marine ecosystems. In Indonesia, the implementation of MPAs in regions like Raja Ampat and Komodo National Park has helped safeguard critical biodiversity hotspots and supported sustainable fisheries, benefiting both marine life and the livelihoods of local communities.

The integration of these NbS for marine habitats and oceans in Southeast Asia presents a holistic approach to restoring and enhancing coastal and marine ecosystems. These solutions, such as coral reef nurseries, sustainable aquaculture, artificial reefs, and the protection of mangrove and seagrass ecosystems, not only contribute to environmental restoration but also increase resilience to climate change impacts, support biodiversity, and provide long-term socio-economic benefits for coastal communities.

1. Coral Reef Ecosystems

- Raja Ampat, Indonesia: Known for its rich coral diversity, Raja Ampat has projects led by Conservation International and local communities to rehabilitate degraded reefs through coral farming and the establishment of marine protected areas (MPAs), preserving biodiversity and supporting sustainable ecotourism.[43]
- Tubbataha Reefs Natural Park, Philippines: A UNESCO World Heritage Site, Tubbataha Reefs has strict protection measures overseen by the Tubbataha Management Office. Patrols and coral rehabilitation efforts, funded by ecotourism fees, safeguard these reefs from illegal fishing and climate-induced damage.[44]
- Pulau Weh, Aceh, Indonesia: Located at the tip of Sumatra, this island has a coral restoration program involving artificial reef structures and coral planting, supported by local NGOs and dive operators, which promotes marine biodiversity and resilience to bleaching events.[45]

2. Mangrove Forests and Coastal Wetlands

- Can Gio Mangrove Biosphere Reserve, Vietnam: Near Ho Chi Minh City, Can Gio's mangrove forests are rehabilitated through community-led planting initiatives. Supported by international NGOs and UNESCO, this site helps mitigate coastal erosion, protect biodiversity, and offers eco-tourism opportunities.[46]
- Bantayan Island, Cebu, Philippines: In response to typhoon damage, Bantayan Island has community-driven mangrove reforestation programs to protect coastlines and reduce storm impact. Supported by local cooperatives, these efforts enhance fish habitats and contribute to community resilience.[47]
- Koh Kong, Cambodia: Koh Kong's mangrove forests are rehabilitated through projects led by conservation groups like Fauna & Flora International, which work with local communities to replant mangroves and protect against coastal erosion and saline intrusion, supporting local fisheries and climate adaptation.[48]

3. Seagrass Meadows

- Bolinao, Pangasinan, Philippines: Seagrass meadows in Bolinao are restored by the University of the Philippines Marine Science Institute, which collaborates with local fisherfolk on replanting projects that help sustain fisheries and protect against coastal erosion.[49]
- Trang Province, Thailand: Trang's seagrass meadows, crucial habitats for dugongs, are protected by community-led initiatives supported by local NGOs. Seagrass restoration efforts here boost fish stocks and improve ecosystem health, benefiting local fisheries.[50]
- Pulau Langkawi, Malaysia: In Langkawi, a UNESCO Global Geopark, seagrass conservation projects led by local environmental organisations work to replant and protect seagrass beds. These efforts enhance biodiversity, protect against erosion, and support local ecotourism.[51]

[43] https://rajaampatbiodiversity.com/raja-ampat-conservation-efforts/
[44] Tubbataha Reefs Natural Park (as an extension of the Tubbataha Reef Marine Park) Philippines : IUCN Report
[45] Planting Artificial Reefs On the Pulau Weh: https://www.crowdfunder.co.uk/p/planting-artificial-reefs-on-the-pulau-weh
[46] https://old.ser-rrc.org/project/vietnam-mangrove-restoration-in-can-gio-ho-chi-minh-city/
[47] Sustainable Livelihood and Recovery for Super Typhoon Haiyan-affected Communities, UKAid, IMEC, ILO Report, Sept.2015: https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@asia/@ro-bangkok/@ilo-manila/documents/publication/wcms_427189.pdf
[48] Climate Change Vulnerability Assessment Koh Kapik Ramsar Site, Cambodia – IUCN Report, Pheakdey Sorn and Sonim Veth
[49] Institutional Issues and Perspectives in the Management of Fisheries and Coastal Resources in Southeast Asia, Magnus: https://digitalarchive.worldfishcenter.org/server/api/core/bitstreams/08682fd3-5d2e-4e0a-b8e1-83b97bd0d6fe/content
[50] Seagrass meadows support biodiversity and people in Trang, Thailand: TECHNICAL REPORT for the IKI Seagrass Ecosystem Services Project: https://www.projectseagrass.org/wp-content/uploads/2023/12/SAN_Project-Seagrass-Report_141223.pdf
[51] https://www.unesco.org/en/iggp/langkawi-unesco-global-geopark

4. Kelp and Seaweed Habitats

- Sibutu Reef, Tawi-Tawi, Philippines: A seaweed farming project in Tawi-Tawi supports local livelihoods while providing an alternative to fishing, reducing overfishing pressure on local reefs. These farms help sequester carbon and support marine biodiversity.[52]
- Off the coast of Sabah, seaweed cultivation projects aim to restore degraded areas and support the local economy. Managed by community cooperatives and supported by government programs, these projects offer sustainable income and contribute to marine health.
- Nusa Penida, Bali, Indonesia: A seaweed farming initiative in Nusa Penida involves local communities cultivating seaweed on traditional farms, which reduces fishing pressure on reefs and provides a sustainable income. This also enhances biodiversity by creating habitat for marine life.[53]

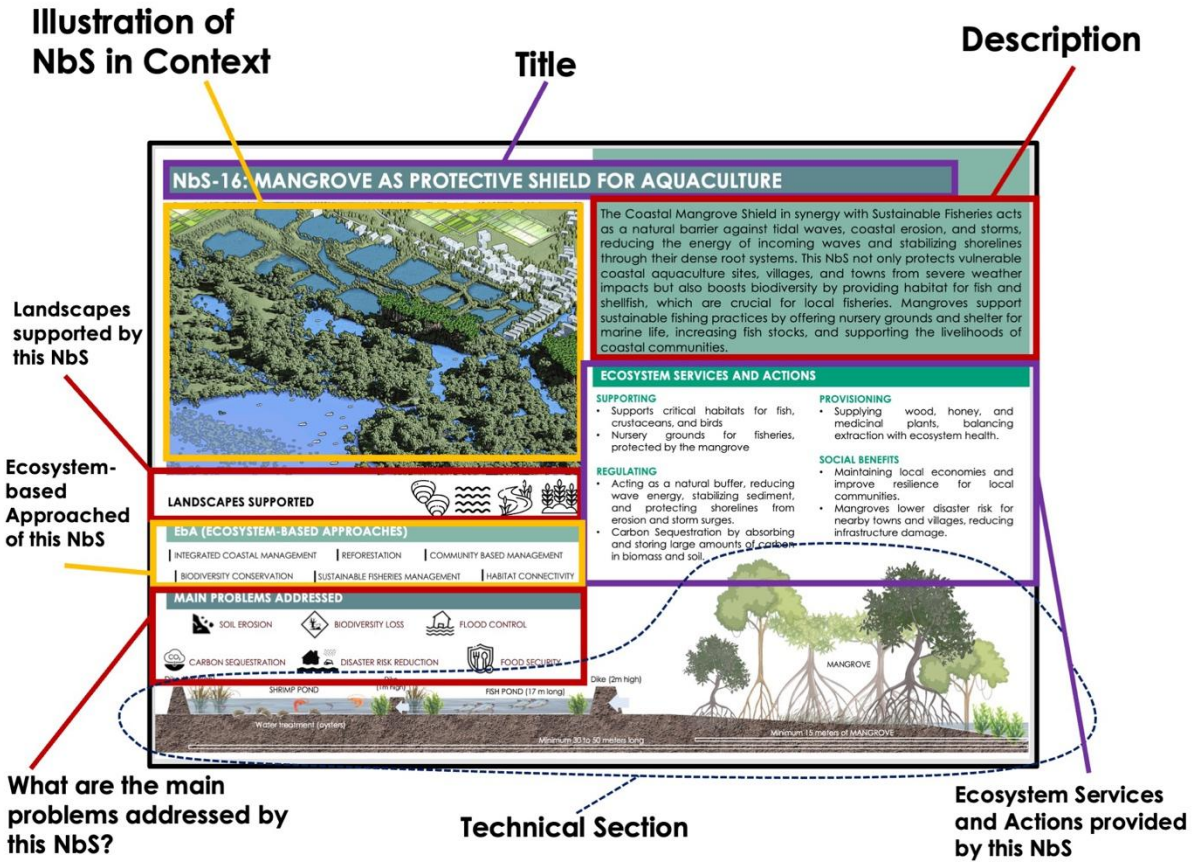
5. Oyster and Shellfish Reefs

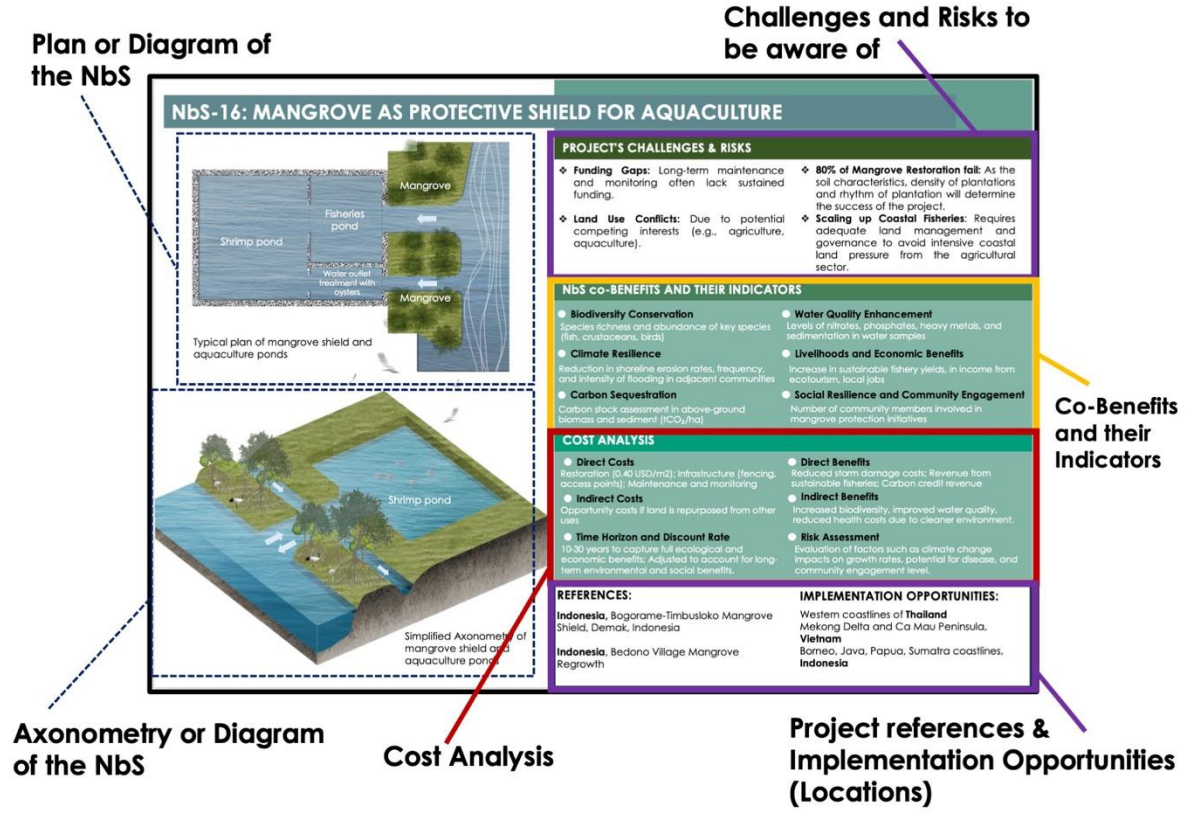
- Batangas Bay, Philippines: Batangas Bay is the site of shellfish reef restoration projects supported by local NGOs, where shellfish beds are restored to improve water quality and provide natural coastal protection against waves.
- Northern Palawan, Philippines: In Northern Palawan, oyster farming projects help restore shellfish reefs, which filter water and provide habitat for fish. These projects support local livelihoods while improving marine biodiversity and coastal resilience.
- Da Nang, Vietnam: In Da Nang, oyster reef restoration projects focus on water filtration and coastal protection. Supported by local government initiatives, these reefs help reduce pollution and buffer against erosion, benefiting both fisheries and the local economy.[54]

NbS practices in Regenerative Marine Habitats and Oceans	
Technical Attributes	Involves planting or transplanting seagrasses and coral fragments in areas affected by degradation. Requires careful selection of resilient species and favorable conditions for growth.
Environmental Attributes	Enhances marine biodiversity, stabilises coastal sediment, and buffers wave energy, protecting coastal areas from erosion.
Project Management Attributes	Often implemented with support from local fishers and diving communities, along with ongoing monitoring to assess health and growth.
Effectiveness for EbA and Eco-DRR	Highly effective in mitigating wave energy, protecting shorelines, and enhancing biodiversity, which strengthens resilience of coastal ecosystems.
Risk Analysis	Risks include degradation from pollutants, physical damage (e.g., from boats), and overfishing. Zoning for marine protection and community co-management can help address these risks.
Alignment with IUCN Criteria	Coral and seagrass restoration meet IUCN criteria, as they provide critical ecosystem services and support livelihoods while being adaptable based on environmental conditions.

[52] From Fishing to Farming in Sibutu Island, Tawi-Tawi, Mohammad Yasin
[53] https://www.coraltrianglecenter.org/2020/06/16/seaweed-farming-returns-to-nusa-penida-mpa/
[54] Oyster reefs and coastal protection, A literature review, Paul Vader, Research group Building with Nature, HZ University of Applied Sciences: https://www.deltaexpertise.nl/images/f/ff/Vader_%282014%29_-_Oyster_reefs_and_coastal_protection.pdf

4. Presentation of the NbS double-page content and List of the 70 NbS Cases presented in the Catalogue





Each of the 70 NbS will be presented with a double-page of description and illustrations. The content will systematically include:

Page 01:

- The number and title of the NbS
- An illustration of how the NbS is integrated and potentially scaled-up in a landscape of Southeast Asia
- The summary description of the NbS
- The landscape categories supported by the NbS
- The Ecosystem-based Approaches (EbA) of the NbS
- The main problems addressed by the NbS
- The Ecosystem Services and Actions provided by the NbS (supporting, regulations, provisioning and social benefits)
- A technical section of the NbS implementation if relevant

Page 02:

- A plan or diagram explaining and illustrating the NbS, if relevant
- Additional graphic materials, such as an axonometry of 3D rendered perspective
- The list of four project implementation's challenges and risks to be aware of
- The 6 main co-Benefits of the NbS and their indicators
- A summary Cost Analysis describing direct and indirect costs, direct and indirect benefits, time horizon and risk assessment in one sentence
- Some references of similar implemented projects, and the location of areas where there is a project implementation opportunity relevant to this NbS in Southeast Asia.

Following the description of the identified NbS to be implemented in synergy with landscape-based holistic strategies and scale-up opportunities, the full list of 70 NbS that will be presented in the Catalogue is presented below:

1. Inland Natural Wetlands
2. Constructed Wetlands
3. River Levee Setbacks
4. Reconnecting Oxbow Lake and River
5. Riverbank Stabilisation
6. Sediment Capture Traps
7. Riparian Buffer Zone, Bed Renaturation
8. Gully Plugging
9. Plastic Waste Capture Biofence
10. Aquifer Recharging Space / Infiltration Channel
11. Bioretention Ponds and Swales
12. Phytofiltration Basins & Water Bunds
13. Small Sand Dams
14. Terraced Green Riverfronts
15. Log Terracing (Water-Delay Infrastructure)
16. River Stream Restoration and Culverting
17. Salt Marsh Restoration
18. Tidal Flat Nourishment
19. Artificial Seagrass Meadows
20. Mangrove Forest Restoration
21. Paludiculture Associated Peatland
22. Planting Mats and Rich Revetments
23. Coral Reef Restoration and Nurseries
24. Coastal Reforestation (Shield)
25. Artificial Oyster Reefs
26. Permeable Green Streets and Roads
27. Green & Blue Roofs and Facades
28. Urban Water Buffer
29. Sponge City Park & Urban Oxbow
30. Urban Forest and Tree Canopy
31. Landfill Regeneration Park
32. Tidal Park
33. Urban Agriculture
34. Pollinator Modules and Corridors
35. Mangrove protective shield
36. Grassed Waterways
37. Beach Nourishment
38. Frontal Dune
39. Constructed Perched Beach
40. Natural Timber Groyne
41. Constructed Nature Island
42. Sand Trapping Fences
43. Windbreaks and Shelterbelts
44. Flood-Based Agriculture
45. Polyculture and Crop Rotation
46. Wastewater-Fed Aquaculture
47. Biochar and Crop Nutrient Management
48. Agri-Waste Smart Soils
49. Anti-Salt Bunds
50. Rainforestation Farming
51. Floating Treatment Wetlands
52. Drainage Reduction in Rice Paddy Fields
53. Seaweed Aquaculture
54. Vetiver Grass Systems
55. Soil Microorganisms and Biofertilisers
56. Bioengineering Remediation of Contamined Soils
57. Upland Reforestation and Agroforestry
58. Forest Fire Management
59. Wildlife Mobility Linkages
60. Ecological Bridges and Underpasses
61. Permeable Railway Infrastructure
62. Phytoremediation Forest Corridors
63. Ecological Airfield Buffer, Habitat Enhancement and Carbon Compensation System
64. Roadside Bioengineering and Slope Management
65. Electro-Wetlands
66. Gravel Wetlands
67. Vertical Dock Reefs
68. Artificial Floating Reefs
69. Marine Sedimentation Basins for Bioturbation
70. Deep-sea Sequestration of Mesopelagic Fauna

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