Nature-Based Solutions for Resilient Asian Deltas

Guidance for implementation, bridging the gap between politicians and financiers

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Executive summary

This study explores how Asian deltas could benefit from an integrated system approach for Nature-based Solutions (NbS). From the perspective of a system approach three interrelated main subsystems are elaborated addressing bio-physical/natural, institutional/governance and socio-economic (finance/investment) aspects, building on already existing information and experiences by involved consortium partners and currently on-going initiatives in Asian deltas. Aims of this study were to 1) demonstrate the added value and trade-offs of NbS, 2) raise awareness for NbS at a delta scale to attract and coordinate investments beyond the scale of individual projects, and 3) Provide guidance for selection of NbS in Asian deltas. The current scoping study was executed by WWF and the Delta Alliance under the Resilient Asian Deltas initiative.

To better illustrate how NbS can be scaled up, a comparison was made between three deltas in Asia i.e. the Mekong, Ganges-Meghna-Brahmaputra (GBM) and Ayeyarwady, describing and analyzing the three subsystems This resulted in delta specific conclusions and recommendations and in an indicative comparative assessment of their current status (by ‘traffic-light’ tables). Information for each delta was collected through online country-specific stakeholder and expert workshops and additional expert consultations. Although each delta has its own unique challenges, many of them have strongly overlapping themes. In many deltas, major systemic transformations may be needed to ensure water, energy and food security, sustainable development and a safe and healthy living environment now and in the future. The implementation of NbS for delta management is, thus, highly dependent on the existing environment, current and future pressures, clear strategies and goals, and institutional and financial frameworks. The pitfalls in governance, institutional, financial and bio-physical settings form the basis for recommendations with respect to upscaling NbS.

Main take-ways from this report that can be instrumental for the way forward are: 1) Amplifying NbS projects on much larger spatial scales will require a landscape approach, addressing both upstream-downstream linkages, channel-floodplains processess and the entire zonation of delta ecosystems; 2) To identify challenges for upscaling towards a landscape approach, adopting a system perspective and understanding system functioning is essential; 3) Regarding the subsystems it is recommended to respect and consider synergies between different ecosystems, develop strong organizational capacity, technical literacy and financial literacy, and respect and include socio-ecological linkages.

Abbreviations

Term	Definition
BNS	Bankable Nature-based Solutions
BWN	Building With Nature
GBM	Ganges-Brahmaputra-Meghna
IUCN	International Union for the Conservation of Nature
NbS	Nature-based Solutions
NDC	Nationally Determined Contributions
PPP	Public Private Partnership
RAD	Resilient Asian Deltas
SDG	Sustainable Development Goal
ToC	Theory of Change
WWF	World Wide Fund for Nature

Contents

1 Introduction

1.1 Rationale

Long-term persistence of worldwide deltas is being threatened by climatic and socio-economic pressures, such as sea level rise, growing population coupled with rapid economic development. Cascading effects of these pressures result in fundamental changes in flows of sediment and water. Sea level rise, land subsidence through groundwater extraction and reduced sediment input from rivers due to upstream river damming are undermining sustained provision of ecosystem services and by extension delta formation and their long-term persistence. This puts livelihoods of millions of people, billions of dollars in investments and trillions of dollars of economic assets at risk.

In Asia, the largest deltas harbor over 400 million people and a wealth of biodiversity. They are critical for national economies, food security and consequently for the development of the entire continent. The largest Asian deltas are responsible for most of the World's rice production. In transition zones between salt and fresh water, fish and shrimp farming are of local to global importance. Although these activities provide income and livelihoods, upscaling and incorporation in the global market economy take its toll on delta ecosystems.

Flows of water and sediment are key to the long-term survival of delta areas. **Nature-based Solutions** (NbS), which are defined by IUCN as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits", make use of ecosystems and their services (Figure 1-1) (for more definitions of NbS see Annex 6.1). NbS will more likely succeed with uninterrupted flows of water, sediment and nutrients. Hence, to implement and upscale nature-based solutions that are meaningful on a delta scale, awareness of boundary conditions with respect to input of sediment and freshwater that originate elsewhere in the river basin, is essential. Only then, sustainable development, conservation and restoration of biodiverse and healthy delta ecosystems that support delta productivity, can be realized. Additionally, function partitioning between NbS and traditional or hard infrastructure in optimized combinations, often referred to as "hybrid infrastructure", may warrant a large potential for future delta management.

Many (case)studies reveal that for upscaling NbS to entire deltas, several challenges need to be overcome, especially regarding governance, financing, and supportive institutional and legal arrangements. With the use of NbS, the aim is to foster sustainable delta development by increasing and optimizing (co-)benefits for multiple stakeholders. One of the main challenges is to make this work in practice and to implement bankable NbS[1] that are owned by multiple stakeholders (WWF 2020). In particular, the economic rationale for NbS implementation, its business case and financing models need to be further developed. Especially the development of financing models that consider non-monetary values and co-benefits could provide attractive information for investors, showing how NbS generates returns on investment. This return on investment can include avoided costs, such as flood damage, but more importantly, also include actual profits, from crop yields and tourism, to safekeeping natural resources, such as water availability and fertile soils, which also relates to biodiversity. Realization of such business models requires a shift from individual short-term economic gain to long-term benefits for multiple beneficiaries.

[1] Bankable NbS (BNS) as a subset of broader NbS. BNS stimulate conservation, have a return on investment and aim to de-risk investment.

Favouring business models that are locally led but acknowledge the wider (catchment) context, helps to obtain maximum return on investments but also to avoid possible negative effects on larger spatial scales such as increasing downstream flood risk by disruptive upstream interventions.

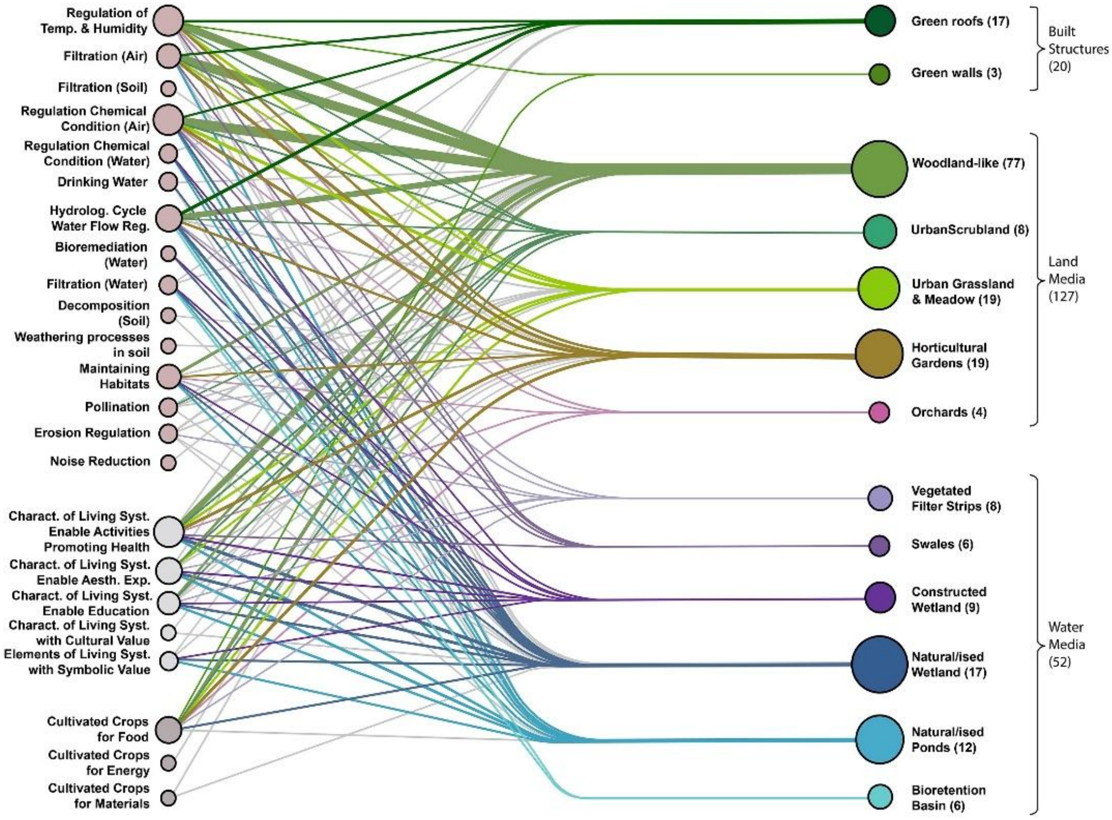

Figure 1-1 Example of linkage between ecosystem services and NbS benefiting humans (adopted from Almenar et al. 2021)

Moreover, NbS can contribute to a wide range of international standards and thereby help governments to achieve international agreements and targets, such as SDGs, NDCs, Sendai Framework and Aichi/NBSAPs. NbS can contribute to several of these simultaneously, if their implementation is combined with an adequate monitoring program. These contributions are also a precondition to tap earmarked international funds (e.g. climate finance), as an option to leverage private-sector asset investments. Here, we strive to provide information for both decision makers and financiers/investors to align policies and investments towards large-scale perspective on sustainable landscapes and implementation of NbS. All of this with the aim to work together towards resilient, healthy, biodiverse and profitable deltas and rivers.

1.2 Aim and target group

The overall objective of this report is to describe how Asian deltas may benefit from an integrated approach for NbS[2], addressing institutional, financial and technical aspects. For this will be built on existing information and experiences of involved consortium partners and from currently on-going initiatives in Asian deltas (Annex 6.2).

[2] Upscaling on NbS refers to mainstreaming NbS approaches and making them an option in the standard portfolio of interventions, as well as realizing large-scale implementation of NbS at landscape level.

The report has the following sub-objectives:

- Demonstrate the added value and trade-offs of NbS;
- Raise awareness for NbS at a delta scale to attract and coordinate investments beyond the scale of individual projects;
- Provide guidance for selection of NbS in Asian deltas.

Box 1.1 Delta challenges in Asia

The last decennia South East Asia showed unparalleled economic growth. Economic growth in the region equals population growth and several countries see an upcoming middle class (ADB, 2017). Population growth and increasing middle income households come with new challenges for deltas. Increasing population puts a pressure on natural resources, air and water quality, and biodiversity of deltas, through urban and industrial expansion, construction of new infrastructure, and intensification of agriculture. The need for clean drinking water results into overexploitation of groundwater reservoirs and the growing water demand for agriculture leads to rapid construction of retention dams and water reservoirs in rivers that feed the deltas, again resulting in large environmental impacts (Figure 1-1). Furthermore, to address increasing demands for energy, hydropower development on mainstem rivers has resulted in severe reduction in sediment transport and deposition in deltas. Many delta cities face uncontrolled growth with more people living in vulnerable areas, such as close to coasts and in floodplains. This increases exposure of people to floods and erosion. On top of this climate change effects in Asia result in more weather-related extremes, such as more hurricanes that make landfall in other places than before, but also in

1.3 WWF Resilient Asian Deltas pillars

This report was developed under the scope of the WWF's Resilient Asian Deltas (RAD) initiative, which aims to change business as usual in order to increase resilience of Asian deltas and in doing so to contribute to the implementation of the following SDGs: Climate change adaptation (13), Secured livelihood (1), Water security (6), Resilient Infrastructure (9), Food security (2), Biodiversity (14, 15), Sustainable Cities (11) and Partnerships (17) (see Figure 1-2 and Annex 6.3). The objectives of this report refer also to the three main pillars of the WWF Resilient Asian Deltas initiative (RAD) with focus on the second pillar: Building with Nature projects, which encompass (or are a synonym for) NbS.

Key principles as identified in the RAD initiative[3] include:

- POLITICAL ACTION: Secure leadership and political commitments
    - Raise the issue of resilient management up the political agenda
    - Mainstream holistic delta visions in each country
    - Increase community participation in decision making
    - Build political partnerships
    - Strengthen regional and transboundary collaboration
- BUILDING WITH NATURE: Implement building with nature solutions
    - Identify & Implement solutions to address the root causes of loss of resilience of deltas
    - Enable decision makers to identify BWN solutions with a Decision Support Framework (DSF)
    - Mainstreaming the DSF and BWN Principles into country planning
    - Private sector partners championing BWN

3 https://wwf.panda.org/discover/our_focus/freshwater_practice/freshwater_inititiaves/resilient_asian_deltas_initiative/

- FINANCIAL FLOWS: Mobilize financing to turn visions into actions
    - Develop a resource mobilization plan for each delta
    - Establish a delta project incubation facility for those needing a financial case
    - Secure financing for a pipeline of projects
    - Push for commitments on financing building with nature investments

For the RAD initiative, NbS can play a role to gain political support and mobilize resources for their upscaling. NbS that flag issues of delta management and raise it on the political agenda may create leverage and political commitment for holistic transboundary delta visions. On a local scale, NbS implementation can be facilitated through platforms to increase community participation and activate civil society. Real success however critically depends on coordinated upscaling of local NbS projects in connection with multi-sectoral objectives at landscape scale.

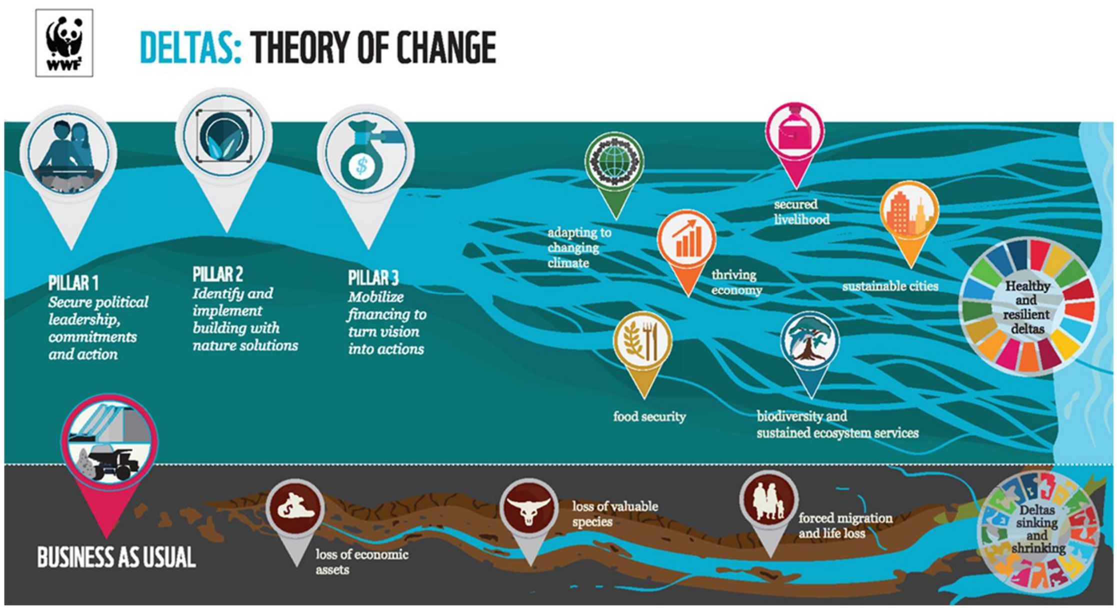

Figure 1-2 The outline of the WWF Resilient Asian Deltas initiative and the three pillars of focus.

1.4 Reading guide

Chapter 2 elaborates an integrated system approach, addressing three main subsystems: the biophysical, the institutional/governance and the socio-economic subsystem. Each subsystem is described briefly in relation to NbS. In the next chapter 3 governance and financial considerations for upscaling NbS are elaborated, explaining important elements of landscape governance and governing capacity. Moreover, structuring the value of NbS and possible finance streams are illustrated. In chapter 4 the natural, institutional and socio-economic systems are described for 3 deltas (the Mekong, GBM and Ayeyarwady), supplemented with an indicative assessment of their current status indicated in ‘traffic-light’ tables. This chapter ends with delta specific conclusions and recommendations. In the final chapter 5 more summarized and generic conclusions and recommendation are made, regarding the implementation and upscaling of NbS, addressing current pitfalls in governance, institutional, financial and bio-physical settings.

Key Messages - Introduction

- Long-term persistence of worldwide deltas is being threatened by pressures from climate change and growing population coupled with rapid economic development undermining sustained provision of ecosystem services and by extension delta formation.
- Unsustainable management practices are putting the livelihoods of millions of people, billions of dollars in investments and trillions of dollars of economic assets at risk.
- Flows of water and sediment are key to the long-term survival of delta areas.
- Nature-based Solutions (NbS) make use of ecosystems and their services and will more likely succeed with uninterrupted flows of water, sediment and nutrients.
- For upscaling NbS to entire deltas, several challenges need to be overcome, especially regarding governance, financing, and supportive institutional and legal arrangements.
- Optimizing (co)benefits for multiple stakeholders should be addressed as well as possible financing models for both bankable and non-bankable NbS.
- NbS can contribute to a wide range of international standards and thereby help governments to achieve international agreements and targets, such as SDGs, NDCs, Sendai Framework and Aichi/NBSAPs; these contributions are also a precondition to tap earmarked international funds (e.g. climate finance), as an option to leverage private-sector asset investments.

2 Integrated system approach

2.1 NbS implementation in river deltas

Often, coastal and river management result in monofunctional (sectoral) and piecemeal interventions that are not linked well in a coherent, comprehensive plan or vision. To shift the daily practice of river basin and delta management towards integrated management of deltas, a change to a system approach is required. This system approach refers to appreciation of all interacting/interrelated subsystems that constitute the system where interventions take place. The natural/biophysical system is an important subsystem in this respect, as it sets the environmental boundary conditions for interventions and for NbS in particular. In spatial planning this subsystem is often referred to as the base-layer. The other two subsystems are the institutional/governance system and the socio-economic (and related finance) system (Figure 2-1).

Systemic change can be instrumental in facilitating the shift towards a system approach. However, they should not be confused, as systemic change refers to a fundamental change that affects all elements and functions of a system. For systemic change it is considered essential to evaluate where the power in the system is situated and how to influence that. In addition, systems are, by nature, dynamic and complex and as such, systemic change is difficult to plan. Hence, innovation, experimentation and adaptation are needed for successful systemic change (Narberhaus, 2016).

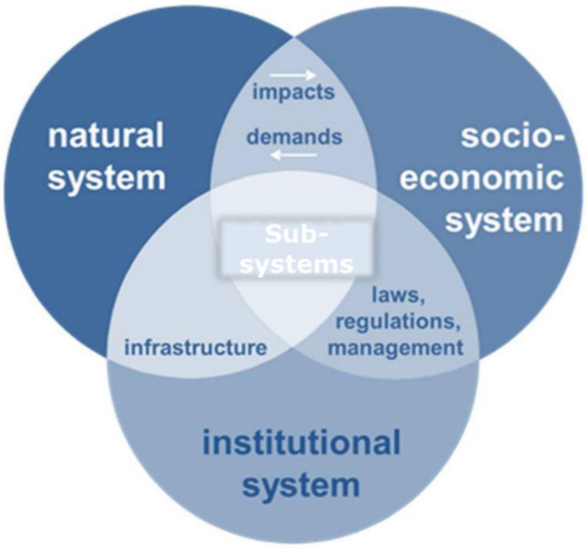

Figure 2-1 The three subsystems that need to be considered for a system approach

The implementation of nature-based solutions for delta management is highly dependent on the existing environment, current and future pressures, upstream-downstream interactions, nature conservation and biodiversity objectives, the socio-economic situation and financial and institutional frameworks. Conditions in the subsystems strongly guide optimized strategies and interventions for river, coastal or delta management. The chosen strategy and types of interventions depend on the type, intensity and probability of the hazard, the presence and status of ecosystems, the presence of assets and people and their livelihoods and on the institutional system in place.

For example, in rural and poor environments communities more often depend on ecosystem goods and services and interventions that do not respect these socio-ecological linkages may result in adverse effects and make communities more vulnerable by negatively impacting their main sources of livelihood and income. In addition, construction of hard infrastructure should be dealt with carefully in countries with no budgets for monitoring and maintenance. In these cases, hard infrastructure failure may have disastrous consequences. Hence, a system approach that considers and integrates the three subsystems, is essential to compile successful intervention strategies. As such, implementation of NbS in deltas should be based an a broad upstream-downstream system perspective, addressing aspects of all three interacting sub-systems (see Figure 2-2).

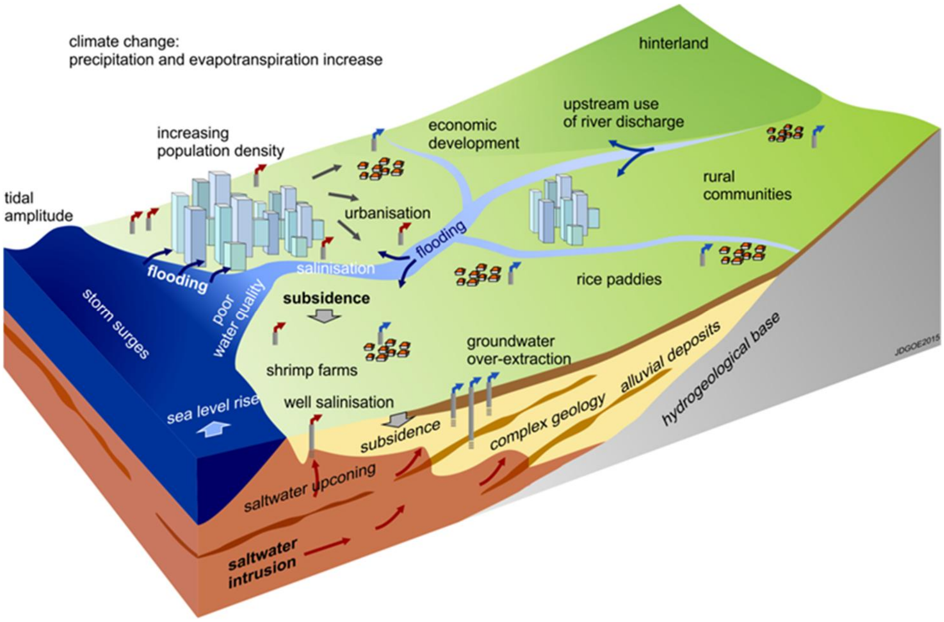

Figure 2-2 Delta land-use and delta challenges from a landscape and system perspective

2.2 Biophysical system

Conserving, restoring and managing delta ecosystems will contribute to resilient deltas including reduction of risks on flooding and erosion. Nature-based solutions, if the definition of IUCN is adhered, will contribute to protecting, sustainably managing and restoring these ecosystems to fulfill societal functions. Hence, NbS can be regarded as the actions needed for ecosystem management and restoration and as such draws strongly on the disciplines of conservation and restoration ecology. First and foremost, if a natural system is present and healthy, its societal function can be ensured by conserving and protecting the ecosystem, which can be supplemented with sustainable management. In areas where ecosystems are unhealthy, threatened or have disappeared, restoration of ecosystems and their respective societal functions can be undertaken. It is of utmost importance that restoration complies with the principles of ecological restoration that are described extensively in ecological literature and textbooks. A main element here is the focus on ameliorating abiotic boundary conditions for ecosystem recovery instead of doing direct replanting or reforestation. Another important precondition is to work with native species. Hence, restoration should start with a proper habitat assessment that carefully sets the restoration objectives.

As for ecosystem occurrence and restoration, for nature-based solutions in deltas and along rivers, environmental boundary conditions are driving ecosystem occurrence, thus, determine the type of NbS that can be considered. In a deltaic context several abiotic parameters are important in setting the stage for ecosystem occurrence and for associated NbS.
First, salinity levels determine the type of organisms encountered. Second, submergence time distinguishes between occurrence of aquatic and submerged vegetation and terrestrial vegetation and the associated fauna. Hydrodynamic forces, such as impact of waves is an important determinant for the type of sediment encountered and for the occurrence of marshes and mangroves that strongly prefer benign conditions. Finally, water clarity, which is influenced by suspended sediment and organic material, is a determinant for submerged species that perform photosynthesis, such as sea grasses and corals. Hence, for delta areas and coasts, ecosystem presence is largely determined by hydro-geomorphic regimes.

For Asian deltas we recognize the following delta ecosystems that will determine possible NbS:

- Sandy beach and dune systems;
- Mangrove systems;
- Coral Reef and Seagrass systems;
- Wetlands & Floodplains.

Background information and references for these delta ecosystems with respect to the main drivers and how these can be influenced and managed is provided in Annex 6.4. Here, the delta ecosystems are individually assessed, including possible NbS to serve as green (or soft) climate adaptation technologies in building towards more resilient Asian deltas (Table 2-1). Considerations are highlighted for restoration and management activities. Distinct hydro- and morphodynamical processes that govern and shape features within the systems need to be carefully examined to understand if rehabilitation or restoration measures should be implemented on the existing system, or if alternative measures are needed. Furthermore, additional pressures facing Asian deltas may influence the long-term feasibility of NbS, such as rising sea-levels, increased warming, rapid socio-economic development and land subsidence.

Table 2-1 Overview of main delta ecosystems and related NbS types

Delta Ecosystem	NbS or restoration actions
Sandy beach and dune systems	• Sand nourishment (on the beach, under water or sand engines) • Sand trapping by vegetation or by sand screens
Mangrove systems	• Permeable structures • Creek digging • Mud nourishment • Multi-species planting
Coral Reef and Seagrass systems	• Coral transplanting • Reef crest restoration
Wetlands & Floodplains	• Re-meandering • Reconnecting floodplains • Tidal river management • By-passes • Riparian buffers

Deltaic ecosystems do not occur in isolation, but rather in a gradient, sheltering each other and creating suitable conditions for other ecosystems to thrive. Systems are often working in synergy such as the Mangrove-Seagrass-Reef seascape, where the coral reef provides shelter for seagrass beds and mangroves behind it and sea grasses reduce acid conditions and capture organic run-off from the land, which benefits the reef. The individual systems establish beneficial relationships with each other and evidence of reverse effects on populations, assemblages or ecosystem functioning is geographically widespread (Olds et al., 2016). Reciprocal connections among coastal and river ecosystems are of vital importance, emphasizing the need for an integrated seascape approach where conditions allow for it. Despite evidence of the synergistic performance of seascapes, deltascapes and riverscapes, research on ecosystem effectiveness is mostly conducted per separated ecosystem; not as the synergistic system it can be (Olds et al., 2016). Nevertheless, some examples of Asian seascapes in deltaic contexts can be found in literature. Hence, the traditional ecosystem focus for NbS may not be the most optimal.

Box 2.1 Upstream – downstream interaction

As deltas are the downstream areas of rivers, they are strongly influenced by processes upstream. Increasing erosion in the upper catchment, due to destructive land-use practices, such as deforestation, often results in more sediment and water running down the river and may contribute to delta formation. However, upstream damming and reservoir building for hydropower and water availability dramatically diminishes uninterrupted flows of water, sediment and nutrients threatening delta (ecosystem) integrity and resilience. Hence, a basin or catchment approach is essential for assessing future challenges for deltas, identifying key factors determining these, identifying possible solutions both within the basins and deltas, and eventually developing sustainable approaches of NbS within deltas. Long-term adaptive delta planning is required to cope with current and future challenges, with due consideration for the suitability and survivability of nature-based measures.

2.3 Institutional and governance system

In implementation of NbS, multiple challenges emerge of which many are institutional and regulatory in scope. Especially for deltas at the mouth of international rivers, coordination of actions tends to be more complex and common objectives are harder to establish. There is a specific field that strives to “coordinate actions in order to achieve common objectives”, which is referred to as delta governance. The specific governance challenge in deltas constitutes the sectoral and spatial distribution of objectives and the trade-offs between these. This almost always leads to partial instead of full realization of single sector objectives and as a result all sectors may feel disadvantaged. In addition, the complexity of river and delta systems and the impact of interventions on the functioning of these, make the design and implementation of actions dependent on proper understanding of the entire system and is often surrounded with uncertainties. This uncertainty and complexity make implementation of innovative interventions, such as NbS, an easy subject to discussion.

The institutional and governance system plays an essential role in decision-making in delta areas on multiple levels. On a national level, strategic decision making often determines investment hotspots. The sectoral division of mandates and tasks at multiple institutional levels, from national to regional to community, complicates function-coupling and execution of multidisciplinary projects. Objectives for management of river basins and deltas are often monofunctional and approached from a single-sectoral perspective. Coordination between countries and between different ministerial departments, such as the Department of Energy, Agriculture, Water Resources and Infrastructure, is urgently needed for holistic and

sustainable management of rivers and deltas. For example, many damming projects in rivers are implemented by the Department of Energy or by the Department of Water Resources. Both departments tend to work from single functions only and often do not consider downstream demands. The Department of Infrastructure that is often responsible for flood risk management, may not be consulted in many of these cases and therefore, upstream developments can aggravate downstream flood risk or reduce downstream water availability. To tackle this for rivers specifically, river basin management organizations are sometimes set up for each different catchment. This can work, but also introduces another administrative layer, hindering more centralized decision-making.
Successfully addressing delta and river management requires the reestablishment of objectives and the redesign of governance arrangements accordingly to achieve alignment and larger geographic and more inclusive decision making. Existing theories that can help to incentivize this change are those of policy entrepreneurship, societal transitions and research through design. These all share a common focus on ideas and concepts and individuals or groups that advance these ideas in society and government. However, realization of such ideas requires people to be able to influence governments and stakeholders and mobilize resources. This, in turn, requires connecting to different sectors and regions to facilitate the negotiation of the trade-offs.

A vision for NbS implementation at delta or catchment scale is needed, encompassing river basin and delta management. This vision should address both upstream-downstream (longitudinal) and channel – floodplains (transversal) processes. Engineering innovations are required to support the vision and emerging trade-offs. For example, adapting vessels to rivers instead of rivers to vessels requires the development of innovations in inland shipping that will on first sight not be classified as NbS. Also, innovations in infrastructure design and urban development that allow rivers to remain dynamic may be relevant to maintain the flows of water and sediment that support biodiverse and healthy delta ecosystems. Recognizing that how these changes come about and can be supported best, is country and culture specific. They require the mobilization of local transition managers, policy entrepreneurs and civil society as a basis for their success. Overall, it can be concluded that institutional collaboration is key to enable large-scale implementation of NbS. Coordinated upscaling of local NbS projects with multi-sectoral objectives requires continued mobilization of financial and human resources at different scale levels, resulting in a pipeline of interconnected NbS and flanking implementation projects. This way NbS will be part of strategies that contain multiple fit-for-purpose types of interventions, such as non-structural, conventional engineering and hybrid measures (mixed hard/soft). Most delta planning projects in Asian delta's lack this integrated landscape approach linking different scale levels, objectives and encompassing the full portfolio of interventions. These types of projects are typically developed on national level with support of international financing and embedded in a top-down approach to delta planning.

2.4 Socio-economic system

The socio-economic system refers to social and economic factors in local communities and households. Delta ecosystems are generating various services, benefiting human society and the environment. NbS aims at integrating one of these services as a primary function into coastal, riverine, urban or agricultural planning, thereby capitalizing on this single function by conservation and restoration of the ecosystem. However, the myriad of other services that the ecosystem delivers are still present. All ecosystem services are thoroughly specified in the Millenium Ecosystem Assessment (2005). However, even in NbS implementation, the secondary ecosystem services, or co-benefits, are typically not further elaborated on in cost-benefit assessments. Disregarding co-benefits of ecosystems and not respecting socio-economic linkages in spatial planning and infrastructure development is one of the issues that needs to be tackled to works towards sustainable management of deltas.

To fully appreciate linkages between the socio-economic and ecological system, valuation of ecosystems services combined with other economic valuation is essential as a first step (see Figure 2-3). Second, to account for social equity, beneficiaries of economic benefits and ecosystem services should be mapped. In addition, the list of beneficiaries of direct and indirect benefits and the inventory of co-benefits, helps to translate the economic analysis into a financing strategy.
For NbS, besides local stakeholders that directly profit from co-benefits, downstream users or cities may profit as well and additionally, national governments may profit through achieving international commitments, such as SDG's or Climate Goals.
Hence, this opens routes for alternative financing constructions on multiple institutional levels, ranging from international financing to local community funds.

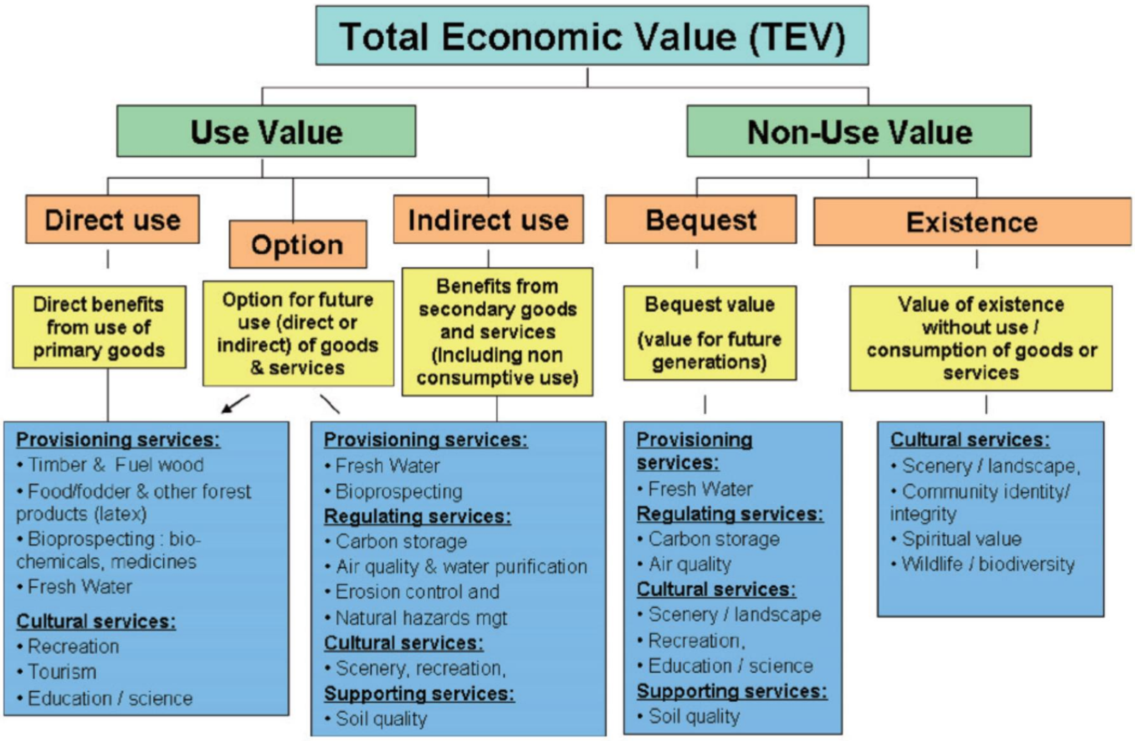

Figure 2-3 The framework of Total Economic Value of ecosystem services (taken from Kumar, 2010).

The economic rationale for NbS implementation addresses the question how to attract and maximize the flow of resources for getting NbS solutions delivered and operational. The main assumption is that NbS are socially and environmentally valuable, but their delivery and operation exceed public funds available. Hence, it is necessary to identify when NbS can attract private investments and allocating public funds where are more needed. It is important to note that not all NbS have a business case, i.e., they are not necessarily considered to be a “Bankable” solution. However, in some cases this is believed to be the case, providing an opportunity to incentivize private sector or blended finance.

The further development of financing project models considering non-monetary values and co-benefits could provide attractive information for investors, showing how NbS generates returns on investment. This return on investment can include avoided costs, such as flood damage, but more importantly, also include actual profits, from crop yields and tourism, to safekeeping natural resources, such as water availability and fertile soils, which also relates to biodiversity. Realization of such business models requires a shift from individual short-term economic gain to long-term benefits for multiple beneficiaries. Favouring business models which are locally led but acknowledge the wider (catchment), benefits to obtain maximum return on infrastructure investment but also to avoid possible negative effects on larger spatial scales or longer timescales.

Key Messages – Integrated system approach

- A system approach strives to enlarge project success by addressing the institutional, socio-economic and natural (biophysical) system.
- NbS perform best if approached on large landscape scales using a ridge to reef approach that considers the entire catchment and flows of water, sediment and nutrients.
- Harnessing the proper abiotic conditions and flows is key to healthy and resilient ecosystems that constitute the backbone for effective nature-based solutions.
- Adopting a seascape and riverscape approach that includes interacting ecosystems is essential for upscaling of NbS.
- Working from a strategic vision with multisectoral objectives combined with a master planning approach will facilitate NbS implementation at all institutional levels.
- Linkages between ecological and socio-economic systems should be respected when intervention strategies are proposed and are extremely essential for effective and sustainable NbS implementation.
- Co-benefis quantification and beneficiary mapping is essential to fully capitalize on NbS opportunities and link international, national and local financing schemes.

3 Governance and financial considerations for upscaling NbS

NbS can increase the resilience of infrastructure networks, empower communities through participation, improve environmental quality and safeguard biodiversity with the conservation and restoration of ecosystems. From an economic point-of-view, NbS can attract a diversity of financing sources and produce both monetizable and non-monetizable benefits. However, single NbS solutions can only deliver the full value of their potential when integrated in a wider landscape[4] planning process (van Wesenbeeck et al., 2019). This process can be used as a platform for realizing environmental, financial and long-term social goals. Incorporating NbS into the planning process at larger spatial scales will also facilitate NbS upscaling.

The upscaling of NbS depends on the articulation of a long-term vision and strategy between key decision-makers, which can lead to the sustainable development of the catchment or delta. It requires a technical and social consensus on the feasibility and value of green infrastructure assets, which is crucial in steering the governance process and investment commitments for NbS. Doing so maximizes the impact of public and private investments between interdependent actors in the landscape. As not all NbS projects are bankable or provide sufficient economic incentive to attract private investments, reviewing non-direct benefits (or co-benefits) can help make a stronger business case for NbS, both for public funding (i.e. non-direct non-monetizable benefits) or for private investors (non-direct *monetizable* benefits). Therefore, upscaling NbS solutions demands framing project investments as elements of landscape portfolios, achieving a financial trade-off between profit and environmentally or socially valuable projects (Klijn, Edelenbos & Hughes, 2007). It also requires undergoing a process of valuing NbS for both direct and non-direct benefits, strengthening financial literacy and creating a multi-level financing strategy. After mapping all value opportunities, a strategy can be made to take advantage of various finance streams relevant to the type of benefits reaped from NbS.

The wider governance framework embodies agreements, negotiations, and compromises between different actors. Commitment at the governance level grounds the conditions upon which the public sector, philanthropic or return-seeking investors would be willing to support NbS project investments. The success of NbS implementation is threatened by modification or enforcement on land-use and tenure, which often competes with other productive uses. Therefore, the long-term sustainability of a landscape approach will depend on the degree of commitment between actors pooling resources, seizing value opportunities[5] and addressing competing demands between land use and other socio-economic values. Upscaling NbS does not only require investments in green assets, a structured and articulated landscape governance process will enable the process, along with creating enabling investments that encourages and supports the collaboration process between the different actors.

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[4] A landscape is a social-ecological system that consists of a mosaic of natural and/or human-modified landcover types. The landscape provides ecosystem services and development opportunities for a diversity of stakeholders and species (IUCN, 2019)

[5] Value opportunities refer to positive attributes of a product or service, in this case, the benefits of NbS.

3.1 Landscape governance process and enabling investments

The success of landscape investments relies on the degree of governance maturity based on five key elements (Table 3-1):

1 Strength of multi-stakeholder engagement;
2 Shared understanding;
3 Collaborative planning;
4 Effective implementation;
5 Monitoring for adaptive management and accountability.

Using these elements, priorities can be better defined, and fundamental agreements can be made on the modification of land use, land cover and land tenure. A structured and articulated landscape governance process increases the visibility of NbS value, which in turn, brings more certainty to actors and their willingness to invest in green infrastructure. In practice, even the most promising NbS upscaling efforts face the difficulty in changing land use. NbS designs often take for granted larger areas and landscape elements, such as coast, sea, rivers, ecosystems and built environment, that are owned by different government departments, private businesses and local community members. In reality, land ownership is often culturally embedded and difficult to change. These inflexibilities in the design process can only be addressed or transformed using the elements in the landscape governance process. For this, a degree of cooperation is needed between actors in the landscape, even with the lowest level of governance maturity, if agreements are conducted in an ad hoc manner. Therefore, aside from asset investments, both enabling investments and land governance investments are crucial in supporting the collaboration and governance process in landscape management. While enabling investments specifically support the level of collaboration, land governance investments aim at enabling land use changes, including building social agreements for relocation or transforming economies linked to unsustainable land use (see Table 3-2 for more comprehensive examples of enabling or land governance investments).

Table 3-1 Overview of the five articulated elements of landscape investment (Denier et al., 2015)

Level of co-operation	Multi-stakeholder engagement	Shared understanding	Collaborative planning	Effective implementation	Monitoring
Low	Ad Hoc Consultations Meetings	Public Information from Landscape stakeholders, easily accessible	An agreed landscape vision document	Landscape actors consider collaborative plans when making individual decisions	High-level monitoring, public reporting
Medium	Multi-stakeholder dialogue and regular meetings by each actor to consider/respond to inputs from other landscape stakeholders	Above + detailed information on land management provided to other landscape stakeholders	Above + detailed landscape strategic plan/program outlining join activities	Above + specific commitments and contributions to achieving agreed landscape objectives	Above + specific commitments/contributions to achieving agreed landscape objectives
High	Above + formal mechanisms for stakeholder representation, formal rules for decision making	Above + mechanisms for requesting information from other landscape stakeholders	Above + clear accountability framework for actor compliance with landscape plan including monitoring and sanctioning	Above + detailed reporting on the implementation of the collaborative plan on the individual decision of relevance to collaborative plans	Detailed monitoring and evaluation of strategy; positive conditional incentives; negative sanctions

Aside from the articulated elements, the landscape management process can be elevated by incorporating a framework in which financial, environmental and social ambitions will be reached in a specific time frame. By defining long-term goals, the process to reach that vision is worked backwards instead, highlighting specific conditions that need to be achieved before such goals can be met. The framework can be utilized to assess whether proposed investment projects will have clear paths for reaching subsequent environmental or social ambitions. This methodology is otherwise known as the “Theory of Change” (ToC), which is often touted by climate change facilities and impact investors as the preliminary stage for building a *convincing* investment proposal for NbS. In fact, funding bodies such as the Green Climate Fund demand reasoning from the ToC methodology in order to reach climate change or adaptation goals. This is evident not only within their strategic programming of funds[6], but forms part of the assessment component for proposal applications to the fund[7] as well as project reviews[8]. Within the ToC methodology, assets, enabling and land governance investments should be articulated, which asks for the presence or development of a mature stakeholder collaboration process. This means that the ToC methodology also needs to include capacity building related to the five elements in the landscape governance approach. This will aid in achieving integrated delta management with NbS at the core.

Table 3-2 Examples of asset investments and enabling investments (Source: Cooper & Matthews, 2020; Denier et al., 2015, p. 61; van Wesenbeeck et al., 2019)

Main risk reduction function	Examples of green infrastructure	Examples of grey infrastructure
Asset investments		
Flooding	Floodplain restoration/lowering Meander restoration Creating/reviving side channels Wetlands and Mangroves Full embarkment removal Wadi's/bioswales Coral/oyster reef Dune	Dams/reservoir construction Summer and winter dikes Embarkments Channel deepening Urban drainage systems Construction of retention areas
Drought	Wadi’s/bioswales	Dam/reservoir construction Construction of retention areas
Landslides	Restoration of natural forests	
Erosion	Meander restoration Full embankment removal Floodplain lowering Wetlands and mangroves Seawalls Coral/oyster reef Dune	Partial embarkment removal Breakwaters
Sedimentation		Channel deepening River training by groins River training by longitudinal dams Channelization

[6] Strategic Programming for the Green Climate Fund First Replenishment https://www.greenclimate.fund/sites/default/files/document/gcf-b23-inf09.pdf
[7] Independent Evaluation Unit of the Green Climate Fund (2019) https://www.cbd.int/doc/presentations/tc-imrr/Summary_of_the_evaluability_of_GCF_proposals.pdf
[8] GCF Programming Manual: An Introduction to the Green Climate Fund project cycle and project development tools for full-size projects.

Enabling investments
Institutional design Policy development and regulation Rights promotion and awareness Capacity building at the organizational level i.e. strategic, finance, marketing, human resource or legal Technical assistance for project structuration, including project financing Stakeholder management processes Financial de-risking (e.g. guarantees)
Land governance investments
Compensation mechanism for land use Economy reconversion investments

3.2 Characterizing governing capacity for coordinating landscape investments

The organizational capacity of a governing entity is crucial for understanding how or if NbS can be upscaled within the respective landscape contexts. This capacity is defined by identifying the level of collaboration between interdependent actors, the level of financial literacy and/or financial coordination, as well as the five elements of landscape governance (Section 3.1). The level of organizational capacity will influence the ratio between enabling investments and asset investments needed.
Coordination strategies for landscape investments will likely depend on organizational capacity as well. For example, with a high level of interaction between different departments and between local and national entities little interference may be needed. However, if this level of interaction is low or non-existent, bottom-up investment strategies may be more feasible or installation of a new governance body can be explored to facilitate planning, financing and implementation of landscape-scale investments.

To bring NbS beyond the project level, landscape governance will likely require one or more financing coordinating entities. Having one will allow the governing body to engage with different investors and enable the coordination of investments beyond the scale of single projects (Denier et al. 2015). The organizational nature of that coordination entity, however, will depend very much on the characteristic of the multi-stakeholder platform, and will require a high level of financial literacy. Typical coordination entities include government agencies and trust funds, investment funds, and special purpose vehicles. These entities, while acting under the supervision of the landscape management, can serve as aggregators of finance, pooling financing from different sources or be limited to an advisory role for landscape investors in specific projects (Denier et al. 2015). The type of coordinating entity will depend on the architecture of implementation in place.

The implementing architecture can range from highly decentralized implementing units running small projects to a highly centralized unit running a large-scale infrastructure project. For highly decentralized units, the entity can act as an investment vehicle that is able to leverage capital while diversifying risk and investment returns, such as providing a fund. In this way, a capital structure[9] can be established, attracting potential donors, development banks International Financial Institutions (IFIs) and private investors.

[9] A capital structure refers to a method of combining debt and equity to fund projects.

The fund could establish policies for channeling finance to smallholder farmers[10] directly or via local finance institutions by offering long-term financing services to them (Palmer 2016). For highly centralized units, a special purpose vehicle (SPV)[11] can be created to bring finance and equity from private and public organizations in charge of implementing the large-scale project.

One fundamental aspect is that any landscape investment made will need to align with the wider landscape context. For example, the success of downstream restoration measures may depend on sediment availability influenced by upstream activities. Due to the upstream-downstream connection, the scale suggests a higher level of collaboration required between the relevant governing entities influencing both upstream and downstream dynamics. A misalignment between the domain of influence of the governing entity and the spatial extent of the required physical intervention would prevent NbS from reaching its full potential. Therefore, the organizational capacity will also need to be characterized for the governing entity's ability to enable collaboration beyond its geographical scope. More information regarding characterization of the match between geographical scope and governance as well as the capacity to coordinate investments beyond single projects are found in the Annex 6.5.

3.3 Negotiation among actors within landscape governance

Negotiation involves defining ecosystem values and the contours of NbS projects, as well as connecting the technical characteristics with cost and benefit allocations (Rode and Wittmer, 2015).
By linking socio-economic activities of interdependent stakeholders to the underlying ecosystem services, the negotiation process becomes essential in upscaling NbS in a landscape context. Negotiation within landscape governance is often achieved between actors or through valueing NbS in order to leverage funds or attract investments. Between actors, agreements for both land-use and compensation can be made by distinguishing between 'earner' and 'payer'.

Actors enter the negotiation process as producers or users of ecosystems services, as well as polluters of ecosystems. They can be categorized in the following way: **Polluters** (payers), **beneficiaries** (payers), **stewards** (earners) and **innovators** (earners). **Polluters** are degraders of ecosystems and should compensate proportionally to the amount or rate of activity, or be imposed with a fine. Payment can be in the form of pollution offsetting schemes, or environmental damage claims. **Beneficiaries** refer to users who benefit from these ecosystem services and should contribute relative to the rate or amount of benefits sown. **Stewards** are typically responsible for the ecosystem or the processes contributing to the ecosystem services, such as managers of ecosystems. Positive incentives can be used to reward ecosystem service provision, and these costs can be offset by e.g. polluters, beneficiaries or the government. Lastly, **innovators** are actors who identify value creation opportunities by linking main ecosystem functions to co-benefits, which can be in the form of eco-tourism, ecosystem service byproducts, etc..

By identifying these actors, an economic rationale can be created for NbS and the payments (from payers) can constitute a basis for funding. Organizing NbS projects in this manner can also provide structure to the financing needs as well as the relevant sources of financing. On a landscape planning level, upscaling can be better achieved by identifying technical and organizational dependencies between projects and clustering them as a single investment

[10] Smallholder farmers are defined as farms owning small plots of land for subsistence farming, while having one or two cash crops. The labour used is largely dependent on the families themselves, characterised by simple, outdated technologies and low returns.
[11] An SPV refers to the creation of an entity specifically engineered for a purpose, often for minimizing financial risk.

(Altamirano, 2019). Although (technical) experts can assess technical dependencies, organizational dependencies will require collaboration between stakeholders as well as institutional responsibility.

Key Messages – The Landscape Governance Process

- Upscaling NbS through a landscape approach requires a degree of governance maturity, which implies a baseline level of collaboration between interdependent actors as well as good organizational capacity.
- Enabling or landscape governance investments are crucial for empowering collaboration between stakeholders or striking a balance between land-use and competing economic activities.
- Before such investments can be made, the organizational capacity needs to be characterized and will require financial literacy, coordination of landscape investments either through a coordination entity or collaboration beyond the geographical scope.
- (Financial) agreements can be made between users and benefactors to form a basis for funding NbS, while also providing structure to meet financing needs on a landscape level.

3.4 Structuring the Value of NbS

The broader governance process provides a basis for funding or investing in NbS. Additionally, the long-term strategic vision of the landscape governance process can be connected with socio-economic goals through additional methodologies such as Theory of Change. The landscape governance process should provide a pipeline of NbS projects, which would reflect the measures for bridging imbalances emerging from socio-economic issues or ambitions against existing patterns of use, misuse and management of ecosystem services.
Creating a financing strategy for funding NbS interventions remains complementary to the landscape governance process. The strategy should support the overall strategic vision, as well as the negotiations between actors around sustainable land and ecosystem use. Part of this activity would involve restructuring NbS as an *asset investment*, such that the project can remain self-sustaining in economic terms (Altamirano 2019, Altamirano et. al Forthcoming). As private financing is highly available, restructuring NbS in this way allows green interventions to remain attractive for private or return-seeking investors. However, private financing is not as accessible if NbS interventions cannot translate into financial pay-offs, despite addressing socio-environmental needs. Therefore, building a business case is highly dependent on the characteristics of the ecosystem values. In addition, both landscape approaches and enabling investments will likely be needed in order to leverage private funds for bankable measures. For ecosystem services which stakeholders agree should remain a public good, public funding will always likely be required, even in the event of a market failure[12]. Yet, the question remains – which NbS-related good or service should be considered under the private or public domain? As proposed by the Financing Framework for Water Security (Altamirano 2017, Altamirano 2019 p.13) the first step to develop the business case of a NBS investment is to define the main functions and services the project will create and categorize these in types of economic goods .Depending on the economic nature of the good of services to be delivered one can proceed to step two and start to identify different types of revenue streams or funding sources, which in generic terms can be taxes, tariffs or transfers (see Table 3-3).

[12] In a situation where there is an imbalance of costs and benefits due to a deviation in the economic outcomes of the project, this is otherwise known as a market failure.

Using the principles of excludability and subtractability, goods or services can be categorized in this manner to clarify how projects can continue delivering sustainable value both in economic and environmental terms. Excludability refers to the degree in which a good can be limited to users by e.g. imposing entrance fees for access or usage of a landscape, while subtractability refers to the degree of competition for the resource usage such that consumption of a good discounts the ability of another user for consuming the good. By applying these principles, opportunities for building a business case are made available, even for non-excludable services such as by setting up a market with readily available business models to support financing of the asset investment. Similarly, knowing whether a good or service is subtractable will also provide a clearer rationale for turning those services into private or toll goods and entering into a negotiation between the relevant actors by applying the 'steward earns, polluter pays' principle (Section 3.3). Benefits that cannot be directly captured can remain as public goods, which are then mainly addressed by public funding.

Table 3-3 Example matrix of applying the principles of excludability and subtractability for capturing values in NbS projects (Source: Adapted from Altamirano 2019 Box 1. Steps to design and implementation arrangement, p.13)

		Excludable	
		Yes	No
Subtractable	Yes	(Private good) Provisioning services without open access.	(Common pool) Provision services with open access, susceptible to be depleted due to overexploitation.
	No	(Toll good) Cultural services with direct use value and entrance fees	(Public good) Supporting services, cultural services with non-use value, regulating services

Framing NbS as a source of economic value is a complex activity in reality and will sometimes require further categorizing of socio-economic values of ecosystem services. Understanding the economic nature of goods or services provided by NbS will also require making a differentiation between non-monetizable and non-direct monetizable benefits, as well as non-use benefits, so that investments can be better classified. One such example is provided in the case of mangrove restoration projects (Table 3-4). Whether such benefits are definitively monetizable or not is dependent on local institutional conditions and context specific preferences (Altamirano 2019) as well as time. Some benefits are valued more by certain stakeholders, provided a good business model is created and whether the value can be captured.

Table 3-4 Benefits of mangrove restoration, as an example of monetizable, non-direct monetizable and non-use benefits

Monetizable benefits	**Non-direct monetizable benefits**	**Non-use benefits (non-transactional)**
• Carbon sequestration • Fish production • Forestry • Agriculture • Fuel production • Harvestable goods • Transport function • Recreation and Tourism	• Flow regulation and flood mitigation • Prevention of saline water intrusion • Sediment retention • Nutrient retention and biological filter • Toxicant removal or retention • Protection against natural forces	• Biologic diversity • Gene bank function • Cultural and historical value • Aesthetic value • Wilderness value • Uniqueness value

Source: STOWA, 2020

Based on the characterization of value for NbS, actors should agree on the main physical function of the project from which value is defined. Table 3-5 provides a simple, example layout for characterizing value, where the sources of monetary values are identified, as well as how such revenues can be captured through various financial mechanisms e.g. taxes on appreciating land due to increase in land value from lowered exposure to a hazard. In the event that the *main function is not of monetizable value*, NbS' non-direct *monetizable benefits* can be made explicit in this process. Where non-direct benefits (or co-benefits) are monetizable, these can be used to leverage additional funding from private actors. As a further elaboration of the example of mangrove restoration, the co-benefits include carbon sequestration and supporting the productivity of offshore fisheries (Table 3-6). In this way, the flow revenue of a simple, mangrove restoration project increases, making a stronger (socio-)economic rationale for NbS. This can clarify how private investments can be better leveraged, as not all direct benefits of NbS are bankable. It also clarifies Although such benefits are monetizable, they require taking into account additional considerations such as potential trade-offs, design and/or market considerations. Furthermore, sociological impacts from such benefits may be difficult to quantify.

Table 3-5 Example layout for characterizing value of nature-based solutions at the project level, using mangrove restoration as an example

Nature-based solution	Main Function	SDG	Main benefit	The typical source of monetary value	Revenue capturing mechanisms
Restoring a mangrove belt	Coastal protection and sea-level adaptation	13	People and asset protection.	Cost reduction compared to grey solutions Increased land value (depending on ownership and land tenure)	Higher land value can be indirectly captured by taxes and directly by collective agreements between landowners

Table 3-6 Co-benefits of mangrove restoration

Co-benefit	Explanation	Direct revenue scheme	Social impact	Additional considerations for the design	Market considerations	Trade-offs concerning the main function
Carbon Sequestration	Mangroves account for only approximately 1% of carbon sequestration by the world's forests, but as coastal habitats, they account for 14% of carbon sequestration by the global ocean (Alongi, 2012)	The source of revenue is the payment of companies purchasing those CO_2 credits emitted by the mangrove project.	- Job generation - Community cohesion	- Minimal area restored required to issue a "tradable" CO_2 capturing service (Broadhead, 2011) - Carbon cycling uncertainties for mangroves (Broadhead, 2011)	As it operates upon carbon markets, the project must be labelled as a "carbon project" for either voluntary trading markets (Goldstandard, 2020) or mandatory trading markets (UN, 2020).	The trade-offs need to be assessed on a case-by-case basis.
Supporting the productivity of offshore fisheries	Sandilyan and Kathiresan (2012) estimate that 80 percent of the world's fish catch depends on	The revenue stream is fish productivity with market value.	- Job generation - Food security - Community cohesion	It implements techniques such as silvofishery that aim to increase fish production in mangroves while	- For turning fishing into a sustainable revenue, the project must (i) guarantee a stable and predictable rate of fish	Maximizing short-term production compromises long-term conservation (WWF, 2015).

Co-benefit	Explanation	Direct revenue scheme	Social impact	Additional considerations for the design	Market considerations	Trade-offs concerning the main function
	mangrove production to some extent (UNEP & TNC, 2014)			conserving them (SilvoFishery, 2020).	production and (ii) appeal to green and socially responsible markets (Jeans, 2015).	

Once the value drivers have been made explicit (Section 3.4), each project should be characterized in terms of the relevant elements for guaranteeing their implementation ability. Following on the example of the mangrove restoration project, the project agreement should be structured according to their lifecycle, cost generation activities, construction & operation risks, and development of indicators to monitor project delivery and service maintenance (see Table 3-7). Incorporating project performance indicators can help make a more convincing case with investors who are used to grey solutions. Additionally, risk profiling is required as these can translate into investment risks, relevant for both public funding or private financing. Upscaling NbS will thus require continuous monitoring, risk profiling as well as mitigation of such risks. The challenge of being able to create operational projects and deliver them on time remains, implying that asset investments are time-bounded even within the landscape governance process. Therefore, value and risk appraisal also require temporal and spatial boundaries to be set, which in reality, requires scoping and quantifying its social, environmental and financial returns prior to the start of the project implementation. In this manner, the interplay of solid structuration of both the landscape governance process and NbS as an asset investment is emphasized.

Table 3-7 Lifecycle of a mangrove restoration project (Sources: Altamirano and de Rijke 2017 p.19; Lazurko and Altamirano 2019; Altamirano and Lazurko 2020)

Planning phase		Design-Construction phase			Maintenance and operation		
Cost generating activities	**Planning Risks**	**Cost generating activities**	**Delivery indicator**	**Construction risks**	**Cost generating activities**	**Service (performance effectiveness) indicator**	**Maintenance and operation risks**
Problem and system analysis Designing a restoration & monitoring plan Land purchase	Land ownership issues	Optimizing hydrological and morphological conditions where relevant Establish seedlings and planting mangroves Allow mangroves to establish naturally	Rate of bed level change is equal to the rate of sea-level change Belt reaches critical width with mature mangroves	Premature planting without addressing hydrological and morphological conditions Medium or severe storm Change in the land use	Maintaining monitoring system Maintaining morphological conditions Community Rangers	Coastal erosion rate Rate of bed level change is equal to the rate of sea-level change	Severe storm Changes in the sedimentation regime Change in the land use Depletion of mangroves (logging)

3.5 Understanding Finance Streams for Resource Mobilization

Understanding the various financing streams is crucial for knowing which financing resources can be leveraged in order to upscale NbS. In addition to those, developing a resource mobilization plan can structure how different landscape investments fit into the different finance streams, such as the resource mobilization plan from the Resilient Asian Deltas Initiative (see Figure 3-1). For a landscape approach, a resource mobilization plan can be made per landscape in order to consolidate and implement NbS upscaling from an integrated landscape approach, such as one per delta as proposed by the RAD initiative under Pillar 3, *'Mobilizing financing to turn vision into actions'*. When structured in this manner, coordinated action and project pipelines can be made. The four types of finance streams relevant are: **Public**, **private**, **international development** and **blended finance**.

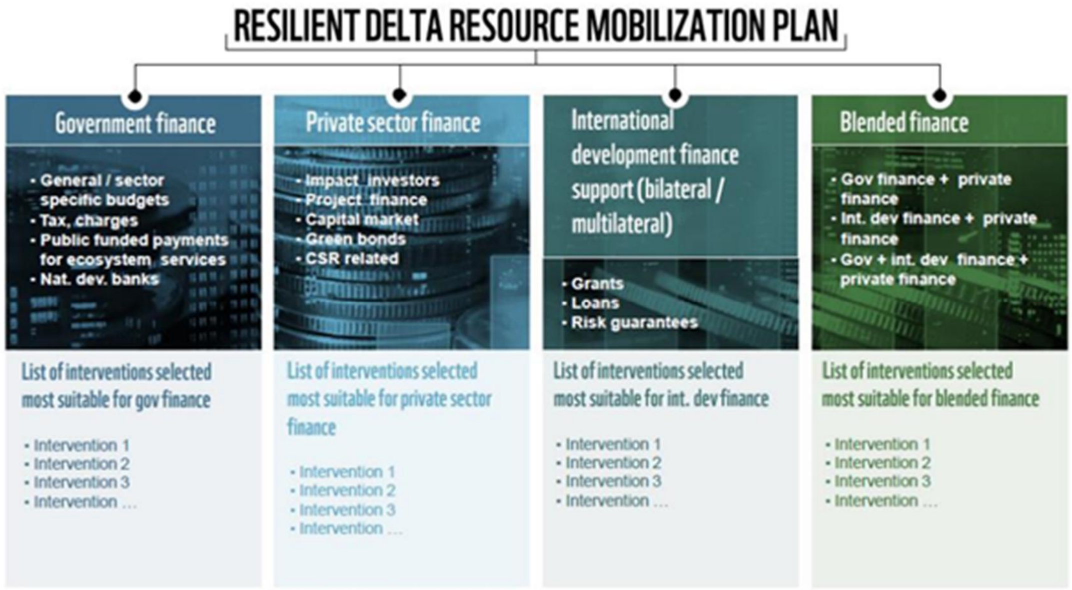

Figure 3-1 Resilient Asian Deltas (RAD) Resource Mobilization Plan (WWF, 2019)

Public finance operates upon the authority of governments to re-allocate tax-payers money to different socially relevant investments. Subsidies are a key instrument for balancing multiple priorities of governments pursuing sustainable development. Hence, government finance should be mobilized only when those investments are not attractive enough for private financers. Governance finance should be used for supporting investments that are mainly characterized by non-monetizable value and should not compete with private investments where possible. A requirement of mobilizing public finance is a clear definition of cost-sharing mechanisms between the central government, sectoral agencies and local authorities needs to be made (OECD, 2019). For example, as subsidies to landowners can result in transformative change if linked to environmental performance (Denier et al., 2015), the central government could allocate a higher national budget to sub-national or sub-units to engage in forward-looking investments. Yet, subsidies can run the risk of being counterproductive if landowners utilize land inefficiently with the aim of capturing subsidies. Nevertheless, direct financing of investments by the public budget are still constrained by sector priorities, which renders allocation rules inflexible and will largely depend on the policy agenda.

Private sector finance should be allocated to projects with a clear revenue source, derived from categorizing monetizable direct and non-direct benefits. For private investors whose only aim is to maximize the pay-off of lending monies, projects may need to deliver a comparable Return on Investment (RoI) to competing ones in other sections such as energy or communications. RoI is used in this manner to compare different projects and assess the expected returns by considering cash flows[13] during the project tenure and the opportunity cost of investing the money in a savings scheme instead. In general, demonstrating a positive RoI will require structuring financing mechanisms, project finance and leverage access to capital markets. Investors can be further assured of the associated risks by means of structuring green and climate bonds. These financing mechanisms are certified and specifically channel funding towards large-scale environmentally-oriented activities that display a similar risk-return profile compared to traditional bonds.

Depending on their mandate and agenda, **international development finance** includes grants and concessional loans provided by multi-lateral or donor countries.
Grants can take technical assistance to address enabling investments that create the conditions for sustainable asset investments. Therefore, this funding source would promote cross-sectorial infrastructure delivery, policy development, and the implementations blueprints. Additionally, Multilateral Development Banks (MDBs) play a pivotal role in introducing new concepts as an alternative for addressing their clients' needs: national and local governments. It includes the introduction of NbS on some countries' agenda and principles such as result-based financial mechanisms. MDBs are interested in investing in projects that strengthen local markets' development, including local green capital markets. For example, the IDB recommends partnering with local financial institutions for expanding their green portfolios (Cooper and Matthews, 2020).

Another instrument for maximizing the impact of public financing and donors is the so-called **blended finance** approach. The blended finance approach improves the risk-return profile of social and environmental investment opportunities with the potential to lead to financial returns. For example, concessional public or philanthropic funding can attract private investment by providing guarantees that the project does not yield expected profits. On other occasions, the concessional public or philanthropic funding can provide technical assistance for building project sponsors' capacity at the level to which they can deliver expected financial performance. Grants can also be used for designing project structures attracting private financing. However, blended finance can only support activities that can produce cash flows over time to repay investors in an acceptable return. Regardless of environmental or social values, blended finance cannot be mobilized for activities with insufficient cash flows.

A glossary of common financial instruments (e.g., bonds, equities, grants etc.) can be found in the Appendix 6.9.

3.6 A decision tree guide for upscaling NbS within the governance and financial process

Given the elements of the governance process and its inter-connected role with the theme of finance, decision-making and action plans can be difficult to make due to its complex nature. To summarise the chapter, a decision tree (Figure 3-2) was made to provide guidance for upscaling NbS. Although not all parts of the decision tree will necessarily have a binary choice, the decision tree makes clear some decision routes that have to be taken with respect to implementing NbS on a large-scale. Although starting points within the decision tree can differ greatly depending on the level of governance maturity, financial literacy, financing strategy and other factors surrounding the implementation of NbS on a landscape level, a logical starting point would be to assess if there is, firstly, a landscape governance process or platform established.

[13] Cash flow is the relationship between revenue and cost from year to year.

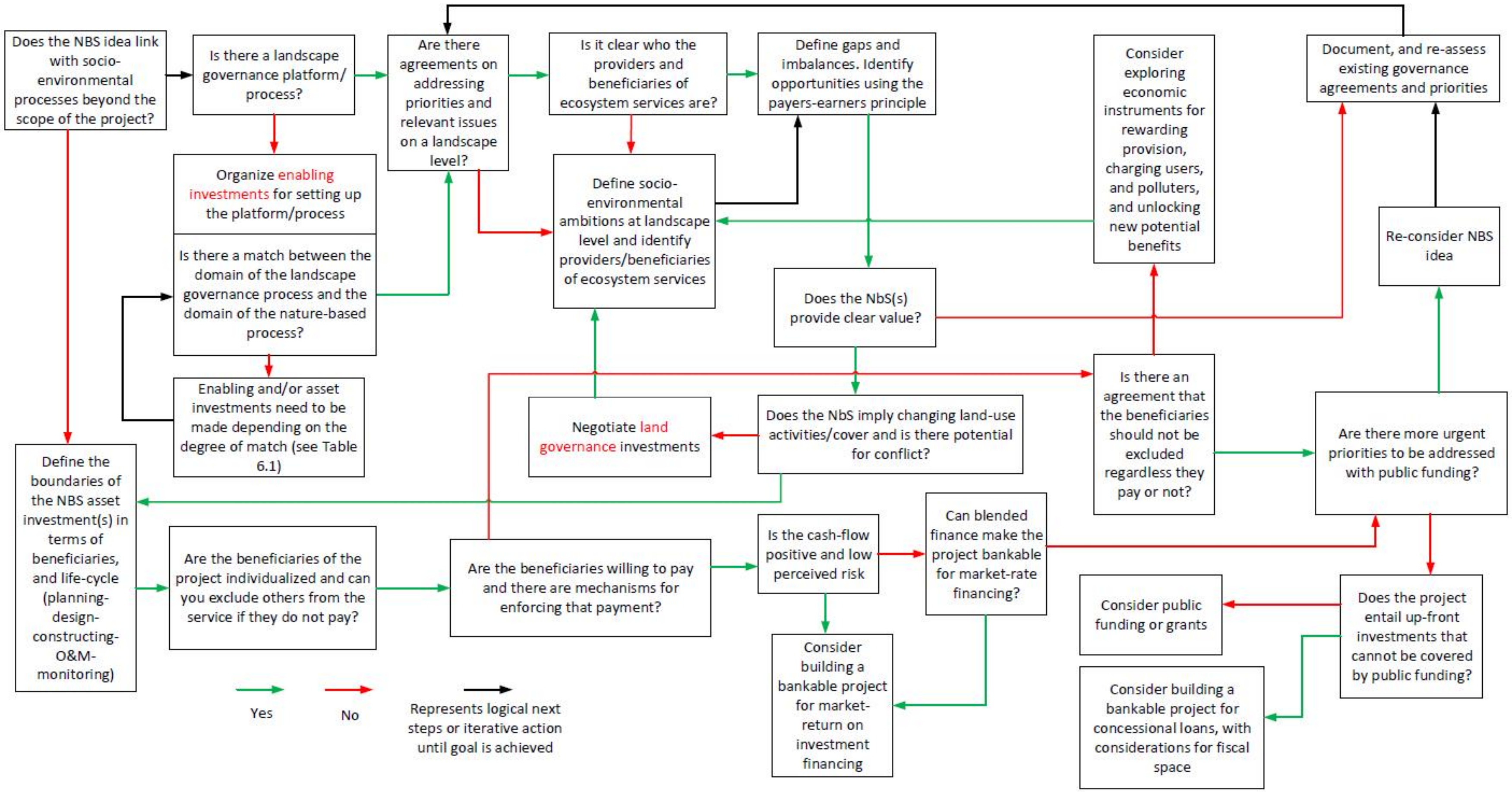

Figure 3-2 Decision tree for upscaling NbS with respect to governance and finance

Box 3.1 Preserving Mangroves in the Coastal Area of Vietnam

It is well known that mangroves are a key ecosystem in the coastal areas that provides many valuable ecosystem services (ES) benefiting both human society and the environment. Examples of ES include raw materials, carbon sequestration, coastal protection from storm surge, erosion prevention, and habitat for fishery. As such, mangroves have been recognized as natural infrastructure asset or a nature-based solution for providing the much-needed ES in the coastal area. However, due to its ill-defined property rights as well as externalities, mangroves are increasingly destroyed or converted to other land use/cover, shrimp farming in particular in many coastal regions in southeast Asia such as Thailand and Vietnam. Protecting and restoring mangroves asset and their sustainable finance emerge as a practical question faced by resource managers and policy-makers.

IUCN and Dutch NGO SNV Netherlands Development Organisation implemented a Mangroves and Markets project funded by the International Climate Initiative in Cà Mau, Vietnam, that presents a business model for sustainably protecting and financing mangrove conservation. Specifically, the project provided seed money for project start-up, technical assistance and training to help shrimp farmers get organic certification under the Naturland, EU Organic, and other organic labels. The certifications require at least 50% mangrove cover per farm, and as return, farmers can sell certified shrimp to the Minh Phu Seafood Corporation (Minh Phu) at a premium price for exporting shrimp to the European market. The project also supported Cà Mau in piloting a Payment for Ecosystem Services system and policy, requiring seafood companies to pay farmers an incentive of VND 500,000 (£17.77) for mangrove conservation and restoration per hectare for providing ecosystem services. As part of the project, Minh Phu also invested in its own Internal Control System team, a supply chain from farm to factory, and financial incentives for collectors, collecting stations, and payments to support project monitoring. The success of the project has led to its replication in Ben Tre and Tra Vinh provinces. By the end of the first phase of the project, over 2,000 shrimp farmers were trained in certified organic shrimp production. Of these, over 1,000 farmers, managing 7,000 hectares of integrated mangrove-shrimp, had signed contracts to maintain 50% mangrove cover and over 500 farmers had been certified using the Naturland organic standard. As of June 2018, the project has trained over 5,000 farmers, and contributed to replanting 80 hectares of mangrove forest and protecting 12,600 ha Mangrove forest.

This case provides an example illustrating how a business model with a public and private partnership (PPP) can be set up based on the seed money from international donors. A market can be created for the ecosystem services of mangroves linked to the existing commodity markets, making PPP a sustainable financing mechanism for the protection and restoration of mangroves ecosystems as natural infrastructure. It is important to note that the project could make an even stronger case if it was structured to also cover other ecosystem services such as carbon sequestration, storm surge protection, integrated with broader landscape interventions, tapping into the wide financial resources from sources such as climate funds and insurance companies to finance coastal resilience and sustainability.

Adapted from Moey (2019): https://panorama.solutions/en/solution/shrimping-horizons-how-shrimp-farmers-are-saving-thousands-miles-mangrove-vietnam

Key Messages – Finance and investment of NbS

- A landscape approach enables identifying financial trade-off between profitable and less profitable but environmentally and socially valuable projects or components
- Private financing could be more conditionally mobilized by creating or strengthening the business case for NbS, through defining and characterizing direct, non-direct and non-use benefits.
- If the NbS project can’t generate alternative revenue sources, public funds might remain the only source to make them possible.
- A resource mobilization plan should be made for each landscape, such that project pipelines can be created and executed more efficiently in terms of financing and implementation.
- In cases where the risk profile is high, a blended finance approach can be utilized to improve the financial returns but will still require NbS to produce a moderate cash flow.

4 Comparative assessment of three Asian deltas

4.1 Introduction

Upscaling of NbS to entire deltas or even catchments, requires a thorough understanding of the three subsystems: natural/biophysical, governance/institutional and socio-economic. For each delta context conditions and challenges will be different.
To better illustrate how these three subsystems can provide limiting and enabling conditions for upscaling of NbS, a comparison was made between three deltas in Asia of their natural/bio-physical, institutional/governance and socio-economic systems. The three deltas selected are key deltas for the project partners and international attention in general, namely the Mekong, GBM and Ayeyarwady. Selection criteria used were: a) Economic importance in Asia, b) International interest, c) Previous project experience.
In this chapter, the natural, institutional and socio-economic systems are described for each delta, supplemented with an indicative assessment of their current status (indicated in 'traffic-light' tables). Information for each delta was collected through online country-specific stakeholder, expert workshops and additional expert consultations (see Annex 6.11). Experts were questioned about the status of NbS implementation, and enablers and constraints for upscaling. This resulted in elaborated delta descriptions (see Appendix, on which this summarizing chapter was built. As the challenges vary within each system, the level of elaboration for each subsystem may differ for each delta.

4.2 Important trends, threats and pressures in the 3 deltas

All three deltas are partly experiencing similar trends and pressures that impact delta ecosystems and related opportunities for NbS. The following generic trends can be recognized:

- Increasing severity of climate change impacts, especially related to sea-level rise (with increased flood risk and salinity intrusion) and increasing frequency of extreme events such as peak discharges, droughts and extreme temperatures
- Subsidence due to groundwater extraction, resulting in increasing coastal erosion and risk of coastal flooding
- Population growth and urbanization
- Accessibility issues due to increasing transport in combination with lack of (well-maintained) infrastructure
- Increasing need for better sanitation and water quality

More specific details per delta are elaborated in the following paragraphs.

Mekong
The Mekong is one of the longest rivers in the world, extending over 4000 kilometers and running through 6 countries. The Mekong delta itself is generally regarded to begin in Cambodia and to end in Vietnam. The part of the delta in Vietnam consists of a deltaic plain of approximately 55,000 km^2, which is largely developed for agriculture and where 20% of the Vietnamese population resides. The Mekong delta is largely characterized by rice fields and shrimp aquaculture, with Vietnam being one of the largest rice exporters in the world and farmers sometimes producing up to 3 crops a year. In the 1980s, many farmers switched to aquaculture as this was deemed more profitable. Shrimp aquaculture requires brackish conditions, with an optimal mix of fresh and salt water. Extensive aquaculture activities have thus resulted in increased salinity intrusion by opening of sluices and deepening of ponds.

More intensive aquaculture sometimes uses groundwater as a fresh water source, thereby increasing subsidence rates. Besides the issue of subsidence, the reduced availability of sediment through upstream damming poses a real threat for the Mekong delta and adjacent coastlines. The reduction of fluvial sediment supply to the delta and embanking of the river and the floodplains prevents sediment deposition over floodplains. Furthermore, a reduction in the sediment budget results in coastal retreat and erosion.

GBM

The GBM is a transboundary river system spanning five countries: Bangladesh, Bhutan, China, India, and Nepal. The GBM delta, with a surface area of around 100.000 km^2, is the world's largest delta. The catchment of those three rivers is about 1.72 million km^2 and with 130 million inhabitants, the GBM belongs to one of the most densely populated areas in the world. This delta faces a high amount of risks from natural hazards such as cyclones and associated storm surges, riverine flooding and large-scale erosion of the coast and in the rivers. Other challenges involve growing urbanization, declining land availability, infrastructure shortages, energy supply constraints and dearth in labour skills (BDP, 2018). The climate change impacts working through the geography of the Bangladeshi part of the GBM delta (Ganges) can have vast adverse effects on the country’s development as it impacts a large number of sectors, of which, the most vulnerable is agriculture. Other highly vulnerable sectors are ecosystem-related, such as foresty (e.g. concerning the Sundarbans mangroves). Being highly dependent upon developments in the upstream area, the diversion, use or storage of flows from the trans-boundary rivers is of major importance to Bangladesh. Impacts on dry and monsoon season flows, salinization, siltation of rivers and sediment deposition in the Meghna estuary are the most important factor. The soil and water combination of Bangladesh makes it a highly fertile land with multiple cropping opportunities, primarily rice. Rice production has surged from 12 million tonnes in 1973 to 36.3 million tonnes in 2018. The importance of fisheries is growing so the structure of agriculture is slowly changing as the share of crop sub sector is falling and that of fisheries increasing (BDP, 2018).

Ayeyarwady

The Ayeyarwady delta in Myanmar is one of the major tropical deltas in the world with 30400 km^2 of it in Myanmar, which is one of the least developed countries in South-East Asia. The River Ayeyarwady flows from north to south through Myanmar, serving as the country's largest river and most important commercial waterway. In the river basin, rapid urbanization results in loss of fertile land, building in flood-prone areas and congestion. This is aggravated by fragmented spatial planning and land speculation (IADS, 2018). The upper delta is susceptible to rapid increases in water levels and bank erosion, given the highly variable discharges of the River Ayeyarwady and its branches. Local sand bars caused by bank erosion and sedimentation increase flood risk and reduce navigability within the waterways. The middle delta faces the issue salinity intrusion, and is characterized by less rapid changes in water levels compared to the upper delta. In this area, increasing pollution and encroachment of agriculture resulted in decreased agricultural productivity and a deterioration of ecosystems and their services. The urban area in the middle delta suffers from unsustainable patterns of urbanization and is highly exposed to frequent floods, concerning namely Yangon and Pathein, and to a lesser extent, Hinthada. Currently, urban infrastructure development for water supply, drainage, sewage systems and flood protection is not keeping up with increasing climatic and population growth pressures, thus hampering socio-economic development. The lower delta is most vulnerable to climate change due to its exposure to sea-level rise, potentially more severe cyclones and changing rainfall patterns that occur on top of riverine flooding and land subsidence. Reduction in sediment loads and alterations in the hydrological regime of the river have resulted in coastal erosion and deterioration or loss

of coastal ecosystems. This is expected to cascade into loss of ecosystem services and worsen poverty of coastal communities.
Myanmar is undergoing a rapid transition from one of the world's most isolated countries to an emerging democracy and opening up to the world through increased international investment. Hence, environmental conservation in parallel with economic development opportunities is one of the greatest challenges for Myanmar in the 21st century (Wildlife Conservation Society, 2013).

4.3 Status of the natural system

In deltas throughout South-East Asia, coastal and delta ecosystems are threatened by ongoing urbanization and economic developments, forcing a removal of these ecosystems. Ecosystem quality in densely populated deltas is strongly impacted by pollution due to lack of environmental regulations and enforcement, and by the lack of water sanitation facilities. Biodiversity is severely jeopardized by unsustainable use of ecosystem resources, through fishing, logging, poaching and harvesting. The reduction of total area of forests and wetlands severely jeopardizes the existence of large predators and several mammals, such as the Bengal tiger. The loss of ecosystems and biodiversity also translates into the loss of the most important services, such as protection against flooding on the short-term, and the production of fish, shellfish and crustaceans on the longer term. Currently, flooding is the costliest hazard in the world, leading to billions of dollars of damage each year. Hence, using NbS to conserve natural resources and ecosystems while making use of and planning for their services can be a fruitful strategy. Main findings of the three deltas are summarized in two tables: Status of delta ecosystems (Table 4-1) and an overview of current implementation of NbS types within the three deltas (Table 4-2).

Mekong
The Mekong delta is a primarily tide-dominated, characterized by sandy beach-ridge on the eastern side of the delta, with more muddy shorelines on the West side of Bac Lieu, Vietnam. Mangroves in the Mekong delta tend to develop along the coast, with a rather large aggregation in the south of the delta in Ca Mau, Vietnam (Bunting, et al. 2018; Ottinger, et al. 2018). However, for the vast majority of the delta plain, land use has changed from natural vegetation to intensive agri- and aquacultural areas. Mangrove forests have been cleared for alternative land uses such as shrimp farming, thus reducing its protection capacity against coastal erosion and flooding. Several mixed mangrove-aquaculture projects have been set up with the aim of integrating aquaculture productivity with mangrove conservation. However, in the lower parts of the delta, there is a continuing trend of mangrove loss since the 1980s due to decreased sediment input from the river and coastal squeeze through sea-level rise and building of sea walls. Mangrove restoration, through planting and through use of permeable bamboo structures, was applied in several areas but with limited success as these solutions do not solve the main bio-physical restrictions for mangrove recovery. Possible interventions to restore mangroves along the coast should accommodate for sea-level rise by including retreat schemes. In more riverine areas, connecting floodplains to the river to trap sediment and increase elevation may serve to counterbalance sea-level rise. In addition, addressing root causes of subsidence, such as uncontrolled extraction of groundwater, should be awarded the highest priority.

GBM
Many of the anticipated adverse effects of climate change, such as sea-level rise, higher temperatures and an increase in cyclone intensity, will damage the forest resources of the country. This will subsequently put pressure on many climate-sensitive species and cause increased erosion and deterioration of soil quality in many upland forested areas. The world's largest mangrove forest, the Sundarbans, is extremely vulnerable to climate change. Sea-

level rise will increase salt water intrusion and negatively affect the forest and its diverse ecosystem (Bangladesh Delta Plan 2100).
Water resources management is complicated by the fact that the flow generated in the 93% catchment of the GBM originates outside the border of Bangladesh before draining out to the Bay of Bengal (Bangladesh Delta Plan 2100). Tidal River Management (TRM) as an NbS was applied to the tidal rivers Hari and Kapotakkho in Satkhira District in the late 1990s. The application of TRM in these sites has only been mildly successful, as it was not adequately applied to the entire respective river basins. Although the nature-based solution is widely accepted by local communities, there are also some opposing groups and bureaucratic complexity. Since 1960s, the Forest Department has been undertaking coastal plantation programmes to stabilise Bangladesh's coastline.

Ayeyarwady

The mangrove area has been heavily exploited and is largely in a degraded state due to human activities such as wood harvesting and coastal development, leading to increased coastal erosion. The region was initially forested, and mangroves grew in tidally influenced areas. However, most of the area has been turned into agriculture polders and the total mangrove forest area in the delta has been seriously degraded over time due to overexploitation of the resource and conversion of land for rice fields and shrimp (and fish) ponds. This was promoted by the government as a way to ensure self-sufficiency in food production. The area covered by mangroves has decreased from 679.019 acres to 111.318 acres in the period between 1980 to 2013, equuating to a 83% loss of mangroves within 33 years in the Ayeyarwady delta (Maung, 2013). The quality of the remaining 17% of the mangroves in the Ayeyarwady region is not good and cannot be used to produce seeds for replantation (DA report, 2015)[14].

Table 4-1 Status of delta ecosystems

Delta	Sandy beach and dune systems	Mangrove systems	Coral Reef and Seagrass systems	Wetlands & Floodplains
Mekong				.....
GBM				
Ayeyarwady				

Deteriorating	Moderate	Healthy and sustainable

Table 4-2 Overview of current implementation of NbS types within the three deltas

Delta Ecosystem	NbS type	Mekong	GBM	Ayeyarwady
Sandy beach and dune systems	Sand nourishment (on the beach, under water or sand engines)			
	Sand trapping by vegetation or by sand screens			
Mangrove systems	Restoration of mangrove			
	Mangrove afforestation			
	Permeable structures			
	Creek digging			
	Mud nourishment			
	Multi-species planting			
	Mixed mangrove-aquaculture			

[14] Since 1980, Asia suffered a net loss of more than 1.9 million hectares of mangrove forests mainly due to changes in land use between 1980 to 1990 (Killmann, 2005)

Delta Ecosystem	NbS type	Mekong	GBM	Ayeyarwady
Coral Reef and Seagrass systems	Conservation of coral reef and seagrass			
	Coral transplanting			
	Reef crest restoration through reef balls			
Wetlands & Floodplains	Restoration of wetlands			
	Re-meandering			
	Reconnecting floodplains			
	Tidal river management			
	By-passes			
	Riparian buffers[15]			
	Sustainable Agroforestry			

Not in place or early stage   Some examples   Completed

4.4 Status of the institutional system

In general, countries are steered by multiple ministries with different mandates and responsibilities. Several South-East Asian countries are strongly decentralized, implying that decision-making is taking place at multiple levels. Often, cross-cutting issues that require a multi-ministry engagement, or worse, where mandates are unclear, are more difficult to tackle. Additionally, the strong incentive for infrastructure development often results in a lack of attention and budget allocation for maintenance. In all three deltas, there is an ongoing process of developing policy, laws and (action) plans. More specific details per delta are elaborated in the following paragraphs. Main findings of the three deltas are summarized in two tables: Status of important governance process elements (Table 4-3) and Status of NbS implementation (Table 4-4).

Mekong

Policy and legal Framework

On national-level, there are several strategy documents, especially the Mekong Delta Plan, Resolution 120 and the (forthcoming) Integrated Master Plan for the Mekong Delta. These include mentioning of eco-system based approaches but do not specifically address NbS. The concept of NbS is still relatively new in Vietnam, and has not yet been mainstreamed in the local practice. International organisations are currently taking the initiative to advocate NbS measures. In the past decade, major legal instruments applicable to climate adaptation and NbS have been rapidly developed, including laws on land (2013), water resources (2012), environmental protection (2013) and forestry (2017). In general, they provide a favorable setting for NbS, although discrepancies under different instruments for the same subject matter still exist. Spatial planning is strongly determined by (central) socio-economic planning, but private or market oriented activities are also very important and are not always aligned with the socio-economic plans of the government.

Institutional structure and process

The planning and implementation of mitigation and adaptation measures in Vietnam are often highly top-down, with strong roles of the central government and local governments. However, there are increasing attempts to initiate projects that strongly promote multi-stakeholder partnerships. The Master Plan integrates relevant existing sectorial plans for the delta, thus strengthening horizontal (inter-sectorial) and vertical (national-provincial-level)

[15] Riparian buffers are the lands and assemblages of plants bordering rivers, streams, bays and other waterways [The Science Behind the Need for Riparian Buffer Protection : ConservationTools]

coordination. Thus far, NbS measures have been mostly applied at the local level. There are not yet many examples of large-scale NbS being implemented.
The lack of incentives to engage local communities in long-term management or restored areas remains one of the factors limiting the upscaling of mangrove restoration activities in Vietnam (Hai et al., 2020). It is estimated that 197.000 ha of mangroves were planted in Vietnam from 1975 to 2018 (Hai, Dell, Phuong, & Harper, 2020). Several initiatives are currently in discussion and planning stages. Regarding cross-provincial linkages, there seems to be only pilot programmes (since 2016). An example of a successful NbS project in Vietnam is the mangrove shrimp farming project in Ca Mau entitled Mangroves and Market Project (MAM).

GBM

Policy and legal Framework

There are several important strategic policy documents, notably the Bangladesh Delta Plan 2100 (BDP 2100), the National Biodiversity Strategy and Action Plan and the Bangladesh Sundarban Delta Vision 2050. The BDP 2100 envisions a long-term, integrated and holistic plan towards environmental sustainability for Bangladesh. It also outlines strategies for restoration and conservation of natural reservoirs, river and flood management infrastructures and improving the management of ecosystem services. For the shorter- and medium-term period, the 7th Five Year Plan (2016–2020) is the main regulatory and policy framework. Beyond the most well-established projects in Bangladesh, the policy for implementation of NbS is not well articulated and there is an absence of monitoring systems which are vital for determining the effects of NbS. There is also a lack of a strong legislative framework, law and enforcement, local stewardship of the lands, imposition of land rights and proper institutional planning.

Institutional structure and process

Bangladesh has a highly centralized government with a strong administrative culture. Efforts are underway to improve core governance systems and to improve sectoral governance (DA, 2010). The BDP 2100 agenda is essentially cross-sectoral, and implementation arrangements involve multiple line ministries, local government institutions, communities and private sector. Clarity of role, interdependence of actions and a coordinated approach are essential requirements of the institutional set up for implementation of the BDP 2100. Yet, resources are limited and there are competing demands (BDP, 2018). Several multi-stakeholder mechanisms are in place at national level (BRIDGE[16], Ecosystem for Life) and international level[17]. There is a general absence of proper Private-Public Partnerships, community participation with gender and social inclusions, stable political economy, and policy makers' awareness regarding the benefits of NbS, making it more challenging to scale up NbS to a national level. Moreover, upscaling NbS faces several challenges with regards to the project design, planning and implementation (ICCCAD, 2020). These include institutionalisation of projects where planning should be built-in and a lack of understanding of short-term and long-term trade-offs and benefits. There is a community of researchers, practitioners and policymakers working at the interface of climate change, nature conservation and sustainable development, which is primarily focused on creating awareness and understanding of the importance of NbS and to scale up their implementation potential in the country.

[16] Building River Dialogue and Governance (funded by IUCN)
[17] Joint River Commission, Feni river agreement, MoU between Bangladesh and India on Conservation of the Sundarban, Bangladesh-India Sundarban Region Cooperation Initiative

Ayeyarwady

Policy and legal Framework

In 2018, several experts and officials developed the first phase of the Integrated Ayeyarwady Delta Strategy (IADS), which defines a long-term development perspective for the delta. The document envisions a safe, prosperous and sustainable delta with a vibrant, diversified economy and ecology that are resilient to salinization, floods and water shortage. Nevertheless, the objectives remain at a rather generalized level without specific targets as the Ayeyarwady Delta's development is at the early stages. The IADS plan includes short-term, non-regret measures such as restoring coastal mangroves. Legislation, policy guidelines, standards and regulations are set at the national level and transferred for implementation to the regions/states, districts, townships and communes/wards. On the other hand, in some sectors, there are neither mechanisms nor political will to enforce laws and policies, and multiple ministries have a competing stake in one or more of the (sub)sectors. The National Coastal Resources Management Central Committee discussed about NbS as a cost-effective and efficient approach during their meetings, but has not resulted in implementation yet.

Institutional structure and process

The institutional and governance situation in the Ayeyarwady delta is complex, and often imposing difficulties in decision-making processes. There are fragmented responsibilities between ministries and departments hindering coordinated water resource management (IADS, 2016). There are increasing initiatives for decentralizing and providing higher control to local authorities, which nevertheless requires more decisive empowerment and capability of local authorities. There is no River Basin Organisation and no institutional responsibility for coastal protection, therefore, integrated management of the delta needs much improvement as the interventions are currently minimal. There are several committees at the national level such as Coastal Resources Management, Wetlands and Disaster Management. The democratization process included the introduction of new land-use policies as a restorative justice measure due to the large-scale land confiscations in the past (Mark & Belton, 2020). Confiscations enabled the rapid expansion of large-scale aquaculture during the 1990s and 2000s in the delta, which in turn defined the investment policy of hydraulic infrastructures (Belton et al., 2018).

Table 4-3 Status of important governance process elements

Delta	Long term vision / policy documents regarding NbS	Regulatory framework and instruments	Shared Understanding on NbS	Multi-stakeholder platforms (multi-sectoral, multi-scale level)	Upstream-downstream cooperation
Mekong	Underway / planned	Underway / planned	Not in place or early stage	Underway / planned	Underway / planned
GBM	Underway / planned	Underway / planned	Underway / planned	Underway / planned	Underway / planned
Ayeyarwady	Not in place or early stage	Not in place or early stage	Not in place or early stage	Not in place or early stage	Not in place or early stage

Not in place or early stage   Underway / planned   Completed / operational

Table 4-4 Status of NbS implementation

Delta	Planning	Design	Construct	Operation & Maintenance	Monitoring
Mekong	Underway / planned	Not in place or early stage	Not in place or early stage	Underway / planned	Not in place or early stage
GBM	Underway / planned	Not in place or early stage	Not in place or early stage	Not in place or early stage	Underway / planned
Ayeyarwady	Not in place or early stage	Not in place or early stage	Not in place or early stage	Not in place or early stage	Not in place or early stage

Not in place or early stage   Underway / planned   Completed / operational

4.5 Status of the socio-economic system

Mekong

The Socio-Economic Development Plan 2016-2020 defined a major objective: *To integrate environmental protection and green economic development within economic growth*.

The long-term strategic vision of the Mekong Delta Plan aims at turning the area into a regional hub specializing in high-value agriculture for international and domestic markets (Weger, 2019). Such ambition requires controlled river floods in the wet seasons in the upper and middle Delta; while restoring the large-scale destruction of mangrove forest due intensive and extensive shrimp farming. The national and local governments have encouraged mixed or integrated mangrove-shrimp systems that must maintain at least 40% of their area under mangrove cover (Nguyen et al., 2018). A promising alternative is to place more emphasis on the regulation rather than the provision of ecosystem services, considering the important role of mangrove forest regulating greenhouse gases (Jarvio, 2018). The Vietnamese government avails several funds for supporting mangrove restoration activities. However, government funding is insufficient for country-scale implementation. Hence, one of the goals of the Viet Nam National Green Growth Action Plan 2014 – 2020 was to increase finances, including access to international finance and the establishment and scale-up of a facility. Most of current initiatives on NbS in Mekong Delta rely on international development finance, and involvement of the private sector in financing NSB measures is still rather limited. There is currently no centralized fund for coordinating the financing streams for NbS specifically.

GBM

In the GBM delta, economic development is an important driver with medium to severe impacts. The agriculture in the GBM delta is mainly driven by rice, aquaculture (shrimps, catfish) and related industries. The delta is also developing in infrastructure and related (geo-engineering) modelling or ICT services. With the low level of investments available, the financial challenge for upscaling NbS is clear. For the practitioners and the local communities, the lack of financial incentives act as a barrier to the implementation and ongoing monitoring of NbS. In the district of Satkhira, one of the most obvious and practical economic development solutions, where NbS is incorporated, is to reap monetizable benefits of the Sundarbans mangrove forestss through eco-tourism, sustainable farm-fishing, sustainable forestry, agricultural activities (rice cultivation and/or vegetables) and maintenance or planting of new mangrove forests.

Ayeyarwady

The health of river, wetlands and marshes represent a critical asset, contributing betweenn 2-6 billion USD the Myanmar economy annually (WWF, 2018). Aquaculture and fishing constitute a key source of income and food security in the Ayeyarwady delta and host an important share of the paddy production (Radford & Lamb, 2020). Rice grown in the delta is more productive per hectare than elsewhere in the basin (WWF, 2018). Additionally, the Myanmar Exclusive Economic Zone (EEZ) occupies 80% of the northeast coastal waters of the Bay of Bengal Large Marine Ecosystem (Akester, 2019), which fish productivity depends on the extension mangrove forests, the continental shelf and the sedimentation process from the river systems. The IADS structures the economic case for ecosystem services and quantifies the estimated values of nature for several economic sectors. The rapid economic dynamics since 2010-2011 imposed new demands and pressures, such as an increase in energy consumption leading to more hydro-power projects that impact (delta) ecosystems. WWF has already noted the need to consider the socio-environmental impact on the development and the role of functional habitats in the long-term sustainability of the Belt and Road Initiative (WWF, 2020). Thus far, the country has made advances in restructuring the investment-related authority, including setting up a Public-Private Partnership Office for coordinating large-scale projects (Tritto, 2019).

Additionally, the implementation of the Belt and Road Initiative in Myanmar sets a condition for keeping country open to international financing institutions. The Forest Department and the Environmental Conservation Department under the Ministry of Natural Resources and Environmental Conservation acts as the governmental financing coordinating institute.

Main findings of the three deltas are summarized in the following two tables (Table 4-5 and Table 4-6).

Table 4-5 Resource mobilization for NbS via the various finance streams

Delta	Governance	Private sector	International development	Blended
Mekong				
GBM				
Ayeyarwady				

Not in place or early stage   Underway / planned   Completed / operational

Table 4-6 Finance coordinating entities

Delta	Government	Non-profit trust	Investment funds	Special Purpose Vehicles
Mekong				
GBM				
Ayeyarwady				

Not in place or early stage   Underway / planned   Completed / operational

4.6 Summary of conclusions and recommendations

Mekong

Mekong delta ecosystems are clearly under pressure, especially mangroves and other intertidal habitats. The concept and implementation of NbS still needs to be further developed and mainstreamed in policy plans, regulatory frameworks and in local practice. Specifically, more sustainable mangrove-aquaculture practices are needed. Owing to low levels of collaboration on a catchment-scale, low financial coordination for pipelining NbS and limited involvement of the private sector in financing NbS, the Mekong delta will require a better balance of upstream-downstream activities, as well as re-establishing ecosystem connectivity, such as restoring environmental flows. Due to the transboundary nature of the Mekong, socio-economic activities, such as damming for increased energy demands or groundwater extraction for freshwater access, will need to be better communicated and negotiated with relevant stakeholders in the delta. Researching and elaborating the co-benefits of NbS are likely to strengthen the case for NbS within the Mekong delta, both financially and socio-economically. Management of the Mekong delta will still require a dedicated finance coordinating entity in order to upscale NbS within the delta as well as implement NbS projects more efficiently by mobilizing other resources than international development finance.

GBM

The GBM delta faces a high amount of risks from natural hazards and socio-economic developments, impacting negatively all delta ecosystems including the Sunderbans mangroves.

Awareness raising on ecosystem importance and NbS is needed within the government and the general population, addressing short-term and long-term (co)benefits and trade-offs. In addition, the governance process requires maturing by establishing clear visions and strategies, stakeholder participation and consultation and strengthening the legislative framework through establishing monitoring systems, regulation and enforcement. Bottom-up activities, such as knowledge-sharing and inclusive community participation need to scale-up as the success of NbS implementation and management proves to be dependent on community participation.
Regarding application of Tidal River Management, short-term local socio-economic needs versus long-term benefits should be addressed through appropriate arrangements in future projects. In general, the level of investments has been low, and will require creating financial incentives (e.g. enabling investments for better cooperation and knowledge-sharing, public-private partnerships). Implementing NbS within the GBM delta will likely include larger-scale Tidal River Management projects, conservation of the Sundarbans and maintaining ecological, sediment and fresh water balance and flows of rivers due to the strong upstream-downstream connection of the GBM.

Ayeyarwady

The middle and lower delta suffers deterioration of delta ecosystems and their services, caused by climate change (sea level rise, storm surges) and socio-economic developments (urbanization, coastal development). The total mangrove forest area is seriously degraded due to overexploitation and the conversion of land for rice fields and shrimp/fish ponds, leading also to increased coastal erosion. Counteracting strategies and NbS should be further developed, such as assisting natural regeneration, establishing buffer zones along rivers, mangrove restoration intitiatives, erosion control methods (a.o. bamboo fences) and sustainable mangrove-aquaculture practices.
Although the Integrated Ayeyarwady Delta Strategy has been established, more specific targets, visions and strategies need to be made, especially regarding conservation and restoration of delta ecosystems and NbS. Land-use management and planning issues are a major bottleneck. Competing stakes across different sectors and ministries, low enforcement and regulation, and fragmented responsibilities hinder the implementation of NbS. Capacity building and higher institutional responsibility is needed for integrated management of the delta, as well as redistributing responsibilities to the appropriate actors, strengthening cross-sectoral coordination and engagement with local stakeholders. Resource mobilisation for NbS is still limited and should be further developed. Additional research and knowledge sharing is needed regarding (economic) valuation of ecosystem services and cost-benefit analysis. Moreover NbS will be enhanced by more detailed methodologies and guidance for implementation, along with more evidence-based information for decision-makers.

5 The way forward

The major deltas of the world show similarities with respect to biophysical processes. They are all deltas, hence, places where the river meets the sea, and they are intrinsically shaped by the interaction between water and sediment. Nowadays under climate change and socio-economic pressures, delta stability and resilience is strongly influenced impacted by anthropogenic interventions that influence water and sediment flows to the delta. However, to steer anthropogenic modifications in such a way that resilience of the delta is increased and not reduced, is merely a governance and socio-economic challenge. This challenge varies along a continuum from proactive political will and sufficient resources available (Mekong) to challenged governance and extremely scarce resources (Ayeyarwady). Often, economic growth and reducing poverty are perceived as being more important and long-term delta resilience is not considered in day-to-day decision making (GMB). Indeed, it is the human and institutional challenges needing to be addressed alongside any technical or natural system intervention, that will finally enable transformation of management approaches in Asian deltas and beyond.

Amplifying NbS projects on much larger spatial scales to substantially yield impact requires a landscape approach for planning and implementation. This should be part of a vision at a delta or catchment scale that addresses both upstream-downstream and channel-floodplains processes. Implementing a landscape approach successfully, generally requires a high level of organizational capacity, financial literacy and technical literacy. To identify challenges for upscaling towards a landscape approach adopting a system perspective and understanding system functioning is essential. We examined how NbS can be upscaled within each of the three subsystems: natural/biophysical, governance/institutional and socio-economic/finance. Recommendations for each subsystem are provided below.

Within the biophysical/natural subsystem, a landscape approach will require moving beyond traditional, mono-ecosystem approaches by **respecting and considering synergies between different ecosystems**. The approach should focus on upstream-downstream linkages, striving to understand flows of water, sediment, nutrient and species throughout the landscape. Additionally, it should embody systems that interact heavily with each other, such as the seascapes, riverscapes or deltascapes. Most importantly, the choice of NbS must be aligned with the natural environmental dynamics of the area. NbSs' that involve ecosystem restoration should be implemented in areas where the ecosystem is suited to thrive, or where the ecosystem can adapt to future changes.

Within the institutional - governance subsystem, **strong organizational capacity, technical literacy and financial literacy** are **required.** A master planning approach can be adopted ensuring that all projects contribute to multidisciplinary master plan objectives. The master plan will guide planning and implementation at landscape and delta level and constitute the link of local NbS projects at landscape scale. In this way, NbS will be part of strategies that contain multiple fit-for-purpose interventions, such as non-structural, conventional engineering and hybrid measures (mixed hard/soft). Establishment of a stakeholder platform can facilitate communication and negotiations between different stakeholders, and guarantee 'bottom-up' inclusion of local stakeholders' knowledge and commitment. Additionally, regular **monitoring and evaluation** activities should be performed, so that lessons learnt from past projects can be applied in future iterations. Moreover, project performance indicators can help make a more convincing case with investors that have less familiarity with NbS. A structured and mature level of governance will allow entities to better coordinate and pipeline NbS projects according to different financing schemes, otherwise known as resource mobilization.

This involves also coordination of landscape investments either through a coordination entity or collaboration beyond the geographical scope.

With respect to the socio-economic subsystem and to financing**, socio-ecological linkages should be respected and included.** Non-direct benefits of NbS should be quantified and integrated to make a stronger case for NbS, even on a landscape-scale. Non-direct benefits that are monetizable can be used to strengthen the business case for NbS in order to leverage private financing. Non-monetizable, non-direct benefits can be utilized to strengthen the business case for leveraging private investments, take advantage of blended finance approaches or to make a stronger case for public funding and provision of services and goods. It will, therefore, require a strong understanding and categorization of how excludable or subtractable goods or services are, as well as defining the nature of goods and assessment of potential trade-offs, costs and revenue generation activities. This should address also temporarily compensating / warrantying livelihoods of local people that are affected by NbS and who will only in the longer term get the benefits of it. The implementation of NbS for delta management is, thus, highly dependent on the existing environment, current and future pressures, clear strategies and goals, and institutional and financial frameworks.

In many deltas, major systemic transformations may be needed to ensure water, energy and food security, sustainable development and a safe and healthy living environment. Although each delta has its own unique challenges, there are several overlapping themes emerging. These exact challenges are not unique for the three Asian deltas subject of this report, but rather are more generic challenges for implementing NbS. The current pitfalls in governance, institutional, financial and bio-physical settings form the basis for recommendations with respect to upscaling NbS and are divided by the 3 sub-systems:

Bio-physical/natural perspective
- Clear assessments should be made on the bio-physical boundary conditions required for specific NbS to be successful (such a availability and quality of sediment or rate of sea level rise)
- Clear and measurable indicators for effectiveness of NbS need to be developed

Institutional and governance perspective
- NbS are inherently appealing to decision-makers as it supports multiple policy goals, and should be advocated as such
- Enable and enforce multi-level, multi-sectoral and multi-scale cooperation to optimize implementation of NbS through the landscape approach
- NbS are often multi-sectoral and needs to be coherently realised in combination with other solutions or activities
- Increase capacity building for the topic of NbS and improve awareness of it through top-down and bottom-up approaches
- Regular monitoring and evaluation activities are needed, addressing good (and bad) practices
- Landscape governance will likely require one or more financing coordinating entities, allowing governing bodies to engage with different investors and streamlining the coordination of investments beyond the scale of single projects

Socio-economic and Finance perspective
- Financers need to be involved in NbS from an early stage to raise awareness about short and long term (co)benefits and to determine most appropriate types of finance streams (public, private, international development and blended finance)
- Both direct and non-direct benefits need to be better elaborated for NbS through appropriate metrics and indicators

- NbS benefits can be hard to quantify, let alone its co-benefits, but this likely remains necessary to provide better perspectives on risk profiles and return on investments (including avoided costs), so as to leverage private financing. Avoiding ecosystem degradation, loss of fertile land and associated livelihoods should also be taken into account
- Government and accelerator funding calls should be transparent and include a science and monitoring component elaborating an integrated system approach, so as to prevent a financially attractive solutions to result in potentially conflicting outcomes, hampering sustainable development or social equity
- Public-Private-Partnerships (PPP) must be more strongly enabled or facilitated to improve the involvement of the private sector and serve as a strong, sustainable financing mechanism for NbS

6 Annex

6.1 Nature-based Solutions – definition and background

Nature-based Solutions (NbS) are becoming an increasingly popular concept in water management practices. Although approaches that advocate working with nature and integrated and holistic design were advocated in the 90's already (Mcharg 1995), nature-based solutions took flight after the Millennium Ecosystem Assessment (MEA 2005). Here the concept of ecosystem services was proposed referring to the benefits people obtain from the natural environment (Millennium Ecosystem Assessment [MEA], 2005) (Box 6.1). Afterwards similar concepts with slightly deviating definitions emerged (Box 6.2), such as green infrastructure and Nature-based Solutions. Other terms refer more to the process of using NbS, such as Engineering with Nature (Ridges et al. 2015) and Building with Nature (de Vriend & van Koningsveld 2012). The latter is defined as a new approach to hydraulic engineering that harnesses the forces of nature to benefit environment, economy and society.

A growing number of international organizations, multi-lateral agencies, financing institutions, and private businesses now see the potential of NbS. NbS is mentioned and credited, amongst others, in the Paris Agreement on Climate Change, in the Intergovernmental Science-Policy Platform on Biodiversity and in the UNISDRR Sendai framework (2015). However, although there are multiple global examples of NbS projects and implementations (for an overview see online portals or catalogues listed in Annex 7.3), most of these efforts are loose and project-based examples. Hence, for large-scale implementation of NbS several challenges need to be overcome (see Box 6.3). For example, showing economic benefits and bankability of NbS projects may help to mainstream NbS as a standard practice.

Box 6.1 Ecosystem Services

Ecosystem services are the benefits people obtain from the natural environment (Millennium Ecosystem Assessment 2005). Four types of ecosystem services are outlined:

- ***Provisioning services** – Consist of all the products obtained from ecosystems, such as food, water, and raw materials*
- ***Regulating services** – The benefits obtained from the regulation of ecosystem processes. In the case of the Ayeyarwady Basin, these include maintaining water quality, flood risk management, climate regulation, waste treatment and disease control, and natural hazard regulation.*
- ***Cultural services** – Related to non-material benefits, such as recreation, tourism, and aesthetic cognitive, and spiritual benefits.*
- ***Supporting services** – Consist of soil formation, photosynthesis, and nutrient cycling.*

Box 6.2 Definitions adapted from ADB 2020

- *Hard/grey Infrastructure: built structures and mechanical equipment, such as embankments, reservoirs, groins, riprap, pipes, pumps, water treatment plants, and canals*
- *Green Infrastructure: strategically planned network of natural and semi-natural areas that are consciously integrated in spatial planning and territorial development , and are designed and managed to deliver specific infrastructural services and to provide a range of co-benefits in both rural and urban settings (EC, 2019)*
- *Nature Based Solutions: "actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (Cohen-Shacham et al., 2016).*
- *Natural River Management: iterative, science-based and participatory water resources management focused on harnessing functions and services of natural river systems while reducing hazard impacts.*

Box 6.3 Barriers and opportunities regarding implementation of NbS

Institutional / governance perspective
- *Lack of political commitment and ownership*
- *Lack of multi-sectoral cooperation; optimization of NbS by sector and not by landscape*
- *Lack of awareness on added value of NbS (or hybrid) compared to traditional solutions*

Finance and investments perspective
- *Different perspectives on risk management / Return on Investments*
- *Investments costs versus maintenance costs (+ avoided costs, what if not..)*
- *Lack of involvement of financiers from early stage*

Bio-physical perspective
- *Lack of clear (and easy measurable) indicators for effectiveness and (co-)benefits of NbS*
- *No clear overview of which products and services are provided by NbS and for which sectors*
- *Interacting (seasonal aspects) of NbS + trade-offs (e.g. for change of water level in reservoir)*

6.2 Current initiatives or programs in Asian deltas

Delta Alliance – Delta Coalition

Delta Alliance is an international knowledge-driven network organisation with the mission of improving the resilience of the world's deltas. The Delta Alliance, with 18 network wings from 15 countries brings people together who live and work in deltas. The Delta Alliance provides a platform where they can share their knowledge and benefit from each other's experience and expertise and as such contribute to an increased resilience of their delta region.
http://www.delta-alliance.org/

The Delta Coalition is world's first international coalition of governments that have formed a partnership to deal with delta challenges. The coalition facilitates a complete body of knowledge on deltas, adaptation, resilience and sustainable urban development.

Most importantly, it allows delta countries to join forces to stimulate best practice, innovation and to increase opportunities for financing in order to facilitate implementation of projects that will reduce vulnerability to climate change.
https://www.deltacoalition.net/

UKRI GCRF Living Deltas Research Hub

This program is focusing on 3 major deltas in Asia: Red River and Mekong deltas in Vietnam and the Ganges-Brahmaputra-Meghna delta in Bangladesh and India.

The Living Deltas Hub's core aim is a significant contribution to better sustainable development outcomes for developing countries in the region, transforming policy and practice based on new approaches to understanding delta change. The Hub will address the significant social-ecological challenges currently confronting these delta systems in a transdisciplinary manner that responds to the interlinked agenda of the UN Sustainable Development Goals. The Hub is coordinated in Newcastle University and has over 20 partners across the delta regions and the rest of the world.

http://www.livingdeltas.org/index.html

CGIAR 2° Initiative launches webinar series on Asian Mega-Deltas

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), its Center and external partners have put together the "Two Degree Initiative," a coalition of partners with the ambition to reach significant climate change, poverty, nutrition and environmental targets. The initiative will focus on low- and middle-income countries and work on a set of global themes that align with a theory of change for transforming the food system.

https://ccafs.cgiar.org/two-degree-initiative-2di#.XzvR6PZuJPY

https://www.irri.org/news-and-events/news/cgiar-2°-initiative-launches-webinar-series-asian-mega-deltas

WWF Resilient Asian Deltas (RAD)

The vision of the RAD initiative is to build long-term resilience of Asia's delta systems, and in doing so, protect and restore rivers and coastal areas that replenish deltas for people, economies and nature.

Launched in late 2019, WWF, the Government of the Netherlands (a core member of the Delta Coalition), and ABInBev, with support from the World Economic Forum, are mobilizing a Resilient Asian Deltas (RAD) initiative to stop six of the continent's largest delta systems – Chao Phraya, Ganges-Meghna-Brahmaputra, Indus, Ayeyarwady, Mekong and Pearl – from sinking and shrinking. By facilitating a broad coalition of public-private champions, including delta governments, investors, insurers, CSOs and private companies, the initiative will tackle the complex challenges facing Asia's deltas and build more resilient societies, economies and ecosystems. To achieve this vision, RAD will catalyse unprecedented political support for and financial investment in 'building with nature', thereby protecting and restoring the natural river and coastal processes that replenish deltas and will keep them above the rising seas.

https://wwf.panda.org/our_work/our_focus/freshwater_practice/freshwater_inititiaves/resilient_asian_deltas_initiative/

Rather than targeting the symptoms of erosion and land subsidence, the initiative will move beyond "business as usual" and focus on assessing and tackling the root causes of the crisis facing these dynamic ecosystems – so that they can continue to support hundreds of millions of people, productive agriculture and fisheries, thriving economies and expanding cities, and sustain the rich biodiversity of the region.the Resilient Asian Deltas initiative will be built on three core pillars, all actioned and implemented at both national and regional levels by RAD Members.

Envisaged impacts of RAD: Increased resilience of the most vulnerable people, Increased resilience of infrastructure and the built environment, Increased resilience of ecosystems and ecosystem services, Improved river health, Increased biodiversity.

6.3 Most relevant SDGs in delta areas

Table 6-1 Relevant SDGs within deltas, targets, challenges and SDG indicators

SDG	SDG Target	Related problem	SDG Indicator
1 Poverty	1.5 resilience of the poor and the vulnerable	Floods Droughts	1.5.1 Number of deaths, missing and directly affected persons 1.5.2 Direct economic loss 1.5.3 national DRR strategies 1.5.4 Local DRR strategies
6 Water	6.4 water-use efficiency / water scarcity 6.5 IWRM 6.6. protect and restore water-related ecosystems 6.b strengthen the participation of local communities	Water scarcity Water pollution	6.4.1 Change in water-use efficiency over time 6.4.2 Level of water stress 6.5.1 Degree of IWRM implementation 6.5.2 Proportion of transboundary basin area with water cooperation 6.6.1 Change in the extent of water-related ecosystems over time 6.b.1 Established and operational policies and procedures for participation
9 Infra-structure	9.1 Develop quality, reliable, sustainable and resilient infrastructure	Limited infra Limited transport	9.1.1 Proportion of the rural population who live within 2 km of an all-season road 9.1.2 Passenger and freight volumes, by mode of transport
11 Cities	11.b Implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters	Heat stress Urban flooding Unhealthy urban environment (air, water, soil)	11.b.1 /2 number of countries with national and local DRR strategies
13 Climate change	13.1. Strengthen resilience and adaptive capacity	Erosion Flooding Salinisation	13.1.1. Number of countries with national and local DRR strategies 13.1.2. Number of deaths, missing persons and affected persons
14 Marine and coastal ecosystems	14.2 manage, protect and restore marine and coastal ecosystems	Ecosystem degradation Loss of ecosystems & biodiversity	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches
15 Terrestrial ecosystems	15.1 conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services	Ecosystem degradation Loss of ecosystems & biodiversity	15.1.2. Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
17 Global Partnerships	17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources 17.17 Encourage and promote effective public, public-private and civil society partnerships; Data, monitoring and accountability	Lack of multi-stakeholder cooperation and partnerships Lack of exchange of knowledge, expertise, technology and financial resources	17.16.1 Number of countries reporting progress in multi-stakeholder development and effectiveness monitoring frameworks 17.17.1 Amount of USD committed to public-private and civil society partnerships

6.4 Overview of delta ecosystems for NbS

6.4.1 Sandy beach and dune systems

Sandy Beaches and Dunes

Approximately 31% of the world's ice-free shorelines are sandy, with a peak in occurrence around latitudes 30°S and 25°N, as shown in Figure 6-1 (Luijendijk et al., 2018). Sandy beach and dune systems are characterized not only by grain sizes (0.0625-2mm) but are also typical of wave-dominated environments (Largier, Cheng, & Higgason, 2010). Wave-dominated coastal systems are defined by the relatively high significant wave height compared to tidal ranges. Crucial to the formation and maintenance of sandy beach and dune systems are the steady supply and net accumulation of sediments (Davis & Hayes, 1984).

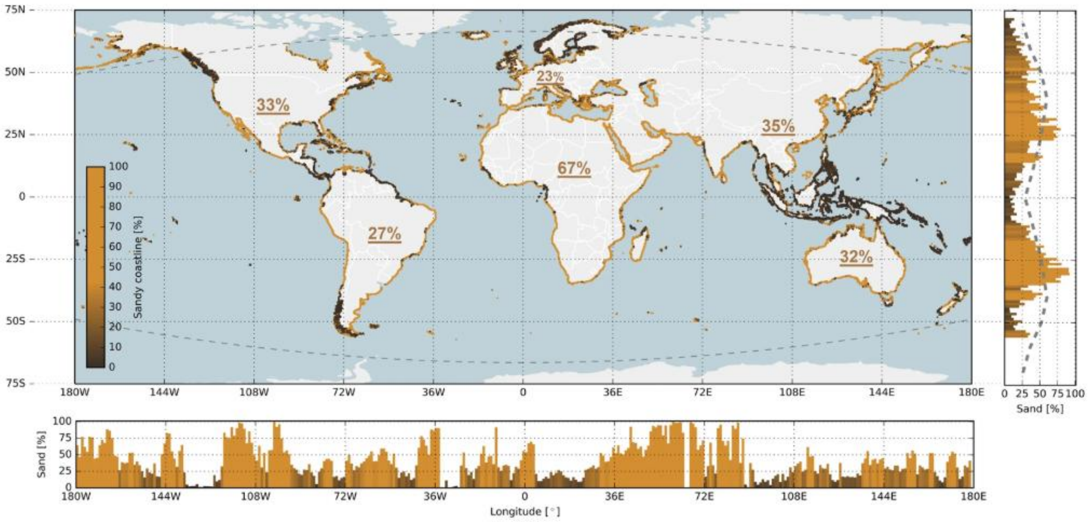

Figure 6-1 Global distribution of sandy shorelines, as adapted from Luiendijk et al. (2018).

Prominent sand dunes in Asia include LaPaz in Philippines, Parangtritis, Pasirbesi and Puger in Indonesia and Bay of Along and Cape Vung Tau along the coast of Vietnam. While beach formation is widely prevalent in Asia and South-East Asia, dune fields are much less present (Hesp, 2008). This is mainly attributed to the lack of sandy sediment and the action of land and sea ice (Masselink, Hughes, & Knight, 2011).

Sandy beaches and dunes have different morphological elements that interact with each other. Sea-facing beaches have three main morphological end-members that reflect its near-past and sediment composition, as illustrated in Figure 6-2.

Dissipative beaches have wide, mildly sloped surf zones containing fine sand, with multiple bars, on which waves break and that are formed by large waves with small periods (Masselink et al., 2011). The opposing end-member is the reflective beach, characterized by a steep beach face containing generally coarse sediments formed by small waves with long periods (Aagaard, Greenwood, & Hughes, 2013). Intermediate beaches are a transitional beach morphology between reflective and dissipative types. Dynamic bars dissected by rips are distinctive for this morphology. These bars either migrate towards shore and form reflective beaches, or migrate offshore to form dissipative beaches (Masselink & Short, 1993). A source of sediment for beach formation or maintenance can also be from littoral drifts of sediment by long-shore currents and aeolian transport, aside from fluvial transportation and deposition(Hanley et al., 2013).

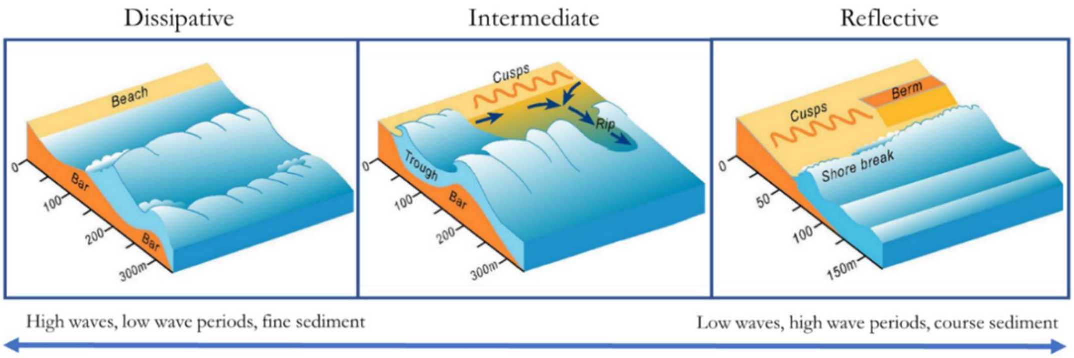

Figure 6-2 Illustration of the 3 beach morphology types and their distinctive features (Masselink & Short, 1993)

Dunes, on the other hand, rely on a combination of sand supply, aeolian transport processes and vegetation for trapping of sand. Embryonal dune formation is encouraged by the presence of vegetation that have high tolerance for salinity and adapted for high sediment deposition environment (Pye, Saye, & Blott, 2007). Surface roughness needs to be high enough to encourage deposition of sediments from aeolian transport or vegetation should be present to trap sediment. The transition to permanent dune systems requires a positive sediment budget with an input of sediment that exceeds sediment that is removed by erosional processes. Erosion is affected both by aeolian and hydrodynamic processes, which may either cause a landward migration of the dunes or a decrease in the size of the system.

Figure 6-3 An example of how dune erosion may look

For shoreline resilience and management, foredune morphology is often examined due to its position as the first line of defense for coastal inundation and erosion. Fore dunes or primary dunes are features that run parallel to the coastline, and in cases where sediment accretion can occur, foredunes can expand seaward to and improve shoreline resilience against flooding and erosion (Sigren, Figlus, & Armitage, 2014).

Mechanisms governing protection against flooding and erosion

Sandy beach and dune systems primarily offer protection against flood and erosion hazards by attenuating and dissipating waves, allowing waves to break more easily as a first line of defense against flooding as well (Hanley et al., 2013). However, the value of their shoreline protective properties is enhanced through concurrent abiotic and biotic processes, such as vegetation and sediment nourishment through longshore transport. In some cases, active restoration is needed in order to preserve these systems to promote protection against flooding and erosion.

Vegetation
Important to the protective functions of these systems are the presence of vegetation in beach and dunes. Vegetation enhances the resilience capacity of these systems by reducing erosion and attenuating waves (Feagin et al., 2019). The presence of vegetation significantly enhances wave energy dissipation properties of both beaches and dunes. Furthermore, vegetation helps to reduce erosion rates and promote net accretion, thus providing a two-pronged benefit in promoting coastal safety along with preservation of the ecosystem (Sigren et al., 2014). A vegetated beach and dune system is more effective at reducing coastal inundation and reducing damages caused by extreme events. Intervention in coastal management should occur when these systems begin to lose their vegetative cover.

Sediment nourishment
Since shoreline erosion and coastal inundation will continue to occur under climate change, beach and dune systems offer protection against coastal inundation by acting as a natural flood defense against surges. To enhance this specific ecosystem function, nourishment measures complement the soft coastal protection technology against these hazards (B.K. van Wesenbeeck et al., 2014). One such example of a nourishment strategy implemented in sustaining beach and dune systems is the Sand Motor Engine project in The Netherlands. As part of The Netherlands is below sea-level, the country faces a myriad of potential hazards arising from SLR, inundation and erosion(Stronkhorst, Huisman, Giardino, Santinelli, & Santos, 2018). Every 5 years, sand nourishment is carried out to replenish the sand budget in that area. The sand nourishment ensures coastline resilience for the next 20 years and offers co-benefits for habitat formation and socio-recreational activities. The Sand Motor project is also significantly different from other sand nourishment strategies as it is a 'mega-nourishment', which ensures a longer-lasting source of sediment in the area for beach and dune maintenance(Taal et al., 2016).

Sensitivities of measures

The underlying mechanism governing the survival of these systems is the *continuous supply* of sufficient sediment. This requires a consideration of upstream activities that interfere with the transport and flow of sediments downstream. Anthropogenic activities, such as damming, severely interrupt the natural sediment and flow regime of the river, potentially disrupting downstream ecosystems and causing unsteady states while the system seeks new equilibriums. Nourishment strategies can also be considered, complementary to assessing sediment flows for management of these measures. However, large-scale nourishments may not be suitable due to the huge demand for sand extraction. Implementing a nourishment strategy for extensive and exposed coastlines are not always feasible due to the amount of restoration effort required.

Furthermore, extraction and mining of sand in rivers induces a positive feedback cycle that further increases risk from climate-related hazards due to the disruption of sediment supply, which will have cascading implications on viability of mangrove forests and seascape management as well. Other human interventions such as land reclamation and dredging can fundamentally alter the hydrodynamics and sediment transport within the system, as well as removing vegetative cover which reduces the beach and dune's ability to stabilize sediments (FAO, 2007).

Global warming and melting of major ice sheets contribute to global increases in sea levels (IPCC, 2007). Other effects of climate change may also include changes in weather and ocean circulation patterns, which may affect transportation pathways of sediment to beaches and dune systems (Hanley et al., 2013). The ecology of vegetated landscapes may also experience regime shifts due to alterations of the habitat boundaries. In conjunction with increased storminess, the processes causing coastal erosion will intensify and create additional stressors on these systems. The combination of enhanced erosion and spatial expansion activities will result in a 'coastal squeeze', reducing the carrying capacity of these ecosystems to protect against flooding and erosion (Hanley et al., 2013).

6.4.2 Mangrove systems

Mangroves

Mangrove forests, which typically occur within the tropical and sub-tropical belts in intertidal and estuarine environments, are vital for the provision of important ecosystem services such as contributing to biodiversity by providing sheltered habitats for many species, including serving as nurseries for juvenile fish, shellfish and crustaceans (Thomas et al., 2017). Mangroves play important ecological roles, such as sequestering carbon by accumulating both above- and belowground stores of biomass and thereby, offering potential for climate change mitigation(Woodroffe et al., 2016). More importantly, due to the intricate and dense root system of mangroves, the use of these ecosystems in reducing flooding and erosion has been advocated, as it is able to significantly attenuate wave and tidal energy.

In the context of risk reduction, strong cases have been made to utilize mangrove forests as a protection measure against incident wave energy produced from events such as storm surges or tsunamis, reducing the risk of erosion and flooding (McIvor et al., 2012; Horstman et al., 2014). Wave attenuation is affected by mangrove-induced drag, thus enhancing deposition of sediments (Smith et al., 2009) and also dissipating wave energy. They present themselves as promising nature-based protection measures against erosion and flooding and have been found to also cope relatively well with sea-level rise(Spalding, McIvor, Tonneijck, Tol, & van Eijk, 2014). Especially, in areas where accretion rates exceed rising sea-level rates, mangroves constitute a potentially suitable measure for climate change adaptation.

Mangroves play an important and active role in sedimentation processes by reducing tidal energy and enabling sediment trapping (Kathiresan, 2003). Sediments typically transported by river discharge are trapped through shear-induced destruction of flocs, asymmetric tidal flow and baroclinic circulation (Kathiresan, 2003; Massel, 2012). In some cases, mangroves are able to trap up to 80% of fine-grained sediments (Furukawa, Wolanski, & Mueller, 1997), contributing further to its potential as a protection measure against erosion or flooding as it accretes (Horstman et al., 2014). This function of mangroves also allows it to reduce the effects of saline intrusion by almost half the rate (Hilmi, Kusmana, Suhendang, & Iskandar, 2017).

One such use-case is the mangrove restoration program in Vietnam, with the purpose of stabilization and protection against erosion, climate change adaptation and restoration of biodiversity (Hai, Dell, Phuong, & Harper, 2020). In the Mekong Delta, the use of herbicides emphasized the need for a mangrove restoration project after the negative effects on ecosystems (Marchand, 2008). In the Red River Delta, mangrove restoration activities were initiated for the purpose of surge protection in the context of climate change (Jhaveri, Sommerville, Hue, & Huy, 2017). The implementation of these measures is not without challenges such as conflicting space usages in the area, management of restoration activities and the need for relevant hydrological and ecological expertise during the planning and implementation process.

Sensitivities of measure

The preservation of these habitats is being threatened by conflicting anthropogenic activities such as damming, dredging, deforestation and expansion of aquaculture activities(UNFAO, 2014). Between 1996-2010, an estimated 50% loss of mangroves occurred in the South-East Asian region alone, equivalent of an approximate 18.5% loss in global mangrove forests (Thomas et al., 2017). Critical to the survival of mangrove forests is the steady supply of sediment (Woodroffe et al., 2016). Therefore, conservation and restoration of mangrove forests can only be considered as sustainable nature-based measures if there is sufficient sediment supply, which is typically provided by rivers. Thus, anthropogenic activities that disrupt the sediment supply, such as damming and dredging, conflict with the suitability of implementation.

Furthermore, the wave attenuating feature of mangroves was found to vary under different slope conditions. The topology of a coast may undergo severe erosion under climate change, resulting in steeper slopes that will reduce the amount of energy dissipated, thus, reducing the effectiveness of mangroves as a protection measure against flooding or erosion by up to 31% (Parvathy & Bhaskaran, 2017). If erosion is the dominant or emerging risk within a system, the steepening of the slopes must be considered. Mangroves have been advocated as a potential measure to mitigate the effects of extreme events, however, implementation requires careful research and understanding of how mangroves can help to reduce disaster risk. The impact of extreme events on mangrove forests depend very much on a host of factors such as spacing between mangroves, density of mangroves and hydro-meteorological factors(Satheesh Kumar, 2015). Furthermore, the success of mangrove restoration projects largely depends on the geological and geomorphological character of the system, since mangroves do not thrive in exposed, sandy deltaic environments (Marchand, 2008).

Land subsidence can impact the effectiveness of mangroves as a protection measure, as mangrove forests will be exposed to submergence, reducing its effectiveness as a tidal and wave damper (Takagi, 2017). This can occur through groundwater extraction for agricultural and industrial use or natural geological processes such as compaction and shrink-swell (Cahoon & Lynch, 1997). This issue also undermines restoration efforts for mangrove forests, contributing to the degradation of mangrove ecosystems. Sea-level rise affects the effectiveness of mangroves as a protection measure against erosion and flooding in a similar way by causing submergence.
In areas where sea-level rise is significant enough to exceed the rates of accretion in mangrove forests, this results in an elevation deficit and increases the risk of submergence (Woodroffe et al., 2016).

Therefore, areas with existing issues of land subsidence and exposure to high rates of SLR require careful consideration as to the long-term implications and effectiveness of mangrove protection measures. In Asia alone, countries such as the Philippines, Vietnam and southern China a are particularly vulnerable to SLR. Vulnerable areas risk a loss of mangrove forests, such as the 17000 ha loss of mangroves in the Sundarbans since 1970s (Ward, Friess, & Day, 2016).

Additionally, it is also important to consider that certain ecosystem benefits and services from mangrove forestation can conflict with specific resilience goals, such as trying to achieve disaster risk reduction and subsequently carbon capture and storage. During extreme events, high wind velocities and high wave energies can result in severe damage to these ecosystems (McIvor, Spencer, Spalding, Lacambra, & Möller, 2015). Depending on the spatial extent of damage, frequent occurrence of extreme events can also cause permanent shifts in ecosystem regimes, such as to an intertidal mudflat, therefore impacting the biological buffering capacity of mangroves (Smith et al., 2009).

6.4.3 Coral Reef and Seagrass systems

Coral Reefs

Coral reefs are carbonate-based ecosystems that typically occur in shallow waters within the tropical and sub-tropical belts. Corals have a symbiotic relationship with the zooxanthellae that live inside its polyps, providing it energy while sheltering these dinoflagellates from grazers. Coral reef system can be composed of barrier reefs, fringing reefs, or atolls. Particular attention on atolls are made as these reef islands are the most vulnerable of the systems under climate change and natural hazard impacts (Woodroffe, 2008).

In Asia, coral reefs are particularly threatened by climate change impacts and other anthropogenic activities such as rapid coastal development, overfishing, blast fishing, construction material mining and degrading water quality (McLeod et al., 2010). The collapse of this ecosystem in Asia directly affects almost half of the world's livelihood and safety, as coral reefs are natural, cost-effective measures against flooding and erosion. Countries with extensive coastlines, i.e. Vietnam, and archipelagos such as Indonesia and the Philippines, would severely suffer from reduction in protection against such hazards if coral reef systems were to degrade completely (ADB, 2014).

Protection against Flooding and Erosion in Reef Systems

Compared to building traditional breakwaters as a measure against coastal flooding and erosion, reef restoration projects can cost up to 15 times less, based on median estimates (Ferrario et al., 2014). The reduction of hazard exposure from coral reefs alone benefits approximately 200 million people, thus, the loss of reef systems has significant implications of vulnerability exposures in the future (Uitto & Shaw, 2015).

Reef systems provide resilience benefits by wave attenuation and energy dissipation by 97% on average(Ferrario et al., 2014). The rough reef structure of coral reef systems reduces waves via frictional dissipation - at sufficiently shallow depths, dominant wave dissipation is subsequently caused by breaking (Symonds et al., 1995; Vetter et al., 2010). Furthermore, a complex canopy structure significantly increases wave friction, a characteristic found in healthier reefs (Monismith, Rogers, Koweek, & Dunbar, 2015).
Such a benefit builds a stronger case not only for generic reef restoration but encourages adaptive delta planning to lean towards management for *a healthier* reef system as well.

The protection that coral reef systems provide against flooding exceed $400 M (USD) for Asian countries including Indonesia, Philippines and Malaysia (Beck, Losado, Reguero, Díaz-Simal, & Fernández, 2018). Damages incurred with or without reefs are illustrated in Figure 6-4, which highlight the protection benefits of a reef system during flooding events.

As a flood protection and erosion measure, reefs provide co-benefits by also contributing to biodiversity and habitat provision. These benefits allow coral reefs to provide ecological goods and services that may be essential to the livelihoods of some countries including fishing, tourism and construction. However, with the combination of climate change and an acceleration in socio-economic development, particularly in Asia, the survival of coral reef systems is under threat.

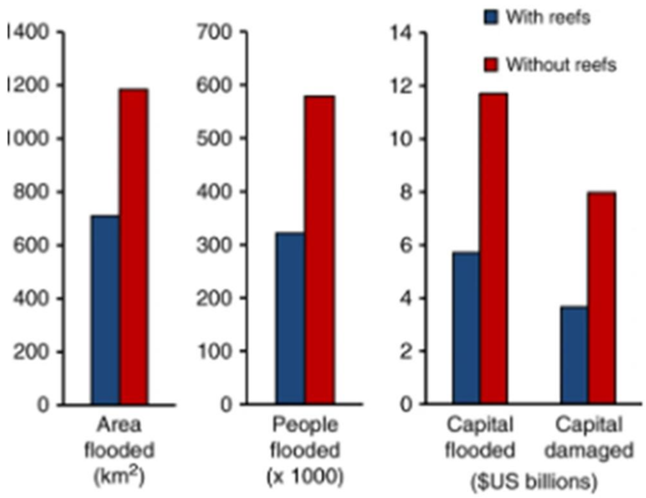

Figure 6-4 Annual damages incurred from flooding with or without reefs (taken from Beck et al., 2018)

Pressures facing reef systems

Coral reefs are amongst the most sensitive ecosystems in the world, facing both direct and indirect stressors originating from anthropogenic activities, such as climate change, destruction of reefs, overfishing and nutrient loadings. Coral reef systems are sensitive to a phenomenon known as bleaching, which occurs when high temperatures persist for too long, causing unfavorable conditions that result in the expulsion of zooxanthellae from the coral reefs. Bleaching generally results in lower growth and increased coral mortality rates (Douglas, 2003). Although some corals are able to recover from bleaching events, increased global sea temperatures resulting from climate change can cause thermally-induced bleaching to last longer than usual, resulting in widespread coral reef mortality (Heron et al., 2017).

Although oceans are able to absorb approximately 30% of the atmospheric CO2 concentrations, the rapid increase in production and subsequently, uptake of carbon dioxide by oceans results in ocean acidification, reducing the overall pH of the ocean and weakening or slowing down growth rates of coral reefs in the process (Lam et al., 2019). Under climate change, intensification of cyclonic events is predicted to occur, which will inevitably cause more widespread destruction in shallow reef systems (Cheal, MacNeil, Emslie, & Sweatman, 2017). These additional stressors greatly intensify the rate of coral reef degradation, reducing its effectiveness to mitigate against flooding and erosion in the future.
It is therefore important to identify such stressors as early as possible in an existing reef system, in order to better evaluate management options regarding restoration.

Anthropogenic activities also heavily influence the health of coral reef systems. The practice of blasting is fueled through demand of reefs as construction materials or fishing purposes. Overfishing or bottom trawling destroys habitats that takes years to recover.

Seagrass systems

Seagrasses are submerged, aquatic vegetation ecosystems that have been widely acknowledged to contribute to coastal protection by influencing wave attenuation, current flow and sediment dynamics (Ondiviela et al., 2014). They thrive in shallow coastal waters and are also found in intertidal environments (Kirkman & Kirkman, 2002). For coastal zone management, seagrass meadows help with reducing current velocities by deflecting the flow of water and provide frictional effects from its canopy (Koch, Sanford, Chen, Shafer, & Smith, 2006). Aside from their coastal protection benefits, seagrass systems help to increase overall resilience of ocean acidification in a system by maintaining high photosynthetic rates under elevated CO2 conditions and creating a more conducive environment for calcifying organisms to grow under despite being under pressure in acidic conditions (Bergstrom, Silva, Martins, & Horta, 2019).

Currently, Asia has the highest diversity of seagrass species in the world(Fortes et al., 2018), but face significant institutional barriers in seagrass restoration and conservation due to a disconnect between scientists, policy-makers and conservation managers (Kirkman & Kirkman, 2002). Yet, seagrass meadows have enormous potential in playing a role for protection against flooding and erosion. Their protective capacity is best illustrated in shallow, low wave energy environments with high interaction between flow and vegetation(Ondiviela et al., 2014). During the devasting tsunami event of 2004 in the Indian Ocean, the most consistent protection against wave damage was by seagrass systems (ADB, 2014).

Sensitivities of measure

Differences in types of seagrass and their sizes have implications for wave attenuating properties. Seagrasses that more aboveground biomass may have better capacity for wave dissipation, while other types with a more extensive root system can contribute better to coastline or seascape stabilization. Other vegetation characteristics such as plant stiffness also significantly influence the hydrodynamic of the local environment (Bouma et al., 2005). When carrying out adaptive planning, the plant characteristics and its subsequent influence on its protective capacity need to be considered before implementing restoration or rehabilitation activities, depending on the requirements of the region for achieving the respective resilience targets.

Seagrasses share some similarities in causes of degradation with coral reef systems, such as bottom trawling and coral mining. They are similarly affected by pollution, which requires an integrated approach in the management of fluvial transport of pollutants downstream into the coastal environments. Excessive nutrient loadings may result in eutrophication, in which some of the negative impacts on ecosystems can include deoxygenation and reduction of light availability(Ahmad-Kamil, Ramli, Jaaman, Bali, & Al-Obaidi, 2013). Other activities that directly disturb sediments such as dredging or land reclamation may result in less desirable conditions for maintaining healthy seagrass meadows(Erftemeijer & Lewis III, 2006). In some countries, seagrass provide important socio-economic services such as serving as raw material for weaving, but risk overexploitation due to demand.

In the context of climate change, overall increase in sea temperatures will affect the metabolism or photosynthetic capacity of seagrasses, which has implications for spatial occurrence and abundance(Ondiviela et al., 2014). Coupled with other responses of climate change, seagrass systems may not be able to adapt quickly enough to accommodate ocean warming, increased storminess and sea-level rise.
Wetlands & Floodplains

Wetlands

Wetlands form at the interface of terrestrial and aquatic ecosystems and thus have features of both. While they are highly variable in appearance and species composition, flooding or saturated soils is a shared characteristic. This characteristic creates low oxygen environments where only specialised microbes, plants and animals are able to tolerate periods of sluggishly moving or standing water. Therefore, wetlands can be found where there is water, from continental interiors to saline coastal areas, and many are associated to freshwater(Keddy, 2010).

Wetlands occur naturally around the globe in every biome (Figure 6-5). They are most abundant in boreal and tropical regions, though a wide variety can also be found inland and along the coast in temperate regions. Coastal and inland wetlands cover over 12.1 million km^2 globally with 46% seasonally inundated and 54% permanently inundated (*Global Wetland Outlook: State of the World’s Wetlands*, 2018).

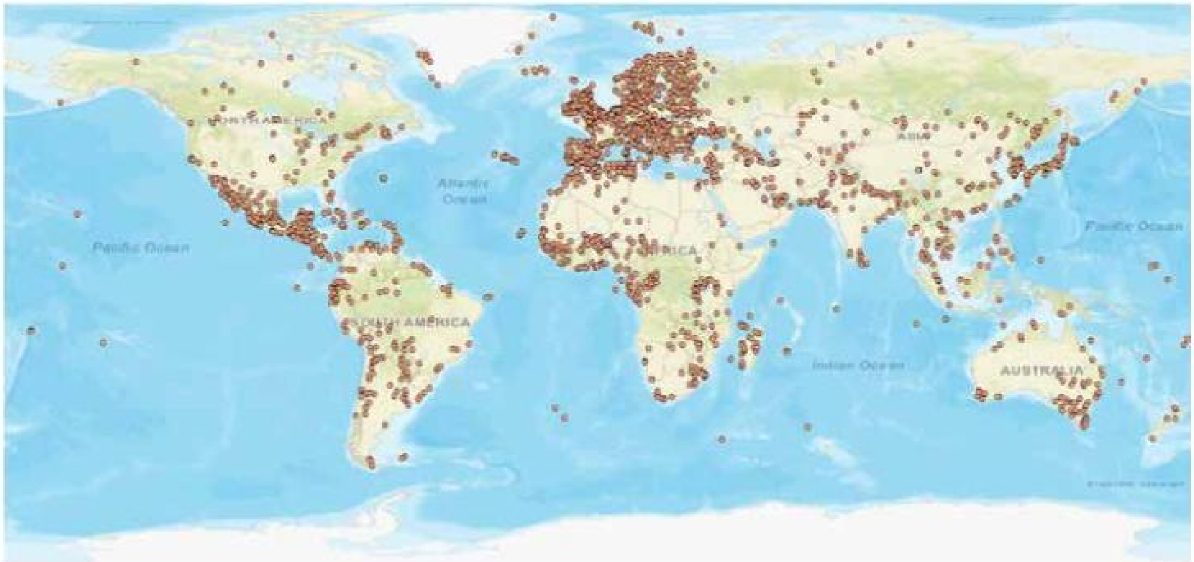

Figure 6-5 Wetlands of international importance globally (Global Wetland Outlook: State of the World's Wetlands, 2018)

Four main wetland types can be distinguished: swamp, marsh, bog, and fen (Keddy, 2010).

Floodplains

Rivers are much wider than the channels we associate them with. The areas next to rivers, which are only covered by water during floods, are also part of the river system, acting as the interface between the catchment and the river. Known as floodplains, in their natural condition they are an important ecological part of this system: they filter and store water, secure both natural flood protection and the healthy functioning of river ecosystems, and help sustain the high biological diversity present there.

Because they flood regularly, floodplains are naturally highly fertile areas. This combined with the use of rivers for transport has historically made them ideal sites for human settlement and agriculture (Christiansen, Azlak, & Ivits-Wasser, 2019).

Global Importance of Wetlands for Sustainable Development

Wetlands are considered to be the most biologically diverse looking at all ecosystems as they provide a home to a wide range of plant and animal species. Whether any individual wetland performs these functions, and the degree to which it performs them, depends on characteristics of that wetland and the lands and waters near it. Assessments for these functions, the wetland's ecological health and condition have been developed in many regions globally. Many have contributed to wetland conservation partly by raising awareness of these functions and the ecosystem services they provide (Dorney, Savage, Adamus, & Tiner, 2018).

Wetlands are important for human survival. They include some of the world's most productive ecosystems and provide ecosystem services leading to numerous benefits (Russi, den Brink, Farmer, Badura, & Coates, 2013). Often wetlands provide more ecosystem services than other ecosystems (Constanza, de Groot, Sutton, Van der Ploeg, & Anderson, 2014; Russi et al., 2013). Based on the Millennium Ecosystem Assessment (2005), a set of different ecosystem services for inland and coastal/marine wetlands could be identified. For inland wetlands food, fresh water, fuel and fibre are the most important. Regulating services are important, particularly for climate, hydrological regimes, pollution control and detoxification, and natural hazards. A different pattern can be seen for coastal/marine wetlands, with food being the dominant provisioning service, and climate regulation also important. Tidal flats, salt marshes and mangroves provide pollution control and detoxification, and, along with coral reefs, regulation of natural hazards (Global Wetland Outlook: State of the World's Wetlands, 2018). In deltas associated ecosystem services are high in numbers and include benefits such as productive agriculture and aquaculture, water provision and physical protection from the periodic impacts of extreme events such as coastal storms and cyclones (Adger et al., 2018).

Sensitivities of measures

There are three main pressures that wetlands and floodplains are currently facing: direct pressures that create biophysical change in wetlands (e.g. land use change, pollution, etc.), indirect pressures that are the processes in society that create the direct pressures, and global megatrends that are behind several indirect pressures (*Global Wetland Outlook: State of the World's Wetlands*, 2018).

Anthropogenic, or human-caused, pressures include land use change, climate change, water abstraction, removal or introduction of species, external inputs (e.g. fertilisers), dam and dike construction, logging, mining, and resource consumption. For millennia, people have drained water from and added water to wetlands which has caused a significant wetland loss globally (*Global Wetland Outlook: State of the World's Wetlands*, 2018). Tidal marshes and floodplains have been dikes and ditched to create agricultural land and pastures. Additionally, dam construction has also radically altered river basins by stabilising flows, and many wetlands have been filled for building and road construction (Ortmann-Ajkai et al., 2018).

On the other hand, natural pressures include solar radiation, weather variation, earthquakes, volcanic eruptions, pests and diseases, and processes such as natural flood cycles and ecosystem succession.

6.4.4 Integrated seascape management approach (mangrove, seagrass, coral)

Coral reefs and seagrass systems attenuate waves, facilitating sheltered waters for mangrove seedlings to establish. Simultaneously, landward of the reefs, mangroves and seagrass serve as fine sediment traps. This prohibits fine material from entering the coral reef system, which thrives on clear waters (van de Koppel et al., 2015). The wave dissipative properties of coral reefs provide optimal conditions for seagrass to thrive behind them, while seagrasses act as a biological buffer between the acidity from mangroves and reduction of acidification in reef systems (Olds et al., 2016; Bergstrom et al., 2019). In some locations such as Indonesia or New Caledonia, mangroves have been found to create high pH, low oxygen and warm water conditions that could potentially assist adjacent coral reefs with adaptation to climate change in a gradual way (Camp et al., 2016; Camp et al, 2017). This underscores the integrated seascape management approach in being able to maximize the individual benefits of each habitat and tackle multi-hazard and multi-risk reductions, such as in Figure 6-6. As indicated, restoration input, sustainable use and management accentuates synergetic potential of the mangrove-seagrass-reef seascape, as advocated by the Sendai Framework for Disaster Risk Reduction (2015-2030), (UN, 2015).

Not only do the individual habitats benefit the others, all the systems combined lend themselves to a more effective protection against the impact of waves and storms(Guannel, Arkema, Ruggiero, & Vertues, 2016). So, what is consequence of loss of one of the three ecosystems in a coastal landscape? Coral reefs suffer from the elimination of seagrass beds. For example, in Mauritius hotels were removing seagrass because it was not deemed aesthetically pleasing. Consequentially, this increased turbidity and the potential damage to proximate coral reefs which need clear waters (Daby, 2003). Also in the Bahamas, a degrading patch of coral reefs has been attributed to the removal of seagrass beds (Sealey, 2004). The effect of removal of coral reefs on mangroves and seagrass has not been studied directly, but a study in Seychelles (Sheppard, Dixon, Gourlay, Sheppard, & Payet, 2005) illustrated that the die-off of corals directly increased wave impact via decreased roughness and increased depths. In turn, wave impact limits recruitment possibilities for mangroves (Balke et al., 2011). Coral reefs and seagrass meadows protect the land from the sea, while mangroves protect the sea from the land. In Sabah, Malaysia, mangrove loss assisted to increased terrestrial sediment runoff, which increased turbidity, which resulted into degradation of seagrass meadows (Freeman, Short, Isnain, Razak, & Coles, 2008). A similar phenomenon was described in Bacuit Bay in the Philippines: coral-reef related tourism promoted mangrove logging, which increased landward erosion destroying coral reef habitat by sedimentation (Hodgson & Dixon, 1988). This outlines logging was neither economically nor ecologically feasible. Deforested mangroves also modify the algal composition: harmful algal species such as Dictyota sp. and Acanthophora sp. were found on corals next to cleared mangrove forests (Granek & Ruttenberg, 2008). What all consequences of loss have in common is that they can be linked to destabilization of elements that can dissipate hydrodynamic energy. Reduced dissipative potential increases flood risk and erosion, which accentuates the synergistic performance of seascapes. If one ecosystem falls, the others will suffer from its disappearance in a seascape.

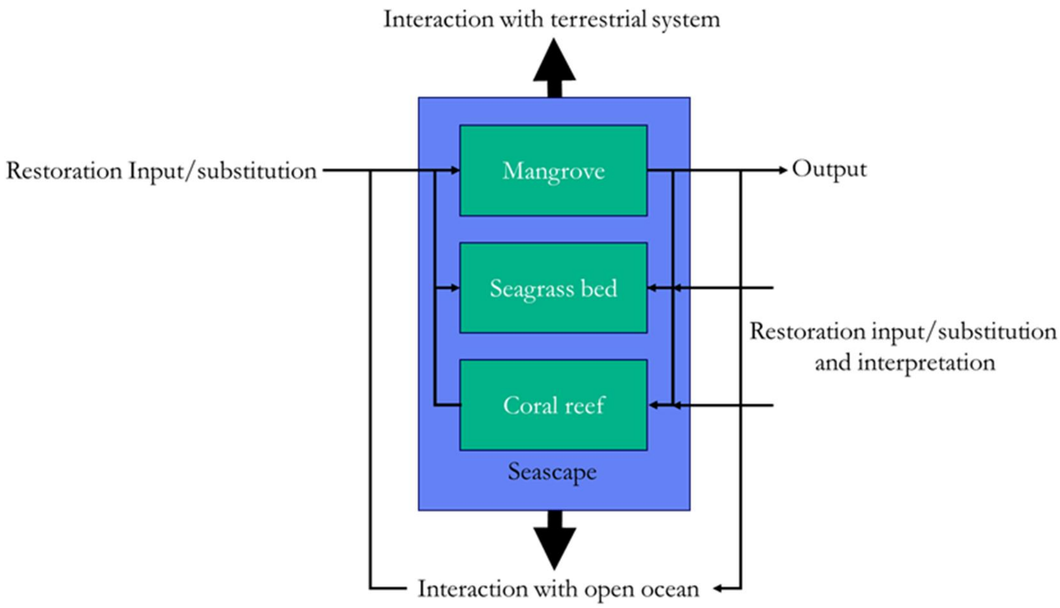

Figure 6-6 Interactions among mangrove, seagrass bed and coral reef ecosystems in relation to the larger environment and management activities (adopted from Moberg & Rönnbäck, 2003).

Examples of Seascapes

Phuket

Phuket, Thailand, and the region south of Phuket facing the Andaman sea harbors many sites with seagrass meadows, mangroves and coral reefs (Chansang & Poovachiranon, 1994). Their interaction has been studied but mainly their trapping potential of organic carbon (Gillis, Belshe, Ziegler, & Bouma, 2017), while less attention has been given to synergistic power of seascapes in terms of coastal protection.

Sihanouk Ville-Kep, Cambodia
From Sihanouk Ville to Kep, seascapes are present (Rizvi & Singer, 2011). Some plans are being made for integrated coastal management to mediate coastal protection by combined ecosystem services of seascapes.

Jayapura City, Borneo, Indonesia
The combined ecosystem services of mangroves, seagrass meadows and coral reefs have been quantified for Jayapura City, Borneo, Indonesia (Rumahorbo, Hamuna, & Keiluhu, 2020).

Ayeyarwady (Irrawaddy) delta, Myanmar
The Ayeyarwady delta fringes the Andaman sea. This sea is known to harbor coral reefs, at the mountain range that stretches south of the Ayeyarwady delta (Mondal & Raghunathan, 2011). Mangroves are also present in this delta (Hedley, Bird, & Robinson, 2010), which makes it likely that seascapes exists in the vicinity of the south west region of the delta (See Figure 6.7). Yet the presence of seascapes is not explicitly mentioned in the context of this delta. It should also be noted that facilitative interactions between ecosystems can only prosper when the systems are in close proximity of each other (Gillis, 2014).

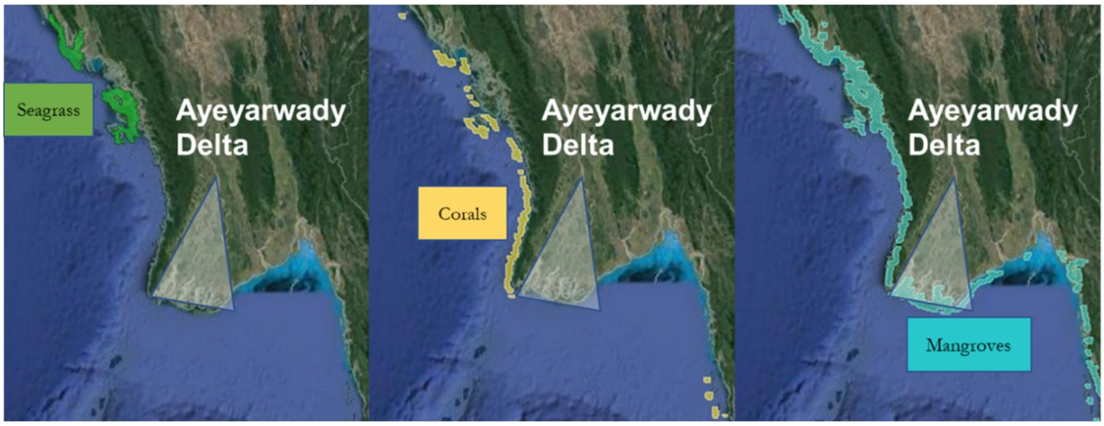

Figure 6-7 Shorelines close to Ayeyarwady Delta with seagrass, coral reefs and mangroves. (source: http://www.myanmarnaturalcapital.org/en/ecosystem/protect-coastline)

6.5 Geographical scope and organizational capacity of governance

Table 6-2 Four scenarios with different emphasis on enabling vs asset investments

		Governance and capacity to coordinate investments beyond the project level	
		No	**Yes**
Geographical and governance match	Yes	**Scenario III Definition:** There is a geographical match with the governance structures, but there is a lack of vision or capacity to capture NbS potential fully. **Practical implication governance:** Actors should build basic agreements, focusing on shaping shared understanding for advancing towards collaborative planning. **Practical implication technical design:** Technical designs (solution) can discuss a point of reference for discussing diverse expectations and values. The technical design should be flexible/open for reflecting progress in the governance	**Scenario IV Definition:** Vision and capacity of actors match the landscape scope to capture NbS potential fully. **Practical implication governance:** Actors should focus on institutionalizing the monitoring and evaluating mechanisms, leading to high predictability on the incentives enabling long-term investments. Furthermore, capacity should be reflected in clear project ownership **Practical implication technical design:** The practical design should reflect the agreements between actors, making clear responsibilities and maintenance and operation. Furthermore, the technical design

		Governance and capacity to coordinate investments beyond the project level	
		No	**Yes**
		Practical implication investment: Return-seeking investors might perceive high risk in asst investments, regardless of the economic potential. Nevertheless, investors are willing to support enabling investments given their expectations for creating the conditions for asset investments. Public funding can support enabling investments, mainly planning processes, and shared understanding. **Next step**: Theory of change advancing towards Scenario IV	should point out the interdependencies between different projects and management scenarios to deal with inherent uncertainties of NbS (e.g., definition of thresholds at which the NbS can deliver the expected functionality. **Practical implication investment:** Return-seeking investors will be willing to support landscape ambitions in the extent to which the monitoring mechanisms provide evidence on ownership and adaptive management. Enabling investments will mainly address project structuration. **Next step**: Theory of change aiming at long-term sustainability within Scenario IV
	No	**Scenario I Definition:** There is no vision, capacity, nor geo-governance matching to capture NbS potential fully **Practical implication governance:** Actors should identify opportunities to leverage higher governance levels (e.g., national government, international agreement-commission) for starting ad hoc consultations and creating public information. **Practical implication technical design:** Technical design operates as promising futures and opportunities, making a case for investing in governance processes. Hence, the proposers of technical designs should avoid showcasing the design as an outcome. The design is a vehicle for building sharing understanding. **Practical implication investment:** Investments will be typically concessional finance and grants, operating as enabling investments for building agreements with other governance units. The Interest in political integration or international collaboration can play an important role. **Next step**: Theory of change advancing towards Scenario III, if the enabling investments and building capacity process leads to a new governance structure Advance towards Scenario III, if the enabling investments and building capacity process leads to more governance structure	**Scenario II Definition:** There a share vision and capacity, but there is not a geo-matching to fully capture NbS potential **Practical implication governance:** In a fractured governance setting, there is a high chance that one governance unit is more capable than the other. Then, coordination can turn into a transfer-capability process upon the co-responsibility for managing the natural resource/assets. The process can be leveraged by higher levels of governance (e.g., national government, international agreement-commission). **Practical implication technical design:** Technical designs should emphasize that coordination is needed between different governance units. However, the solution should not be showcased as the final outcome, but a common ground for building common understanding. Another alternative is exploring designs reducing the dependency on the upstream dynamics (e.g., under the control of other governance units). **Practical implication investment:** Enabling investments for building agreements with other governance units and transferring technical capacity. Enabling investments for exploring innovative technical solutions reducing dependency. Low-hanging and non-regret asset investments that do not depend on other governance units **Next step**: Theory of change aim at long-term sustainability within Scenario II Or Theory of Change advancing towards scenario IV, if the enabling investments and building capacity process leads to a new (overarching) governance structure.

6.6 Mekong delta description

The Mekong delta is the third largest in the world, with almost 20 million people living within it. As the Mekong catchment also crosses multiple boundaries, the system requires complex management and careful balance of upstream-downstream activities. Any measure implemented without careful consideration may have cascading implications, as the history of the Mekong can attest to it.

- Overview of bio-physical system and current conditions for NbS in an upstream-midstream-downstream structure;
- Impact of conditions on implications for NbS;
- What is the political governance of the Mekong Delta, including the financial and economic perspective (barriers for NbS implementation);
- Tie it up together (what is specific to the Mekong case? Upcoming or future plans for integration of NbS? Upscaling? Local to internation to transboundary?).

6.6.1 Bio-physical system

Figure 6-8 Extent of the Mekong Delta in South-east Asia. An in-set of the coastline morphology is on the top right corner of the figure, adapted from (Anthony et al., 2015).

Originating from the Tibetan plateau, the Mekong river flows through Myanmar, Lao PDR, Thailand and Cambodia (upper delta) before finally meeting the sea in a delta formed in Vietnam. Due to high sediment supply between 3500-5300 years ago, the area developed from an estuary into the delta it is today. With a 700km-long coastline, it is a primarily tide-dominated environment, characterized by sandy beach-ridge on the East side of the delta, with more muddy shorelines on the West side of Bac Lieu as illustrated in Figure 6-8 (Goodbred Jr. & Saito, 2012; Anthony et al., 2015). The total annual discharge of the Mekong river is 14,500m^3/s (Piman & Manish, 2017), with an approximate sediment load of 50-160 Mt just upstream of the delta(Besset, Anthony, Brunier, & Dussouillez, 2016), however current estimates and projections are significantly (up to 90%) lower than the pristine river system[18] (Eslami et al. (2019), Hackney et al. (2020), Bussi et al. (2021), Nowacki et al. 2015, Binh et al. 2020, Schmitt et al. 2019, Bussi et al. 2021). This sediment starvation is driven by upstream impoundments and significant amounts of sand mining (Bravard et al., 2013, Eslami et al. 2019, Jordan et al., 2019) along the river which in turn leads to river bed and bank erosion, nearly 40% tidal amplification in the delta and historical records of salt intrusion (Eslami et al. 2019)., placing significant pressure on the agriculture and the livelihood of

[18] Down to nearly 5-15% of the pristine sediment load

people living in the Mekong Delta (e.g. Wassmann et al. 2004, Le et al. 2007, Anh et al. 2018). The Mekong delta is highly prone to effect of internal climate variability on sea level mainly driven by atmospheric circulation pattern known as ENSO (e.g. Wang 2001). Due to the high nutrient load and biodiversity of the Mekong delta, it contributes up to 50% of Vietnam's food supply(Besset et al., 2019), making it an important source of food security for the region. In the delta, the main natural ecosystems that can be found are mangrove forests, wetlands and floodplains. Mangroves in the Mekong delta tend to develop along the coast, with a rather large aggregation in the south of the delta in Ca Mau, Vietnam (Bunting, et al. 2018; Ottinger, et al. 2018). However, for the vast majority of the delta plain the land use has been changed from natural vegetation to intensive agri- and aquacultural areas.
Besset et al. (2019): Huge reduction in sediment loads (by 50% or more) causes reworking of sediments along the shoreline due to low sediment supply.

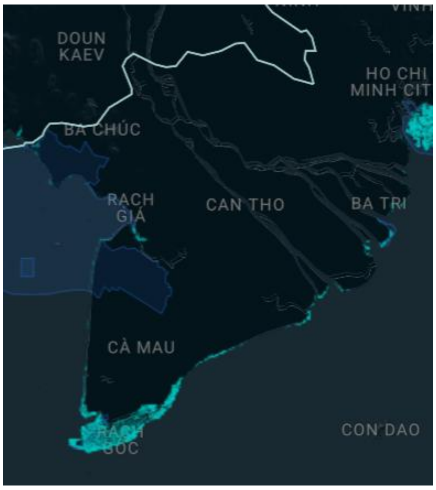

Figure 6-9 Cyan-shaded areas indicate the occurrence of mangroves. Adapted from Global Mangrove Watch(Bunting et al., 2018). Accessed: 19-8-2020

Natural and antropogenic factors

With ongoing rapid development in the region, the Mekong delta faces disruptive activities such as damming, deforestation, alteration of natural flood cycles by dykes and dams, riverbed mining and groundwater extraction. Imbalance between upstream and downstream activities may have lasting impacts on the growth or persistence of delta ecosystem services and functions. The Mekong delta faces a variety of issues, for example the net erosion due to sediment starvation resulting from an undervaluation of the ecosystems services natural sedimentation provides. The reduction in fluvial sediment supply to the delta is primarily due to dam construction upstream (Le Duc Trung et al, 2020). but available sediment within the delta is also reduced by intensive river sand mining. In addition to a reduction in the available sediment, dyke construction and other flood management can prevent sediment deposition over the floodplains. This alteration of natural processes can prevent sediment accumulation from compensating for erosion and relative sea-level rise. Riverbed erosion (20-30 cm/yr) has resulted in nearly 2 cm/yr increase in tidal amplitudes with significant implications for flooding in urban areas. This tidal amplification, together with deeper estuarine channels drives increasing salt intrusion (0.2-0.5 PSU/yr) that significantly disrupts the freshwater supply in the delta (Eslami et al. (2019), Binh et al.. (2020).
The upstream dams, apart from sediment trapping, alter the hydrological cycle. Previously, wet season flood pulse filled the Tonle Sap Lake. The lake would function as a retention area which would release freshwater to the delta during the dry season. Due to tapering of the flood pulse, the Tonle Sap Lake has lost its retention functionality that leads to an extension of the saline period in the dry season. Previously, salt intrusion would maximize during February and March; but, currently, this period extens from December to April.

Another example is the high rates of land subsidence related to a range of drivers and processes varying in space and time. Due to its young age and vastness of the recently deposited fine-grained and soft sediments, especially in the south in Ca Ma peninsula (Figure 6-8, mud-dominated coast), the delta experiences high rates of shallow natural compaction (Zoccarato et al., 2018). Closer towards the coastline these compactions rates can go up to 3-4 cm/yr in the top 20 meters, as also measured by RSET measurements in mangrove forests in the Mekong delta (Lovelock et al., 2015). However, as sedimentation rates in the monitored areas exceeded (5-6 cm/yr) subsidence rates, the areas were able, until recently, to maintain and gain net elevation.

This clearly stresses the importance and dependency on high sedimentation rates of these mangrove areas in order to counterbalance the effect of ongoing and unstoppable land subsidence as a result of natural compaction (Zoccarato et al., 2018). On top of high natural compaction rates along the fine-grained coastlines, land subsidence rates throughout the delta are enhanced due to human activities such as infrastructural loading, shallow surface water drainage and deeper groundwater extraction (Minderhoud et al., 2018). In the last two decades the strong increase in groundwater extracting, much larger than the natural recharge of water into the subsurface, caused a wide-spread drawdown of hydraulic heads, which lead to accelerated aquifer-system compaction causing increase rates of land subsidence (Erban et al., 2014; Minderhoud et al., 2017). Projections of extraction-induced subsidence show that groundwater extraction alone may be the single highest driver of relative sea-level rise in the Mekong delta in the coming decades, and large parts may sink already below sea level (Minderhoud et al., 2020).

Superimposed on this, sea-level change along the Mekong Delta is a huge threat to the livelihood of the Mekong delta. Change in sea level is not only modifying the mean conditions along the coast of delta, but also developing the impact of tides and storm surges on the Mekong delta as the boundary condition for those variables. The Mekong delta is probably already lower than used in most SLR impact studies (Minderhoud et al, 2019).

Box 4.1 Sea-level rise projections for the Mekong delta

Recent projections reported by (Oppenheimer et al. 2019) result roughly in 4.7, 6.0 and 9.0 mm/yr sea-level rise over the 21st century with respect to RCP2.6, RCP4.5 and RCP8.5 scenarios respectively[1]. For the period 2007-2100, this quantifies approximately a range of 0.44 m - 0.85 m mean sea-level rise around the delta, which plays a key role in determining the timing and designing of the spatial planning in this huge delta. Following figure shows the state-of-the-art sea-level projections according to three different RCPs around the Mekong delta. Table 4.1 shows that the range of sea-level rise substantially increases if RCP8.5 pathway will be followed. For the period 2007-2050, differences between scenarios RCP2.6 and RCP8.5 is only around 5 cm, but it develops up to 48 cm by the end of century. It should also be noted that difference between high-end and low-end is reaching from 7 cm to 29 cm along the 21st century. This hints that high-end and low-end conditions have a huge impact on the outcome of sea-level rise around the Mekong delta. In terms of spread and amplitude of HE and LE conditions, characteristics of the RCP8.5 distinguishes from other two RCPs.

Table 4.1 High-end and low-end projections of sea-level rise (m) based on three different climate scenarios for intersected periods over the 21st century. Value of LE and HE is defined from ±1 standard error of median sea-level projections. Sea level data is provided by Oppenheimer et al. 2019.

Period/Scenario	RCP2.6 (LE/HE) m	RCP4.5 (LE/HE) m	RCP8.5 (LE/HE) m
2007-2050	0.17/0.23	0.27/0.38	0.35/0.52
2007-2075	0.17/0.23	0.31/0.43	0.46/0.65
2007-2100	0.21/0.28	0.42/0.57	0.71/1.00

Important trends, threats and pressures[19]

Socio-economic:

- Increased energy demands resulted in more dams planned for the Mekong. Dams disrupt sediment and nutrient supply to the Delta, reduces connectivity between ecosystems and biodiversity loss, reduces functionality of interconnected ecosystems.
- Main drivers of change in the Mekong: increasing population growth and density, worsening income inequality.
- Unsustainable levels of resource (predominantly sand and water) use due to economic stance (demand-driven growth versus balanced/subsistence use)
- Grey infrastructure development

Governance

- Lack of integrated planning, poor governance, corruption and wildlife crime.

Bio-physical:

- Reduction in sediment flow decreases replenishment capacity of delta, increased vulnerability to climate change and its natural capacity to counterbalance land subsidence. CC impacts include saline intrusion, SLR, increased storminess and coastal erosion.
- Mangrove forests have been cleared for alternative land uses, reduces capacity of protection against coastal erosion and flooding. Continuing trend of mangrove loss from 1980s.

[19] https://awsassets.panda.org/downloads/greater_mekong_ecosystems_report_020513.pdf

- Nature-based barriers in the Mekong include mangroves and corals. Mangroves have high coastal storm protection, with a restoration scheme of 1.1 million USD pumped into northern Vietnam to save 7.3 million USD worth of grey infrastructure maintenance. https://doi.org/10.4000/geomorphologie.11336 (Besset et al., 2015): Net shoreline erosion in the Mekong delta primarily due to reduced sediment storage. Instigated by enhanced subsidence (excessive groundwater extraction), riverbed mining and fluvial trapping from dams.

Additional literature

- Erosion: these are the most reliable estimates:
  - Bravard et al. (2013) https://doi.org/10.4000/echogeo.13659
  - Eslami et al. (2019) https://doi.org/10.1038/s41598-019-55018-9
  - Jordan et al. (2019) https://doi.org/10.1038/s41598-019-53804-z
  - Binh et al.. (2020) https://doi.org/10.1016/j.geomorph.2019.107011
- Mangroves as nature-based measures in Mekong:Issue of mangrove squeeze due to conversion of land into shrimp aquaculture and building of grey infrastructures (sea dykes) [Besset et al., 2019] https://doi.org/10.1016/j.ecss.2019.106263.
- SEI reporting on Mekong sediment flows: https://mediamanager.sei.org/documents/Publications/Bangkok/SEI_2017_Report_Mekong_sediment_LoRes.pdf Sediment flow and delivery mainly impacted by riverbed mining and damming.

Overview of most relevant NbS in the Mekong delta

NbS type	Main functions (Ecosystem services)	Co-benefits	Social impact	Market considerations	Trade-offs in relation to the main function
Mangrove	• Reducing flooding and erosion • Contributing to biodiversity • Recreation and tourism • Aquaculture production • Forestry • Agriculture • Fuel production • Harvestable goods • Sediment capture • Wave attenuation	Storing carbon Support offshore fisheries Carbon sequestration Habitat provision/nursery grounds Sediment/ nutrient filtering Water purification	• People and asset protection • Job generation • Community cohesion • Food security • Supports recreation/tourism • Supports diversified livelihoods • Requires areas set aside for restoration	It operates upon carbon markets. 'The project must apply for being label as "carbon project" for voluntary trading markets [6] or mandatory trading market. For turning fishing into a sustainable revenue, the project must (i) guarantee a stable and predictable rate of fish production and (ii) appeal to green and socially responsible markets. [11]	Maximizing short-term production compromises long-term conservation Trading in employment now for safety of livelihoods in the future.
Mangrove-shrimp farming	• Food provision • Aquaculture production • Mangrove conservation • Biodiversity • Shoreline protection	Carbon sequestration Water quality improvement Water purification	Improved community livelihoods	Yield will likely be lower, thus increasing the required selling price. Sustainable production will have to find a way to markets that are willing to pay a premium for this.	Maximizing short-term production vs. Sustainable aquaculture practice (that may lead to lower yield)

NbS type	Main functions (Ecosystem services)	Co-benefits	Social impact	Market considerations	Trade-offs in relation to the main function
Restoration of floodplains/ Wetlands	• Flood management • Promoting sediment deposition • Water resources supply	• Habitat provision • Water filtration • Flushing out agrochemicals • Carbon sequestration (if vegetated) • Increased soil fertility	• Require areas set aside for restoration, which may result in people having to move out • Soil fertility positively impacts agriculture	For those producing in these areas, loss of productive land may have to be compensated. Reduced flood risk may directly benefit stability of production in the direct hinterland	Potential loss of employment and production in these areas in return for safety and stability of livelihoods in hinterland for the future.
(Small-scale) sand engine	• Erosion prevention	Regulation of dunes	• For beaches/ dunes to provide flood protection, they require sufficient space • Supports recreation		• High revenue of sand mining business vs. Maintenance of sand budget
Coral reefs	• Wave attenuation	• Habitat provision, nursery grounds • Improve biodiversity • Tourism			

6.6.2 Governance system

Policy and legal Framework

As examplified by the Vietnam has wide experience in preparing plans for economic sectors. The central government has initiated a number of studies to deal with planning challenges and collect sectoral data (agriculture, construction, aquaculture, water resources planning). Increasingly, the interdisciplinary nature of the issues and interests of various stakeholders create difficulties in information exchange, matching sectoral interests. Consequently, truly integrated spatial planning remains difficult. Not only multiple ministries, agencies and planning branches are involved but also multiple levels of government (central, provincial, district, city and local people's committees).The Master Plan for Socio-Economic Development until 2020 for the Mekong Delta plays a very important role and should be the foundation for other sectoral plans. However, this master plan has not yet been approved by the government. Spatial planning is strongly determined by (central) socio-economic planning, but private/market oriented activities are also very important and not always follow the socioeconomic plans of the government.

In the past decade, major legal instruments applicable to climate adaptation and the application to NbS, including laws on land (2013), water resources (2012), environmental protection (2013) and forestry (2017), have rapidly developed, which in general provide a favourable setting for NbS.

Resolution 120 on a climate resilient and sustainable Mekong Delta (2017) and its action plan (Decision 417 issued in 2019) mark the paradigm shift of the development model of the Mekong Delta to a climate-resilient and sustainable one. Compared to the MDP, Resolution 120 has broader implications for NbS by recognizing the value of saline water and the ecological benefit of natural forests.

Water governance in the Mekong Delta has been improving over the years to meet the needs for managing its dynamic development. There is a well-defined legal framework for water management (i.e. the Law on Water Resources).

Conclusion: Vietnam has experience in plans, and is equipped to that. Example milestones: MDP and Res 120 (2017); now starting new master plan. So there is an ongoing process of developing policy, laws and plans.

Institutional structure and process

In Vietnam, multiple Ministries are dealing with water and water-management issues Ministry of Natural Resources and Environment (MONRE) and Ministry of Agriculture and Rural Development (MARD). The planning and implementation of mitigation and adaptation measures in Vietnam are often highly top-down, with strong roles of the central government and local governments. However, there are increasing attempts to initiate projects that strongly promote multi-stakeholder partnerships. An example of a successful NbS project in Vietnam is the Mangrove shrimp farming project in Ca Mau entitled Mangroves and Market Project (MAM). International organisations and funders (IKI, IUCN, SNV) were the initiators of this project. They are leading the implementation with strong supports from the Ministry of Natural Resources and Environment (MONRE), department at the provincial level (DONRE), Ministry of Agriculture and Rural Development (MARD) and department at the provincial level (DARD), as well as forest management board. The project also involved the market (i.e. Min Phu Seafood company) and the local farmers groups and cooperatives (https://snv.org/project/mangroves-and-markets)

Mekong Delta Plan

The Mekong Delta Plan comprises a vision and a strategy with proposals for adjustment in governance and tuning, integrating measures in the different sectors. The main elements in this MDP are (MDP, 2013):

- Integrated long-term vision (2100) and strategy for a safe, prosperous and sustainable development of the Mekong Delta in view of plausible socio-economic and climatic developments;
- Recommendations on strengthening intergovernmental cooperation and institutional arrangements, legislation and financing options in order to create a transition in agriculture policy, adequate land and water management and rationalising sector investments by integrated planning and cost benefit analyses;
- Coherent view on short term (2015-2025) priority and 'no-regret"measures.

In the process of making the Mekong Delta Plan MoNRE and the MDP-team have involved a good number of stakeholders and experts, regional and national.

Summarizing tables with governance aspects (status of development)

Status of development	Long term vision / policy documents regarding NbS	Regulatory framework and instruments	Shared Understanding on NbS	Multi-stakeholder platforms (multi-sectoral, multi-scale level)	Upstream-downstream cooperation
No (not in place)			The concept of NbS is still relatively new in Vietnam, and has not yet become mainstreamed in the local practice. International		There seems to be only pilot programmes (since 2016) on cross-provincial linkages. The existing cooperation seems very limited to unsystemic

Status of development	Long term vision / policy documents regarding NbS	Regulatory framework and instruments	Shared Understanding on NbS	Multi-stakeholder platforms (multi-sectoral, multi-scale level)	Upstream-downstream cooperation
			organisations are currently the taking the initiatives to advocate NbS measures.		information sharing.
Underway/ planned	National level scale vision for Mekong Delta is laid out in legal documents. These include mentioning of NbS/ eco-system based approaches but however do not specifically address NbS.	The current regulatory framework in general provides a comprehensive and favourable setting for NbS though discrepancies under different instruments for the same subject matter still exist.		Examples of success, but also failures; several efforts, international funders; success to date are limited at local levels but not at landscape level;	
Completed/ operational				Mekong River Commission	

Status of NbS implementation

	Planning	Design	Construct	Operation & Maintenance	Monitoring
No (not in place)		There are not yet many examples of large-scale NbS implemented. Several initiatives are currently in discussion and planning stages.	There are not yet many examples of construction of large-scale NbS implemented. It is estimated that 197,000 ha of mangroves were planted in Vietnam from 1975 to 2018 (Hai, Dell, Phuong, & Harper, 2020).		Monitoring remains a gap in projects.
Underway/ planned	NbS measures have been mostly applied at local level.			There are successful cases at local levels, although unclear about the sustainability after projects end.	
Completed/ operational					

6.6.3 Socio-economic development and financing perspectives

Long-term ambitions of economic development of the Mekong Delta

The Mekong Delta counts with a long-term strategic vision defined in 2013, aiming at turning the area in a regional hub specialized in high-value agriculture for international and domestic markets (Weger, 2019). Such ambition requires controlled river floods in the wet seasons in the upper and middle Delta; while restoring the large-scale destruction of protective mangrove forest due intensive and extensive shrimp farming. In this regard, the long-term vision called for the development of a full vertical agricultural product value chain for a safe, prosperous and sustainable future. In the coastal area, the unsustainable shrimp business model should shift to a modernized aquaculture strategy. Recently, the Socio-Economic Development Plan 2016-2020 defined as a major objective to integrate environmental protection and green economic development within economic growth.

In this context, the role of NbS solutions is clear. The future of the lower part of the Delta depends on successfully implementing a saline-based aquaculture production system, including different environmental zones to facilitate mangrove regeneration and sustainable shrimp production. Since then, the national and local governments have encouraged mixed or integrated mangrove-shrimp systems that must maintain at least 40% of their area under mangrove cover (Nguyen, Rodela, Bosma, Bregt, & Ligtenberg, 2018).

Placing economic incentives around mangrove ecosystem services

Uptake of sustainable shrimp production by communities has been slow - mixed mangrove farming only provides 5% of all farmed shrimp produced in Vietnam (Järviö, Henriksson, & Guinée, 2018). In turn, the extensive production system by smallholders makes up 90% of the total shrimp production area and 60% of the total volume produced in the region (Joffre et al., 2015). These small producers capture high values from commercializing black tiger shrimp. The integration of mangroves trees, represents for them, much lower production levels per area, even when there is evidence that mixed mangrove farming deduced overall risk of crop loss (Phung, 2012).

The regulatory framework seems to place important incentives for limiting the implementation of integrated mangrove shrimp systems. In the past, Vietnamese regulation only required farmers to have a mangrove to pond area of 40%, while such ration should be higher than 50% (Joffre et al., 2015). At the moment, landholders can only make extractive use in the 30% of mangrove forest (Jarvio, 2018). However, the challenge is enforcing those requirements at a landscape level. A farm-scale approach limits connectivity of the mangrove strand to the tidal estuarine. Furthermore, according to satellite photos, 61% of the mangrove forest was removed from pond areas (Jarvio, 2018). Overall, higher rates of farm conversion into mangrove demands to explore the additional equivalent source of income.

The lack of incentives to engage local communities in long-term management or restored areas remains as one of the factors limiting the upscaling mangrove restoration in Vietnam (Hai et al., 2020). In this regard, mangrove co-management in the Mekong Delta in Vietnam has been shown to be an effective way of long-term management. Upon these bases, there are multiple recommendations suggested by experts favouring the uptake of sustainable mangrove business case. The bottom line is advancing in policies that frame request of the minimum area under mangrove cover from a farm-scale to landscape-level (Joffre et al., 2015). It entails strengthening the governance of mangrove and shrimp aquaculture at the landscape level, in a way that farmers can transcend decision-making beyond the farm-level.

A promising alternative is placing more emphasis on the regulatory rather than the provision of ecosystem services, considering the important role of mangrove forest regulating greenhouse gases (Jarvio, 2018). An important opportunity is linking the ambitions of mangrove restoration to the United Nations Framework Convention on Climate Change (UNFCCC), the Clean Development Mechanism and in the Paris Agreement. In fact, Vietnam poses mangrove conservation and restoration as one of the mitigation options presented in the Intended Nationally Determined Contributions. According to Vietnam, 30,000 ha of mangrove restoration has the potential of approximately 4.41 Mt CO2e (Hai et al., 2020). Therefore, mangrove restoration can be framed as CO2 retention projects issuing carbon emission credit markets. Additionally, organic certification can be by accounting for land use and land-use change emissions (Järviö, Henriksson, & Guinée, 2018).

Funding vehicles for sustainable Mekong Delta
The Vietnamese government counts with several funds for supporting mangrove restoration activities. However, government funding would be not enough for country ambition. Hence, one of the goals of the Viet Nam National Green Growth Action Plan 2014 – 2020 was increasing finances, including access to international finance, and the establishment and scale-up of a facility.

Table 6-3 Funding vehicles in the Mekong delta

Vehicles	Description	Sources
Support Program to Respond to Climate Change in Vietnam	Coordination platform for climate funding, which mobilizes donor funding in support of a comprehensive climate change policy.	Link 1 Link 2
Viet Nam Forest Protection and Development Fund managed by the Ministry of Agriculture and Rural Development	The VNFF supports the implementation of the Viet Nam Forest Development Strategy 2006-2020, and it is in charge of structuring REDD+ Fund	Link 1 Link 2 (REDD+ Fund) Link 3
Viet Nam environmental Protection Fund managed by the Ministry of Natural Resources and Environment	The VEPF recieves capital sources from the state budget; sponsor, contribution, commission from domestic and international organizations, individuals to support finance for environment protection activities through the country.	LInk 1 Link 2
The Trust Fund for Forest and the Vietnam Conservation Fund	It supports the implementation of the Forest Delevelopment Strategy, receiving funding from Official Development AID	Link 2
Fund for Aquatic Resources Protection and Development	The VNFARPD will be a public out-of-state budget financial and non-profit institution, established at central and provincial levels. (So far no operational)	Link 2

[1] https://www.greengrowthknowledge.org/sites/default/files/downloads/best-practices/GGGI-Viet-Nam-Country-Planning-Framework-2016-2020.pdf

Summarizing tables with socio-economic and financial aspects

Resource mobilization for NbS (finance streams)

	Governance	Private sector	International development	Blended
No (not in place)		Involvement of private sector in financing NSB measures is still limited.		
Underway/ planned				
Completed/ operational			Most of current initiatives on NbS in Mekong Delta rely on international development finance	

Financing coordinating entities

	Government agencies	Non-profit trust	Investment funds	Special Purpose Vehicles
No (not in place)	X	X	X	X
Underway/ planned				
Completed/ operational				

There is not yet a centralized fund for coordinating the financing streams for NbS specifically.

6.6.4 Summary of conclusions and recommendations

Bio-physical aspects

- Reduction in sediment flow because of upstream damming and riverbed mining decreases the resilience (replenishment capacity) of the delta, resulting in increased vulnerability to climate change (sea level rise, saltintrusion, coastal erosion) and its natural capacity to counterbalance the current enhanced land subsidence due to groudwater extraction;
- For the vast majority of the delta plain the land use has been changed from natural vegetation to intensive agri- and aquacultural areas;
- Mangrove forests have been cleared for alternative land uses (such as shrimp farming), which, reduces the capacity of protection against coastal erosion and flooding;
- There is a continuing trend of mangrove loss from 1980s due to decreased sediment input from the river and coastal squeeze through sea level rise and building of sea walls.

Recommendations

- Create better balance between natural vegetation and agri- and aquacultural areas, involving spatial planning and sustainable practices with less pollution and groundwater extraction;
- Possible interventions to restore mangroves along the coast should accommodate for sea level rise by including retreat schemes. N.b. Mangroves have high coastal storm protection, e.g. with a restoration scheme of 1.1 million USD in northern Vietnam to save 7.3 million USD worth of grey infrastructure maintenance;

- In more riverine areas, connecting floodplains to the river to trap sediment and increase elevation may to some extent serve to counterbalance sea level rise and coastal erosion;
- Stopping root causes of subsidence, such as uncontrolled extraction of ground water should be given highest priority as this will reduce relative sea level rise and coastal erosion.

Governance aspects
- The concept of NbS is still relatively new in Vietnam. Although policy documents provide a favorable setting for NbS, this topic is not being specifically addressed and not yet become mainstreamed in the local practice

Recommendations
- Clearly address NbS in policy and implementation plans, solve possible discrepancies under different instruments and involve private/market oriented activities
- Develop incentives to engage local communities in long-term management of restored areas
- Enhance upstream-downstream cooperation and cross-provincial linkages

Socio-economic and financing aspects
- Increased energy demands resulted in more dams planned for the Mekong. Dams disrupt sediment and nutrient supply to the Delta, reduces connectivity between ecosystems and biodiversity loss, reduces functionality of interconnected ecosystems
- Main drivers of change in the Mekong: increasing population growth and density, worsening income inequality
- Unsustainable levels of resource (predominantly sand and water) use due to economic stance (demand-driven growth versus balanced/subsistence use)
- Grey infrastructure development
- Involvement of private sector in financing NbS measures is still rather limited
- There is not yet a centralized fund for coordinating the financing streams for NbS specifically

Recommendations
- Controlled river floods in the wet seasons in the upper and middle Delta while restoring the large-scale destruction of protective mangrove forest due intensive and extensive shrimp farming
- For mixed or integrated mangrove-shrimp systems maintain (and enforce) at least 40% of their area under mangrove cover; a promising alternative is placing more emphasis on the regulatory rather than the provision of ecosystem services, considering the important role of mangrove forest regulating greenhouse gases
- Address the coordination of financing streams for NbS and enhance the involvement of the private sector

6.7 Ganges-Meghna-Brahmaputra delta description

6.7.1 Bio-physical system

The Ganges-Brahmaputra-Meghna (GBM) is a transboundary river system spanning five countries: Bangladesh, Bhutan, China, India, and Nepal. The GBM delta, with a surface area around 100.000 km2, is the world's largest delta.
The catchment of those three rivers is about 1.72 million km2 and with 130 million inhabitants the GBM belongs to the most densely populated areas in the world.

In the southwestern part of the GBM delta in Bangladesh, the Sathikira District is situated, as part of the Khulna Division with an area of around 4000 km2 and harbors a population of around 2 million people. There are a number of main rivers flowing through and/or around the Sathikira district: the Betna, the Morichap and the Kalindi-Jamuna River. Figure 6-10 provides the geographical location of the district including a detailed overview of the main rivers.

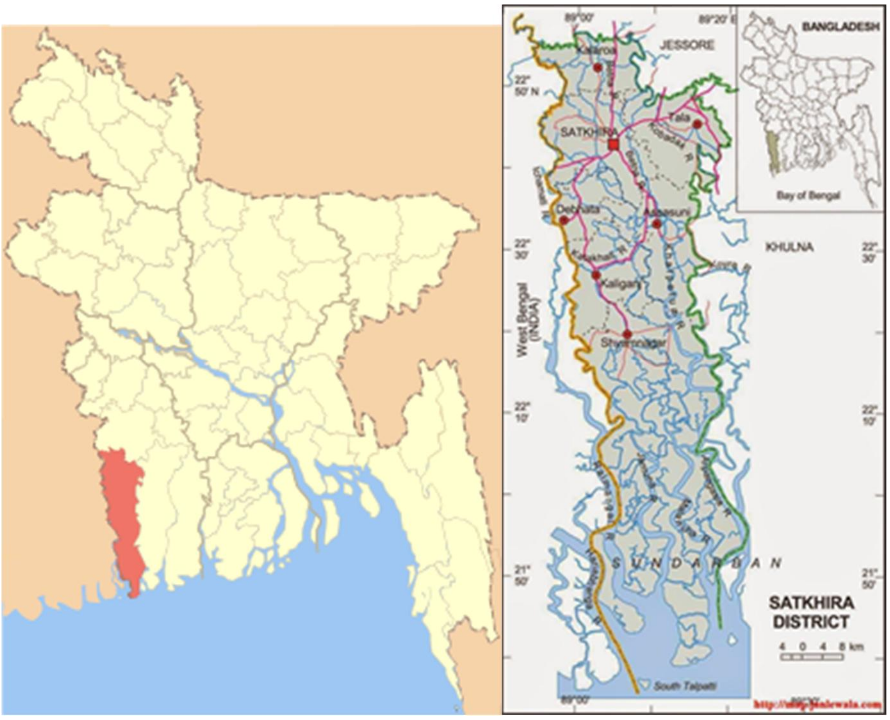

Figure 6-10 SItuation of Sathikira District, part of the Khulna Division

Summary of main processes and related problems

- Many of the rivers are subject to tidal action.
- With the tide flowing in, high number of sediments get deposited in the river system, providing not only fertile ground for the local population, but also affect the river and its system in negative ways, such as impact on navigation.
- As a result of the ebb tide occurring with lower speeds, the deposited sediments stay, raising the riverbed and killing the river completely.
- Rapid sedimentation as a result of lack of upstream flow which helps in sediments from these rivers. The construction of embankments has resulted in decreasing volume of water entering the river and also the flow velocity of the water in these tidal rivers.
- Water logging as a result of embankments, limiting the water flowing into the river.
- Salinity: as a result of Farakka Barrage built over the Ganges river, water from this river was made to divert to the Hugli in Bangladesh. Water supply significantly decreased with increasing entry of seawater into the Ganges basin. This in turn has increased river and groundwater salinity in the region. Other factors increasing salinity that are increasing salinity are among others saltwater shrimp farming.

Summarizing table with impacts on biophysical mechanisms related to most NbS

Impact	Natural factors	Anthropogenic factors
Negative	• High-rate of subsidence • Extreme weather events • Sedimentation of the rivers. • Decreasing waterflows into the river. • Salinization. • Sea level rise	• Embankments • Damming • Dredging • Deforestation • Expansion of aquaculture activities • Coastal squeeze
Positive	• Sufficient supply of sediment (and nutrients)	• Undamming upstream • Mud-engine'

Nature-based Solutions

The concept of Nature Based Solutions is rather well established in Sathkira: most recently, a study led by CNRS and the ICCCD (Falzon, Tasnim, 2020) focused on identifying the most notable problems in a collaborative way, and initiated the restoration of a previously encroached canal, which can now be used by the local population for fishing purposes. The higher lying goal of the project was well received by the stakeholders involved: working with the natural context, rather than against it, as it is well possible to enhance the lives and livelihoods of villagers. The many rivers flowing through the district provide ample opportunities to implement various structural and non-structural nature based solutions. Furthermore, the existence of the Sundarban mangrove tidal forest in the south, designated as a World Heritage Location can also trigger the use of NbS.

Tidal River Management

In order to mitigate the waterlogging crisis in various Upazilas of Satkhira, the national government has taken various initiatives over the years with technical and financial support from, among others the Dutch government and other international donors. From the local people and the civil society there is a demand to ecologically restore 11 major rivers that flows through the area. At the same time, the Bangladesh Water Development Board (BWDB) and the government of Bangladesh also understands the importance of the rivers for the local economy of the area. However, they have propagated different approaches to somewhat similar goals. Whereas the central government and engineers preferred more structural solutions; the local people and civil society have advocated for a nature-based solution, commonly referred to as Tidal River Management (TRM). Under popular demand and with the support of hydrological knowledge institutes, the Government of Bangladesh applied TRM to the tidal river Hari and Kapotakkho in the late 1990s. The application of TRM in these sites has only been mildly successful, because it has not been adequately applied to the entire respective river basins. Although the nature-based solution is widely accepted by local communities, there are also some opposing groups and bureaucratic complexity. The inundated flood plains are being converted into aqua cultural land by mostly absentee and rich landlords. They lease land from poor landowners for doing aquaculture. They are the ones who mainly oppose the solution since they do not get any compensation as not all the lands are owned by them. Furthermore, collecting compensation is a very difficult process; many documents are required which requires a lot of time to gather and poor small land owners it is a hassle. Additionally after managing to get the documents, filling the application to getting the money is also a lengthy process.

Afforestation[20]

Since 1960s, the Forest Department has been undertaking coastal plantation programmes to stabilise Bangladesh's coastline. In this era of changing climate, coastal afforestation has become an essential climate action to protect our coast and the people. Initiatives like "Community Based Adaptation to Climate Change through Coastal Afforestation Project" (2008-2016) of the UNDP, supported by the LDC Fund, and "Climate Resilient Participatory Afforestation and Reforestation Project" (2013−2016) of the Forest Department, funded by Bangladesh Climate Change Resilience Fund (BCCRF), have redefined coastal afforestation as a climate change adaptation measure. This approach was followed by CREL and is expected to be further promoted by SUFAL.

Box 4.2 Sundarbans

Among the unique natural resources of Bangladesh, the Sundarbans are the largest area of natural mangrove forest in the world. This vast forest is located in the delta of Bay of Bengal, formed by the confluence of the Ganges, Brahmaputra and Meghna rivers. It is also one of the most extensive natural ecosystems in Bangladesh and provides enormous economic and ecological benefits to the country. On the one hand, the Sundarbans continuously contribute to climate change mitigation by sequestering more carbon than terrestrial forests, which is why mangroves are described as the "carbon powerhouses" of the planet. Moreover, the Sundarbans Mangrove Forest provides direct or indirect support, mostly in the form of economic activities such as tourism and transport, to over 3.5 million people with an average annual revenue of US$ 744,000 (Chand et al., 2012; Uddin et al.,2013). This mangrove forest also serves as a coastal defense mechanism against storm surges (Sakib et al.,2015; Dasgupta et al., 2017), with the latest storm surge being the Super Cyclone Amphan which hit the south-west coast of Bangladesh in May 2020 A recent study by Menendez et al. (2020) on the flood protection benefits of mangroves ranked Bangladesh in the top three countries receiving greatest benefits from mangroves, measured in terms of the number of people protected from coastal flood events by mangroves[1].

Lastly, the Sundarbans harbor a rich biodiversity of flora and fauna; many mammals, including Bengal tiger and two freshwater dolphin types, among others, live in this fast-eco-system. However, the many benefits of the forests are being threatened, both by natural phenomena (such as sea level rise as a result of climate change and salinity) and human induced activities, such as infrastructure development. There is a serious need for conservation, while acknowledging that the area is of huge economic benefit for the local people. Concepts such as eco-tourism can therefore be considered.

Summarizing table with most relevant NbS types (and related to socio-economic aspects)

NbS type	Main functions	Co-benefits	Social impact	Market considerations	Trade-offs in relation to the main function
Delta management: Mangrove, vegetation management	Coastal protection.	Coastal erosion, food production, protection of communities to storm surges, habitat for fish and other	Food security, job generation, less vulnerable to storms, traditional	Even the modest reduction in surge levels that mangroves provide can help lower embankment heights and reduce	Uncertainties: the extent of protection that mangroves provide depends on

[20] https://www.thedailystar.net/opinion/environment/news/it-new-concept-bangladesh-1851772

NbS type	Main functions	Co-benefits	Social impact	Market considerations	Trade-offs in relation to the main function
		wildlife, attractive landscape for tourism.	medicines, raw materials.	the cost of construction. Also, the decrease in water flow speed provided by mangroves reduces infrastructure maintenance costs.	various factors such as the width and density of the mangrove forest, the diameter of the mangrove tree stem and roots, the depth of water bodies and the tidal stage at which waves enter the forest.
Floodplain conservation: costal embankments, tidal river management, river zoning, wetland conservation.	Mitigating waterlogging.	Improving the water quality and quantity, ecosystem restoration, less sedimentation in the river, nutrient rich land, reduced salinity, land value increases at the long term.	This is a natural water managemen t process with very little human intervention but it needs strong participation and consensus with a great deal of sacrifice by the stakeholders for a specific period (3 to 5 years or even more).	The inundated flood plains are being converted into aqua cultural land by mostly absentee and rich landlords. They lease land from poor landowners for doing aquaculture. They are the ones who mainly oppose the solution since they do not get any compensation as not all the lands are owned by them.	There is a mismatch between the people who take care of the costs and the beneficiarie s, at least in the short term.
Forest protection/restoratio n/creation	Erosion management	Carbon storage	Diversificatio n of livelihoods and income generation, raw materials, Co2-reduction	The citizens are protected from climate induced adverse impacts. Improve participatory forest management.Impro ve climate resilience and biomass production, while simultaneously enhancing incomes and livelihood options.	

6.7.2 Governance system

NbS require multiple actions by different levels of stakeholders over broad ecosystems, so breakdown in the cooperation and collaboration between these stakeholders can lead to conflict. Without strong legislative framework, law and enforcement, local stewardship of the lands, and proper institutional planning, it is very difficult to carry forward the actions when conflicts arise. There is also an absence of proper Private-Public Partnership, community participation with gender and social inclusions, stable political economy, and policy makers' awareness regarding the benefits of NbS. These issues make it hard to scale up NbS to a country-wide level (ICCCAD, 2020).
The main institutional framework, most recently developed, and anchoring many of the water-related aspects of the country is the Bangladesh Delta Plan 2100 (BDP2100).

The BDP2100 envisions a long-term, integrated and holistic plan towards environmental sustainability for Bangladesh. The goals of BDP 2100 advocate for climate change resilience, disaster risk reduction, water security and environmental development, as well as protection and conservation of wetland and ecosystems. It also outlines strategies for restoration and conservation of natural reservoirs, river and flood management infrastructure and improving the management of ecosystem services (Bangladesh Planning Commission, 2018).

Looking more at the policies defined for the shorter- and medium-term period, the Five Year Plans, developed by the General Economics Division under the Planning Commission are the main regulatory and policy framework. Bangladesh's 7th Five Year Plan (2016–2020) aimed to develop strategies, policies and institutions to allow Bangladesh to accelerate and comply with new commitments to meet SDGs. It highlights strategies for water resources management and distribution, environmental and climate change issues, green growth, and disaster management plans, which are essential sectors for NbS implementation (General Economics Division, 2015).

Other than the national plans stated above, Bangladesh also has action plans for biodiversity conservation, for example the National Biodiversity Strategy and Action Plan along with several legal instruments (Bangladesh Biodiversity Act 2017; Ecologically Critical Area Management Rules, 2016; and Protected Area Management Rules 2017) (ICCCAD, 2020).

The main actors involved, looking both from a national perspective, and in lesser sense in Satkhira, are, among others:

Community of Practices and Fora:

- Nature Based Solutions Bangladesh: This is a community of researchers, practitioners and policymakers working at the interface of climate change, nature conservation and sustainable development. The COP is primarily focused on creating awareness and understanding of the importance of NbS and to scale up their implementation potential in the country.

Research Institutes:

- International Centre for Climate Change and Development;
- Institute of Water Modelling;
- Center for Environmental and Geographic Information Services.

Government Agencies:

- Ministry of Water Resources;
- General Economics Division under the Planning Commission;
- Bangladesh Water Development Board;
- Khulna Water Supply and Sewerage Authority;
- Local Government Engineering Department;
- Bangladesh Forest Department.

NGO's:

- UTTARAN;
- Center for Natural Resource Studies;
- Mukti;
- Sundarban Social Development Center;
- IUCN (BRIDGE project).

Communities:

- People's participation is vital for NbS as NbS have been shown to be most successful when the local community are involved in the implementation and management of NbS (Irfanullah, 2020a).

Summarizing tables with governance aspects (status of development)

Status of development	Long term vision / policy documents regarding NbS	Regulatory framework and instruments	Shared Understanding on NbS	Multi-stakeholder platforms (multi-sectoral, multi-scale level)	Upstream-downstream cooperation
No (not in place)		• Bangladesh climate change strategy and action plan[21] (10 years vision but not yet approved);		• Ecosystem for Life (E4L) duration 2010 - 2014 (partly continuing though BRIDGE project;	
Underway/ planned			• MoU between Bangladesh and India on Conservation of the Sundarban (signed on 2011) (emphasizes that the Sundarban is a single eco-system shared between the two countries); • [1]Bangladesh Sundarban Delta Vision 2050.	• BRIDGE[3] (Building River Dialogue and Governance; • Studies on the National Park Sundarbans form both sides. Around 14 documents were made on various topics (biodiversity, water resources,	

[21] MoEF,2009,Bangladesh Climate Change Strategy and Action Plan 2009, Ministry of Environment and Forests, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh. Xviii + 76pp.

Status of development	Long term vision / policy documents regarding NbS	Regulatory framework and instruments	Shared Understanding on NbS	Multi-stakeholder platforms (multi-sectoral, multi-scale level)	Upstream-downstream cooperation
				development, and so on) from 2010;	
Completed/ operational	• Delta plan 2100;	• Bangladesh climate change trust fund (BCCTC) (established on October 2010); • Bangladesh Sundarban Delta Vision 2050[22]	• BRIDGE (Building River Dialogue and Governance (funded by IUCN)[23]; • River Commission (JRC) signed on 1972 (for common interest and sharing water resources, irrigation, floods, and cyclone control; • Bangladesh-India Sundarban Region Cooperation Initiative (since 2015) (broad vision for the future of joint efforts by Bangladesh and India within the provisions of the 2011 MoU);	• Feni River Agreement (allows India to withdrawals water for drinking water purposes); • River Commission (JRC) signed on 1972 (for common interest and sharing water resources, irrigation, floods, and cyclone control;	• To share the water of the Ganga river(signed on December 1996 a 30 year during treaty);

Status of NbS implementation

	Planning	Design	Construct	Operation & Maintenance	Monitoring
No (not in place)					
Underway/ planned	• Bangladesh climate change trust fund (BCCTC) (established on October 2010);				• Studies on the National Park Sundarbans form both sides. Around 14 documents were made on various topics (biodiversity, water resources, development,

[22] IUCN Bangladesh.(2014). Bangladesh Sundarbans Delta Vision 2050: A first step in its formulation – Document1: The Vision, Dhaka, Bangladesh:IUCN,vi_23pp.
[23] IUCN BRIDGE GBM, 2019. Meghna Research Collaborators Meeting (Bangladesh and India): Data and strategy for basin wide land use and socio-ecological change analysis, 11-12 June (Shillong, India) report. Bangkok, Thailand: IUCN. 13pp.

	Planning	Design	Construct	Operation & Maintenance	Monitoring
					and so on) from 2010
Completed/ operational	• River Commission (JRC) signed on 1972 (for common interest and sharing water resources, • irrigation, floods, and cyclone control; • Bangladesh-India Sundarban Region Cooperation Initiative (since 2015) (broad vision for the future of joint efforts by Bangladesh and India within the provisions of the 2011 MoU); • Bangladesh Sundarban Delta Vision 2050[1]	The Ministry of Environment and Forests (MoEF) of Bangladesh won the Earth Care Award 2012 (sponsored by the Times of India) for spearheading the Least Developed Countries Fund (LDCF) project “Community Based Adaptation to Climate Change through Coastal Afforestation in Bangladesh”. This year’s Earth Care Awards category was "Community-based adaptation and mitigation". This project, executed by Bangladesh’s Ministry of Environment and Forests (MoEF) and implemented by UNDP, has reached 18,269 households engaging citizens in afforestation, agriculture, livestock, and fishery-based livelihood adaptation and training measures.			

6.7.3 Socio-economic development and financing perspectives

Scaling-up NbS faces several challenges with regards to the project design, planning and implementation (ICCCAD, 2020). These include institutionalisation of projects where planning should be built-in and a lack of understanding of short-term and long-term trade-offs and benefits. Furthermore, in many projects, there is a lack of information for the local communities about long-term planning (stewardship of nature) and there is an absence of project intervention at the household level. With these issues, project longevity and sustainability can be a concern, as we can often see a lack of willingness of the stakeholders to think beyond the project period, and there can be a lack of imposition of land rights and therefore, the "tragedy of the commons" can occur. With the low level of investment available, there remain challenges to upscaling the NbS and covering wider areas. Though climate change poses a great risk to human wellbeing and the global economy, less than 5% of climate finance goes towards dealing with climate impacts, and less than 1% goes to coastal protection, infrastructure and disaster risk management, including NbS (Seddon et al., 2020). For the practitioners and the local communities, the lack of financial incentives act as a barrier to the implementation and ongoing monitoring of NbS.

In the GBM delta economic development is an important driver with medium to severe impacts. The agriculture in the GBM delta is mainly driven by rice, aquaculture (shrimps, catfish) and related industries. This delta also develops in infrastructure and related (geo-engineering) modelling or ICT services.

Current and alternative livelihoods, economic incentives

One of the most obvious and practical economic development solutions, where nature based solutions are incorporated in Satkhira district are further exploration and exploitation of the Sundarbans mangrove forests. Possible opportunities for, especially the local population are:

- Eco-tourism;
- Sustainable farm-fishing;
- Sustainable forestry;
- Agricultural activities, in the form of rice cultivation and/or vegetables;
- Maintenance/Planting new mangrove forests, not per se adding economic value, but focusing more on sustaining the economic potential of the NbS system and thus for the district and its population.

Inventory of funding and financing options applicable to NbS

In general:

- none or limited funding options from the GoB;
- financing options through WB, ADB, EKNl, foreign partners and communities.

Challenges of Implementing NbS

The following challenges have been identified as forming a barrier for potential further implementation of NbS in Bangladesh in general:

- Beyond the most well-established projects in Bangladesh, the policy for implementation of NbS is not well articulated and there is an absence of monitoring systems which are vital for determining the effects of NbS;
- Low level of knowledge, meaning the practices, interventions, and case studies: these are often poorly documented;
- Institutionalization of projects where planning should be built-in and a lack of understanding of short-term and long-term trade-offs and benefits;
- lack of information for the local communities about long-term planning (stewardship of nature) and there is an absence of project intervention at the household level;
- Lack of willingness of the stakeholders to think beyond the project period;

- Lack of financial incentives, for not only research and planning, but also implementation;
- Lack of a strong legislative framework, law and enforcement, local stewardship of the lands, and proper institutional planning;
- There is also an absence of proper Private-Public Partnership, community participation with gender and social inclusions, stable political economy;
- Policy makers' awareness regarding the benefits of NbS.

Summarizing tables with socio-economic and financial aspects

Resource mobilization for NbS (finance streams)

	Governance	**Private sector**	**International development**	**Blended**
No (not in place)			• [3]Bangladesh climate change strategy and action plan (10 years vision but not yet approved);	
Underway/ planned			• [2]BRIDGE (Building River Dialogue and Governance;	
Completed/ operational				

Financing coordinating entities

	Government agencies	**Non-profit trust**	**Investment funds**	**Special Purpose Vehicles**
No (not in place)				
Underway/ planned		• Studies on the National Park Sundarbans form both sides. Around 14 documents were made on various topics (biodiversity, water resources, development, and so on) from 2010;	• Bangladesh climate change trust fund (BCCTC) (established on October 2010);	
Completed/ operational				

6.7.4 Summary of conclusions and recommendations

Bio-physical aspects

- Climate change combined with development pressure will damage ecosystems, put pressure on many climate-sensitive species, enhance the potential damage of cyclones and influence coastal erosion/sedimentation balance, enhance salt water intrusion and deterioration of soil quality; still there is abundant sediment in the lower delta reaches, conveyed by the tidal flow from the sea, which will help raising land in the flood plaines;
- Being highly dependent upon developments upstream, the diversion, use or storage of flows from the transboundary rivers, as well as the decreasing flows within the western delta are of major importance to impacts on dry and monsoon season flows, salinization, siltation of rivers and sediment deposition in the lower delta tidal river reaches (BDP, 2018);
- The world's largest mangrove forest, the Sundarbans, is extremely vulnerable to human development and climate change. Since 1970s there has been 17000 ha loss of mangroves (Ward, Friess, & Day, 2016).

Recommendations (which were similarly addressed in BDP, 2018)
- Develop a strategy for sediment management;
- Maintain the ecological balance and values (assets) of the rivers;
- Sundarbans Conservation;
- Gain efficiency in TRM as well as its expansion;
- Action research for improved ecosystem services;
- Make adaptive delta management practical on the ground.

Governance aspects
- Although the word NbS is unfamiliar, the concept, when explained, is known in Bangladesh. There is still a lack of awareness among not only the population, but also the government. A policy for implementation of NbS is not well articulated and there is an absence of monitoring systems which are vital for determining the effects of NbS;
- There is also a lack of a strong legislative framework, law and enforcement, local stewardship of the lands, imposition of land rights and integrated institutional planning and implementation;
- Absence of functional Private-Public Partnership, effective community participation with gender and social inclusions, a stable political economy, and policy makers' awareness regarding the benefits of NbS, make it hard to scale up NbS to a country-wide level;
- Moreover scaling-up NbS faces several challenges with regards to the project design, planning and implementation (ICCCAD, 2020). These include institutionalization of projects where planning should be built-in and a lack of understanding of short-term and long-term (co)benefits and trade-offs;
- The application of TRM in Satkhira District in the late 1990s has only been successful to a limited extend, because it has not been adequately applied to the entire respective river basins and was not supported by functional institutional arrangements, addressing interests of all local stakeholders concerned, especially regarding the process of acquisition and requisition of land and compensation for temporary loss of income during TRM operation.

Recommendations
- Operationalizating and integration of NbS in existing policy and implementation plans;
- Upscaling and organization of monitoring and evaluation of NbS;
- Knowledge sharing and dissemination/awareness raising on NbS;
- Creating effective people's participation, as people's participation is vital for NbS. NbS have been shown to be most successful when the local community are involved in the implementation and management of NbS (Irfanullah, 2020a);
- Clear budgetary flows and mechanisms have to be created and institutionalized for local governments to seriously consider use of NbS as alternatives. This can be done by e.g. incentivizing and/or anchoring use of NbS in regulations and creating integration between government agencies at the local level;
- Regarding application of TRM the short-term needs (local) versus long-term benefits (regional, national) should be more addressed through appropriate arrangements.

Socio-economic and financing aspects
- The soil and water combination of Bangladesh makes it a highly fertile land with multiple cropping opportunities, primarily rice. Rice production has surged from 12 million tonnes in 1973 to 36.3 million tonnes in 2018;
- Agriculture is the most vulnerable sector to salt intrusion and unintended flooding. The other highly vulnerable sectors are forestry and ecosystems (a.o. the Sunderbans mangroves);
- The importance of fisheries and livestock is growing so the structure of agriculture is slowly changing as the share of crop sub sector is falling and that of fisheries (incl. shrimp farming) and livestock increasing (BDP, 2018);

- With the low level of investment available, there remain challenges to upscaling the NbS and covering wider areas. For the practitioners and the local communities, the lack of financial incentives act as a barrier to the implementation and ongoing monitoring of NbS.

Recommendations
- Create investment mechanisms and incentives for stakeholders at all levels, to implement NbS;
- Public-Private partnerships as incentives;
- In Satkhira district one of the most obvious and practical economic development solutions, where NbS are incorporated, are further exploration and exploitation of the Sundarbans mangrove forests beyond the protected area, through eco-tourism, sustainable farm-fishing-livestock, sustainable forestry, agricultural activities (rice cultivation and/or vegetables) and maintenance/planting new mangrove forests.

Research and Development
- Quanitification of NbS as eco-system services;
- More evidence based research;
- Pilot Projects with stakeholders involved, to develop and ensure an effective and institutionalized incentive system for NbS implementation.

6.8 Ayeyarwady delta

6.8.1 Bio-physical system

The Ayeyarwady delta is one of the major tropical deltas in the world with 30400 km2 in Myanmar, one of the least developed countries in Southeast Asia. The region was initially forested, and mangrove grow in tidally influenced areas. However, most of the area has been turned into agriculture polders and the total mangrove forest area in the delta decreased from 2345 to 1786 km2 between 1924 and 1995 due to logging and clearance for agriculture and aquaculture activity (Hedley, Bird, & Robinson, 2010). Accordingly, the four sections of the Delta suffer from the consequences of the ill-informed expansion of economic activity. Such dynamics were documented by the Integrated Ayeyarwady Delta Strategy drafted by Myanmar authorities in 2018.

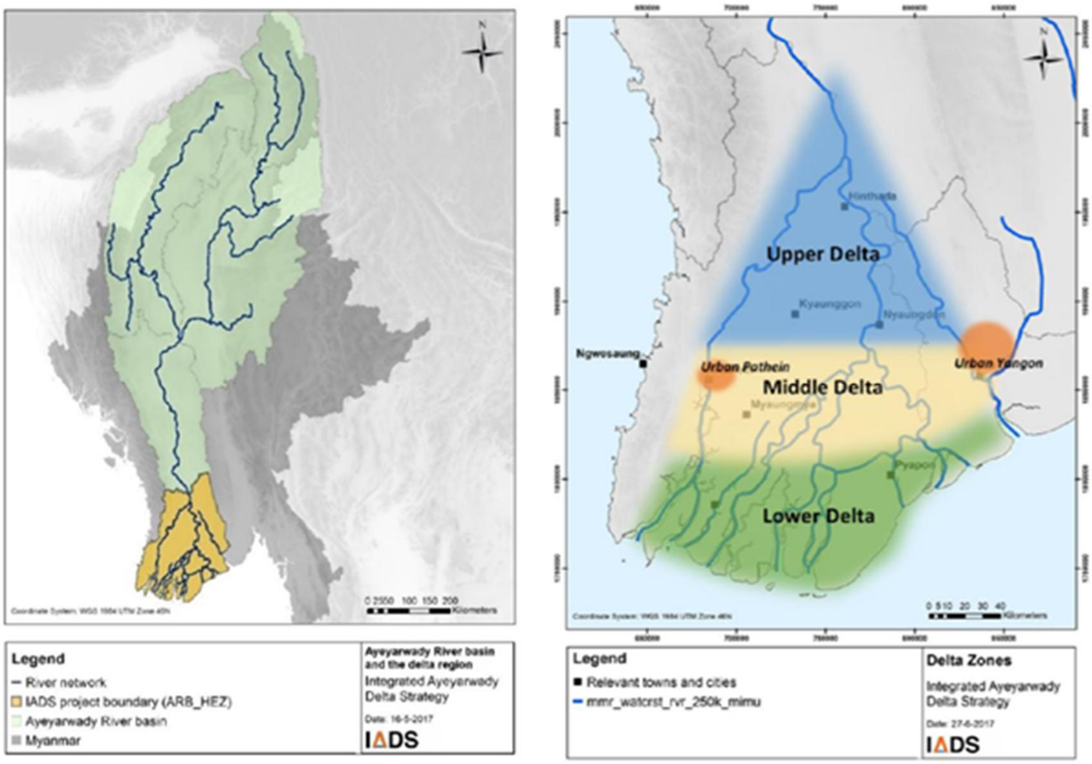

Figure 6-11 Situation of the Ayeyarwady delta

The upper delta is prone to rapid increases in water level and bank erosion given the highly variable discharges of the River Ayeyarwady and its branches. Local sand bars caused by bank erosion and sedimentation increase flood risk and reduce navigability. The middle delta suffers salinity intrusion, and it is characterized by less rapid changes in water levels comparted to the upper one. The lower delta is most vulnerable to climate change because of its exposure to sea level rise, potentially more severe cyclones and changing rainfall patterns that occur on top of riverine flooding and land subsidence. Finally, the urban area suffers from unsustainable patters of urbanization exposed to frequent floods mainly Yangon and Pathein and to a lesser extent Hinthada. The subaquatic delta is the hidden foundation.

The current socio-economic dynamics and climate change would worsen the ongoing threats in the four sections:

- Persistence of logging in the upper delta increases the risk of destructive peak discharges given higher surface runoff and sediment loads. Existing infrastructure might fail, leading to increasing cost for repairing and even rebuilding hydrological and other public infrastructure.
- In the middle delta the salinity intrusion and changing rainfall patterns increases risk of flooding, drought and yield loss. Moreover, changing seasonal rainfall patters, salinity intrusion and groundwater intrusion compromises the supply of drinking water to people.
- The deterioration of coastal ecosystems in the lower delta would lead to loss land, land subsidence coastal erosion increasing risk steaming from increasing sea level rise and more frequent storms. Fresh water availability is also at risk due to longer dry spells and higher peak dischargers. Overall, the lower delta would gradually lose all the productive and economic benefits worsening existing poverty.

- Urban infrastructure for water supply, drainage, sewage systems and flood protection might not keep up with increasing climatic and population growth. Slums would growth, city center congested with many without access to water and sanitation rights. The uncontrolled expansion disables flood protection increasing their frequency and magnitude and hampering event more the socio-economic development.

The most important trends, threats and pressures are summarized in Table 4-2 (IADS, 2018):

Table 6-4 The most important trends, threats and pressures in the Ayeyarwady delta

Climate change	• Increasingly intense rainfall events; Threat to water quality and increased peak discharges in rivers.
	• Sea level rise: Threatening the coastline and increasing coastal flooding risk and salinity intrusion.
	• More and longer dry spells; threatening water quality, water availability (drinking water and irrigation), and navigability of rivers.
	• Increasing temperatures; threat to health, and shortage of water availability for the urban and rural area by increasing evaporation, water demand, threat to human health and disease pressures (for animals and crops).
Population growth	• Urbanization; Loss of fertile land, building in flood prone areas and congestion. It can potentially become urban sprawl which expands the threats to health and environment. This is often accompanied by an increase in hardened (urban) surfaces that result in higher peak discharges in urban areas and rivers during rainfall events.
	• The mangrove area has been heavily exploited and is largely in a degraded state due to human activities such as wood harvesting and coastal development, leading to an increased coastal erosion.
Economic pressures	• Population increase; increasing energy, food and water demands; these might result in health issues, drinking water shortages and potential famine.
	• Upstream dams and sand mining reduce sediment replenishment.
	• Increasing need for sanitation and better water quality; reduced sanitation and drinking water access results in more diseases and other health issues.
	• Land subsidence, due to groundwater abstraction, threatening the coastline and potentially increased coastal and inland flooding.
	• Increasing transport demand; congestion. Poorly connected cities, villages and towns through proper roads and water ways results in non-development of the economy, slow evacuation possibilities during floods and increased urbanization due to rural isolation.
	• Industrialization; the increase in pollution and encroachment of agricultural land result in decreased agricultural potential and environmental issues. • Fragmented spatial planning and land speculation.

Summarizing table with most relevant NbS types (and related to socio-economic aspects)

NbS type	Main functions	Co-benefits	Social impact	Market considerations	Trade-offs in relation to the main function
Mangrove:	• Coastal protection • Reducing flooding and erosion • Sediment capture • Wave attenuation	• Protection of communities to storm surges • Contributing to biodiversity • Habitat provision/nursery grounds for fish and other wildlife • Food production,	• Less vulnerable to storms • Food security • Job generation • Supports recreation/ tourism • Supports diversified livelihoods	Even the modest reduction in surge levels that mangroves provide can help lower embankment heights and reduce the cost of construction. Also, the decrease in water flow speed provided by mangroves reduces	Maximizing short-term production compromises long-term conservation and safety Uncertainties: the extent of protection that mangroves provide

NbS type	Main functions	Co-benefits	Social impact	Market considerations	Trade-offs in relation to the main function
		• Support offshore fisheries • Attractive landscape for tourism • Carbon sequestration • Sediment/ nutrient filtering • Water purification • Harvestable goods (a.o. for fuel)	• Traditional medicines • Raw materials.	infrastructure maintenance costs. It operates upon carbon markets. 'The project must apply for being label as "carbon project" for voluntary trading markets or mandatory trading market.	depends on various factors such as the width and density of the mangrove forest, the diameter of the mangrove tree stem and roots, the depth of water bodies and the tidal stage at which waves enter the forest.
Mangrove-crustacean farming / fish farming	• Food provision • Aquaculture production • Mangrove conservation • Biodiversity • Shoreline protection	Carbon sequestration Water quality improvement Water purification	Improved community livelihoods	Yield will likely be lower, thus increasing the required selling price. Sustainable production will have to find a way to markets that are willing to pay a premium for this.	Maximizing short-term production vs. Sustainable aquaculture practice (that may lead to lower yield) Limited access to technical knowledge to design and maintain productive farms, and other resources such as finance.
Restoration of floodplains/ Wetlands (incl. 'Room for the River' approach)	• Flood management • Promoting sediment deposition • Water resources supply	• Habitat provision • Improving the water quality and quantity • Flushing out agrochemicals • Carbon sequestration (if vegetated) • Increased soil fertility • Ecosystem restoration • Less sedimentation in the river • Reduced salinity • Land value increases at the long term.	• Require areas set aside for restoration, which may result in people having to move out • Soil fertility positively impacts agriculture • This is a natural water managemen t process which needs strong participation and consensus • Supports recreation/ tourism	For those producing in these areas, loss of productive land may have to be compensated. Reduced flood risk may directly benefit stability of production in the direct hinterland Landownership issues? Can be done in unproductive agricultural land or aquaculture ponds	Potential loss of employment and production in these areas in return for safety and stability of livelihoods in hinterland for the future There maybe a mismatch between the people who take care of the costs and the beneficiaries, at least in the short term..

NbS type	Main functions	Co-benefits	Social impact	Market considerations	Trade-offs in relation to the main function
			• Act as water retention and reduces flood risks		
Forest protection/ restoration/ creation	Erosion management	Carbon storage Regulating climate and water availability	Diversification of livelihoods and income generation, raw materials, Co2-reduction	The citizens are protected from climate induced adverse impacts. Improve participatory forest management.Improve climate resilience and biomass production, while simultaneously enhancing incomes and livelihood options.	
Coral reefs	Wave attenuation	• Habitat provision, nursery grounds • Improve biodiversity • Tourism			
(Small-scale) sand engine ?	Erosion prevention	Regulation of dunes	• For beaches/ dunes to provide flood protection, they require sufficient space • Supports recreation		High revenue of sand mining business vs. Maintenance of sand budget

6.8.2 Governance system

Institutional and governance situation in the Delta is complex, and often imposing difficulties in decision-making processes. The Integrated Ayeyarwady Delta Strategy points out that there are fragmented responsibilities between ministries and departments hindering coordinated water resource management (2016). There are increasing initiatives for decentralizing and providing higher control to local authorities, which nevertheless require more decisive empowerment and capability of local authorities. Myanmar sanctioned a Water Framework Directive, and more related legislation is being developed. Legislation, policy guidelines, standards and regulations are set at the national level and transferred for implementation to the regions/states, districts, townships and communes/wards. On the other hand, in some sectors, there are not mechanisms nor the political will to enforce laws and policies, and multiple ministries have a competing stake in one or more of the sub-sector. The most relevant players are (i) MOTC (DWIR) for water transport, river systems and water resources management; (ii) MoALI (IWUMD, DoF,DoA, and DRD) for irrigation, rural water supply, fisheries, and forestry; and (iii) MoNREC for water quality and environmental protection/conservation. However, the vertical structuration of various ministries and their degree of autonomy prevents horizontal coordination (See Figure 6-12). Other Ministries with a stake include the Ministry of Construction, responsible for urban drainage, water supply and sanitation and Ministry of Livestock and Fisheries and Rural Development (MOLFRD) for domestic water and rural water supply and sanitation. Vertical coordination, between the ministries/departments and the lower administrative levels, is generally better. The national budget is also set at the state level, but the local administration can have its own budget and funds for project implementation

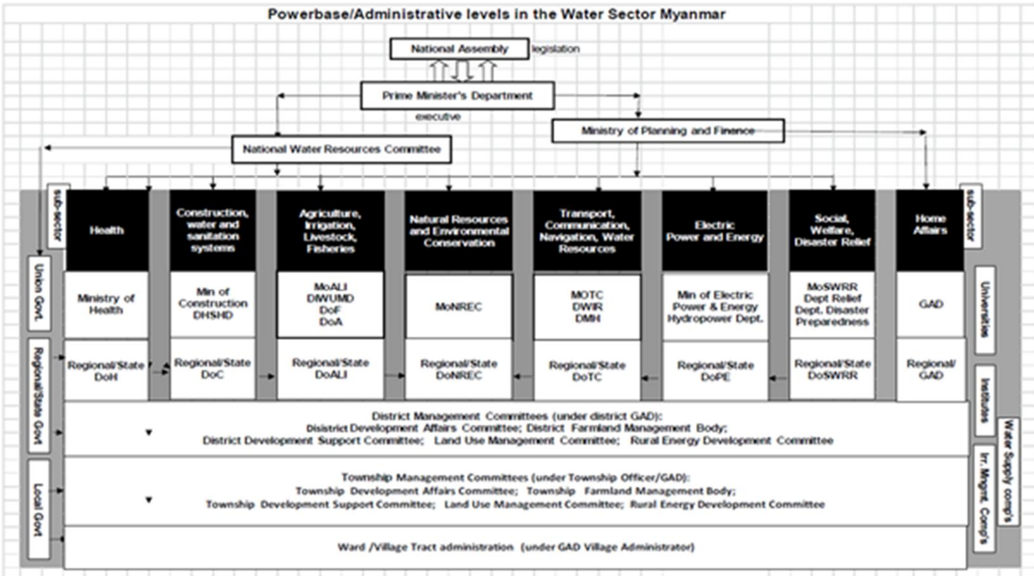

Figure 6-12 Powerbase/Administrative levels in the water sector of Myanmar (IADS, 2018)

In 2018, several experts and officials developed the first phase of the Integrated Ayeyarwady Delta Strategy (IADS), which defines a long-term development perspective. The document envisions a safe, prosperous and sustainable delta with a vibrant, diversified economy and ecology that are resilient to salinization, floods and water shortage. Accordingly, it defines five main objectives:

- Objective 1: Ensure safety from floods;
- Objective 2: Develop climate-smart agriculture, fisheries and livestock;
- Objective 3: Improved water supply and sanitation;
- Objective 4: Conserve and restore ecosystems and promote their sustainable use;
- Objective 5 Develop effective institutions and equitable governance for delta management and planning.

Nevertheless, the objectives remain at a rather generalized level without specific targets as the Ayeyarwady Delta's development is at the early stages. The IADS plan includes short-term non-regret measures such as data production, community-based FEWS and restoring coastal mangroves. Such measures are coupled with the need for strengthening the capacity building. The authors of the IADS warns that a consistent Delta plan might require decades of social negotiation, also pointing out the urgency of canalizing the increasing number of flows of capital entering in the Delta.

Summarizing tables with governance aspects (status of development)

Status of development	Long term vision / policy documents regarding NbS	Regulatory framework and instruments	Shared Understanding on NbS	Multi-stakeholder platforms (multi-sectoral, multi-scale level)	Upstream-downstream cooperation
No (not in place)					
Underway/ planned	National Coastal Resources Management Central Committee discussed about NbS as cost-effective and efficient approach during their meetings but no implementation at the moment				
Completed/operational	Myanmar Climate Change Master Plan Objective for action area 4: Increase access to technology for urban climate resilience			National Coastal Resources Management Central Committee? National Wetland Committee? National Disaster Management Committee?	

Status of NbS implementation

	Planning	Design	Construct	Operation & Maintenance	Monitoring
No (not in place)	-	-	-	-	-
Underway/ planned					
Completed/operational					

6.8.3 Socio-economic development and financing perspectives
Long-term ambitions of economic development of the Delta

The health of river, wetlands and marshals represent a critical asset, contributing to two to six billion US to the Myanmar economy annually (WWF, 2018). According to literature, aquaculture and fishing constitute a key source of income and food security in the Ayeyarwady Delta, and host an important share of the paddy production (Radford & Lamb, 2020). According to WWF, “rice grown in the delta is more productive per hectare than elsewhere in the basin” (WWF, 2018). Additionally, Myanmar exclusive economic zone (EEZ) occupies 80% of the northeast coastal waters of the Bay of Bengal Large Marine Ecosystem (Akester, 2019), which fish productivity depends on the extension mangrove forest, the continental shelf and sedimentation process from the river systems.
The IADS structure the economic case for ecosystem services. It quantifies the estimated values of nature for several economic sectors. From agriculture, ecosystem services were value within the range of 91 to 171 US Millions. For the freight sector, including inland rivers, the value ranges 8 to 23 US millions.
Ecosystem service in fishers might represent up 1,130 US millions and for potable water supply up to 639 US millions. Economic value estimated for biodiversity as supporting services is less reliable (Table 6-5).

Table 6-5 Estimated annual value of ecoystem services (SOBA, 2017)

Ecosystem service	Estimated values (USD million)			Reliability of range of estimates
	Low	Medium	High	
Ecosystem services quantitatively estimated				
Agriculture (irrigation water supplies provisioning services)				
Yield gains in monsoon	29	40	50	
Ability to produce crops outside monsoon	62	91	121	
Freight (inland rivers – modal substitution provisioning services)				
Freight task savings	8	13	23	
Fisheries (protein replacement provisioning services)				
Freshwater capture	350	440	530	
Aquaculture	380	490	600	
Potable water supplies (water quality regulation services only)				
Treated tap water	57	91	125	
Local treatment	129	321	514	
Biodiversity (supporting services)				
Forests	1,300	2,645	4,418	
Wetlands	4	7	10	
Mangroves	146	297	497	

The analysis also includes a qualitative characterization of services for a number of sectors, which data is insufficient (Table 6-6).

Table 6-6 Qualitative characterisation of ecoystem services (SOBA, 2017)

Ecosystem services not quantitatively estimated				
Agriculture (provisioning services excluding irrigation water supplies)				
Soil retention and fertility, nutrient cycling, pollination, pest control, and non-irrigation water.	Insufficient data to value. Likely to be significant across irrigated cropping, dryland cropping, and stock.	n/a		
Potable water supply (water provisioning				
Supply of groundwater and surface water (volume) for consumptive use in households (drinking, cooking, personal hygiene, clothes washing, etc.).	Insufficient data on consumption volumes and economic values of alternative water sources (including replacement costs) to develop estimates. Insight from international water supplies suggests these values would be significant (greater than the regulating ecosystem services that have been estimated).	n/a		
Flooding (regulating and provisioning services)				
The Ayeyarwady Basin's natural flooding regime (locations, frequency, and extent) results in risks (damage to property, lives, and crops) as well as soil replenishment. Ayeyarwady Basin management will change the flooding regime, the marginal benefits, and the costs attributable to flooding.	Data on locations and extent of flooding available are insufficient to estimate economic values. Values are likely to be significant.	n/a		
Hydro-power (intermediate provisioning service)				
River flows, in conjunction with built capital (dams and turbines), provide an intermediate provisioning service to electricity generation. These values would ideally be assessed against any trade-offs relating to specific hydro-projects (e.g., costs of relocating communities).	Insufficient data available on costs of electricity to be supplied and costs of next best substitute to estimate marginal benefit of hydro-power. Values will be project specific. Values are likely to be significant.	n/a		
Gravels and natural quarrying products (provisioning service)				
These products are often extracted from riverbeds in the Ayeyarwady Basin for use in building homes, other buildings, and public infrastructure (such as roads and bridges).	Insufficient data on extraction rates, costs of extraction, and costs of substitutes to establish credible estimates at this stage. Values are likely to be significant.	n/a		
Ecotourism (cultural service)				
The Ayeyarwady Basin's natural beauty will be one of the drawcards for the emerging tourism industry. This provides a major cultural ecosystem service.	There are insufficient data on tourism and ecotourism, although the sector has significant potential to be a major contributor to economic activity.	n/a		
Total ecosystem services	**> 2,464**	**> 4,435**	**> 6,888**	

On the other hand, the rapid economic dynamic imposed by the economic opening in 2010-2011 imposed new demands and pressures. For example, the energy consumption increased in 15%, leading to an energy deficit that would be addressed by hydropower projects. While those projects can address the needs of economic development, they also compromise the health of the ecosystem upon which the Delta relies for their long-term sustainability.

Focusing on enabling investment for sustainable development

As explained, the IADS warns that a consistent Delta plan might require decades of social negotiation, also pointing out the urgency of canalizing the increasing number of flows of capital entering in the Delta. The plan illustrates as a matter of example, eventual a short-term, mid-term and long-term asset investments for flood protection combining green and grey solutions (Table 6-7). Nevertheless, the definition of specific asset investment for the Delta demands a more detailed technical scoping, considering the democratic transition process aiming at breaking the authoritarian past by establishing new modes of governance (Mark & Belton, 2020). It implies dialogue upon the development needs and economic opportunities, without losing sight into the complexity of the socio-political transition (Ivars & Venot, 2019).

Table 6-7 Example of grey and green strategies for flood safety in four zones

	SHORT TERM	MID TERM	LONG TERM
YANGON REGION	Restore and protect Mangrove areas Increase natural storage capacity (SuDS)	Continue SuDS Reallocation of vulnerable activities	Expand if and where necessary Accept relocate
	Improve drainage Enforce embankments Flood proof buildings and infrastructure	Increase pumping capacity Expand embankments	Storm surge barrier
LOWER DELTA	Restore and protect Mangrove areas Mangrove – Aquaculture systems	Tidal River Management (TRM)	Relocation of livelihoods
	Flood proof buildings and infrastructure Shelters	Coastal embankments	Storm surge barrier
MIDDLE DELTA	Flood based agriculture	Room for river Relocation of vulnerable activities	Relocation of livelihoods
	Active river stabilization and channelization Enforce embankments Flood proof buildings and infrastructure	Flood control structures Controlled flood areas	Diversions
UPPER DELTA	Amphibious housing	Room for river Risk zoning for economic activity	Relocation of vulnerable activities
	Active river stabilization and channelization Enforce embankments Flood proof buildings and infrastructure	Flood control structures Controlled flood areas	Diversions Distribution work

There are several aspects related to water and land rights that should be considered when setting enabling investments and considering the long-term sustainability of asset investments. Land tenure is a major issue to consider in the planning and the development of any strategy in the Ayeyarwady Delta (Vicol & Pritchard, 2020). In particular, the democratization process included the introduction of new land-use policies as a restorative justice measure due to the large-scale land confiscations in the past (Mark & Belton, 2020). Confiscations enabled the rapid expansion of large-scale aquaculture during the 1990s and 2000s in the Delta, which in turn defined the investment policy of hydraulic infrastructure (Belton et al., 2018). Therefore, there ongoing tensions emerging from some efforts to catalyze positive change by fostering a market-based and smallholder-led agricultural development (Vicol & Pritchard, 2020). There are groups pushing for reproducing the industrial-scale farming model arguing productivity payoffs, competing against groups championing the vision of smallholder development, arguing the failure of large-scale land concessions (Mark & Belton, 2020).

The sharp drop in west foreign investment due to the Rohingya crisis (2017) re-direct country's attention to east Asian capital, around the 1700-km-long China-Myanmar Economic Corridor as part of the China's Belt and Road Initiative. Therefore, it is not a minor challenge to define the substantive scope of enabling investments, creating the conditions of social dialogue and negotiation for aligning smallholders' interests and large-scale development ambitions. So far, the country has advanced in restructuring the investment-related authority, including setting up a Public-Private Partnership Office for coordinating large scale projects (Tritto, 2019). Additionally, the implementation of the Belt and Road initiative in Myanmar set as conditions keeping open the country to international financing institutions, to invite other tenders and having the last word in the projects ahead. In this regard, the WWF has already noted the need to consider the socio-environmental Impact on the development and the role of functional habitats in the long-term sustainability of the Belt and Road Initiative (WWF, 2020).

Summarizing tables with socio-economic and financial aspects

Financing coordinating entities

	Government agencies	Non-profit trust	Investment funds	Special Purpose Vehicles
No (not in place)				
Underway/ planned				
Completed/operational	Forest Dept, Environmental Conservation Dept under MoNREC?			

6.8.4 Summary of conclusions and recommendations

Biophysical aspects

- The middle delta suffers salinity intrusion, increasing pollution and encroachment of agriculture resulting in decreased productivity and in deterioration of ecosystems and their services;
- The lower delta is most vulnerable to climate change (sea level rise, potentially more severe cyclones, changing rainfall patterns) that occur on top of riverine flooding and land subsidence;
- Reduction in sediment loads and alterations in the hydrological regime of the river result in coastal erosion and in deterioration and loss of coastal ecosystems and their services;
- The total mangrove forest area in the delta have been seriously degraded over time due to overexploitation of the resource, coastal development and to the conversion of land for rice fields and shrimp (and fish) ponds, leading to increased coastal erosion;
- The area covered by mangroves has decreased about 83% from 679.019 acres to 111.318 acres in the period between 1980 to 2013 (Maung, 2013). The quality of the remaining 17% of the mangroves is not good and cannot be used to produce seeds for replantation (DA report, 2015).

Recommendations

- Assisting Natural Regeneration (ANR) of mangrove forests in degraded areas;
- Establishing buffer areas along the rivers and main streams in Ayeyarwady Delta;
- Newly accreted lands or ‘wasteland or abandoned aquaculture ponds and farm’ should be considered for mangrove plantation initiatives;
- Using erosion control methods such as bamboo fence to reduce the incident wave energy and catch sediments;

- Integrated mangrove-shrimp farming for alternative livelihood.

Governance situation

- The Integrated Ayeyarwady Delta Strategy (IADS) remains at this early stage at a rather generalized level without specific targets e.g. for restoring coastal mangroves;
- In some sectors, there are not mechanisms nor the political will to enforce laws and policies, and multiple ministries have a competing stake in one or more of the (sub)sectors;
- The National Coastal Resources Management Central Committee (NCRMCC) addressed NbS as cost-effective, efficient approach, not yet resulted in implementation (WWF, 2020);
- The institutional and governance situation in the Ayeyarwady delta is complex with fragmented responsibilities, often imposing difficulties in decision-making processes and requiring more decisive empowerment and capability of local authorities;
- Land-use management and planning issues are a major bottleneck;
- There is no River Basin Organisation and no institutional responsibility for coastal protection, so integrated management of the delta needs much improvement (WWF, 2020);
- ECD under MoNREC is a focal department and recently submitted voluntary inputs/ proposal to SCF Forum on Financing Nature-based Solutions.

Recommendations

- National Coastal Resources Management Central Committee (NCRMCC) is constituted as a main national-level body for the policy and management of coastal areas where NbS will be a key intervention for climate resilience and adaptation. To become functional its capacity needs to be developed;
- Institutional responsibility for coastal protection needs to be defined;;
- Effective governance requires strengthening of government engagement with local stakeholders
- There are several different national-level committees important in strengthening cross-sectoral coordination among government agencies. These include:
    - National Environmental Conservation and Climate Change Central Committee
    - National Land use Committee/ National Land Resource Management Central Committee or National Land use Council
    - National Wetland Committee
    - Community Forestry National Working Group (CFNWG)
    - National REDD+ Taskforce

Socio-economic and financing aspects

- In the river basin rapid urbanization results in loss of fertile land, building in flood prone areas and congestion, aggravated by fragmented spatial planning and land speculation (IADS, 2018);
- The urban area in the middle delta suffers from unsustainable patters of urbanization exposed to frequent floods, mainly in Yangon and Pathein and to a lesser extent Hinthada;
- Urban infrastructure development for water supply, drainage, sewage systems and flood protection is not keeping up with climate change and population growth, hampering socio-economic development;
- The health of river, wetlands and marshes represent a critical asset, contributing to two to six billion US to the Myanmar economy annually (WWF, 2018), with aquaculture and fishing constituting a key source of income and food security;
- The rapid economic dynamics since 2010-2011 imposed new demands and pressures, e.g. increase of energy consumption leading to more hydropower projects impacting the (delta) ecosystems;

- So far, the country has advanced in restructuring the investment-related authority, including setting up a Public-Private Partnership Office for coordinating large scale projects (Tritto, 2019);
- Additionally, the implementation of the Belt and Road initiative in Myanmar set as conditions keeping open the country to international financing institutions
- Forest Dept, Environmental Conservation Dept under MoNREC acts as the governmental financing coordinating institute.

Recommendations
- WWF has already noted the need to consider the socio-environmental impact on the development and the role of functional habitats in the long-term sustainability of the Belt and Road Initiative (WWF, 2020);
- Ensuring, through e.g. consultation and capacity building, improved local livelihoods is a key success factor for any NbS.

Research and development addressing knowledge gaps
- Detailed economic valuation and cost-benefit analysis;
- Need of extensive data and valuation of ecosystem services to share evidence-based information with decision makers;
- Need to develop methodologies and guidance to be adaptable in Myanmar;
- Knowledge sharing from existing/ past NbS projects;
- Institutional or regulatory setting to implement NbS. Some administration may not have legal instruments or duties/responsibilities to implement NbS although they are the main actor (example as DoF taking care of Dolphin conservation in which case Wildlife Department would be more suited);
- Land-use issues;
- Platform to connect practitioners and authorities.

6.9 Glossary of financial instruments

Table 6-8 Existing assets and financial instruments adapted to landscape investment and investors (FAO, 2015)

Asset and financial instrument types	Attributes	Implications	Relevance to landscape investment	Types of investors
Equity	Share of a given company, Gains conditioned over company value growth, Dividends received	Shareholder ownership and commitment to success, Need for exit strategies	Investment in landscape restoration champions (companies in particular value chains) from the agriculture, forest, and agroforestry sectors Relevant for entrepreneurial activities because of higher risk acceptance in comparison to loans (which need guarantees) Particularly relevant in the agriculture sector where markets are volatile	Private equity impact funds Traditional investors (commercial banks, pension funds) Development finance institutions (DFIs), High-net-worth individuals
Loans	Medium to long term Repayment obligation Carry interest	Need for business models with guaranteed returns Strong ownership and management skills required	Provide governments with resources for developing financing mechanisms (e.g. supporting phases of national forest funds) Provide companies and governments with resources for implementing landscape restoration, Can be repaid through investment in landscape restoration options based on	Traditional investors (commercial banks, pension funds) DFIs National and local banks as intermediaries Microfinance institutions (for

Asset and financial instrument types	Attributes	Implications	Relevance to landscape investment	Types of investors
			commodity production, Microloans through microfinance to small-scale projects	small-scale projects)
Bonds	Instrument of indebtedness of the bond issuer to the holder, Issuer owes Interest to the holder	Attractive for longterm investments Interest must be paid to the bond holder at frequent intervals	Long-term financing opportunity for large-scale projects, Refinancing of (running) largescale projects, Adapting green bonds to landscape restoration	Impact funds Traditional investors (commercial banks, pension funds) Governments
Grants	Normally one-time support involving no repayment	Not self-sustaining Limited entrepreneurship/ ownership Can create dependency	Readiness phase of large-scale project preparation, Support to small-scale projects, Support to least-developed countries	Grant programmes of DFIs Small grant programmes of DFIs State grant programmes NGO-managed grant programmes Private foundations
Subsidies	Selective payments that subsidize particular inputs or practices	Opportunity to support transformational change	Support to agro-environmental measures, supporting functional landscape restoration Incentives to plant forests and manage forests and agro-systems sustainably	States Environmental funds DFI pilot programmes (similar to grants)
Compensation payments/ rewards for ecosystem services	Payments for conservation and management efforts	Can compensate for opportunity costs and loss of income	Can support limitation of economic activities in competition with landscape restoration, Provide incentives for certain conservation behavior	States Environmental funds Conservation NGOs
Direct payments or incentives for environmental products/ services	Through market transactions for ecosystem services (in some cases serving the same objectives as PES, pro-environment subsidies and compensation payments)	Market-based approach to payments for ecosystem services	REDD+ implementation as an international PES scheme, Local PES scheme for forest restoration and sustainable agriculture in the upstream part of watersheds, Many PES options to support sustainable long-term transformational change for landscape restoration	States Environmental funds Private companies
Buy-back agreements and outgrower schemes	Binding contracts issued by forest, agroforestry or agriculture companies, guaranteeing viable markets from products	Can stimulate landscape stakeholders to organize Guarantee sales to small producers and cooperatives	Enable small-scale producers to engage more strongly in the landscape vision, Enhance interactions among private stakeholders within the value chains	Private companies Governments Private equity impact funds Traditional investors
Guarantees	Cover part of the risk for investors	Mitigate risks for companies along the value chain	Partial risk mitigation in private equity impact funds investing in landscape interventions	Traditional investors DFIs

6.10 Overview of several (portal) websites or catalogues regarding NbS

Initiative	Description	Portal link
World Bank	Nature-based Solutions: a Cost-effective Approach for Disaster Risk and Water Resource Management	https://www.worldbank.org/en/topic/disasterriskmanagement/brief/nature-based-solutions-cost-effective-approach-for-disaster-risk-and-water-resource-management
Asian Development Bank: Protecting and Investing in Natural Capital in Asia and the Pacific	ADB guidelines for investment in river management	https://www.adb.org/projects/50159-001/main#project-documents
Building with Nature Expert Workshop and Writing Session	Reported findings from the session conducted on 10-11 July 2019 in The Netherlands	https://www.deltares.nl/app/uploads/2019/08/Folder-Accelerating-adaptation-through-Building-with-nature-in-Asia-V2.pdf
NbS at Deltares	Brief overview of NbS and BWN projects and examples	https://www.deltares.nl/en/issues/building-with-nature-is-possible-everywhere/
The Water as Leverage programme	Leveraging the necessary investment for the implementation of catalytic projects	https://waterasleverage.org/
H2020 EU Project Nature insurance value: Assessment and Demonstration (NAIAD),	Operationalizing the resilience dividends of ecosystems with the insurance sector	http://naiad2020.eu/
EcoShape	Building with Nature Consortium and Network	https://www.ecoshape.org/en
European Commission	NbS implementation within the EU: Funding, Projects, Results, Publications	https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en
EC-EU policy for CCA and DRR	Initiatives and actions to support NbS for DRR and CCA	https://en.unesco.org/sites/default/files/drr_climate_adaptation_info_meeting_european-commission_nicolas-faivre_eu-policy-initiatives_nature-based-solutions.pdf
NbS Bangladesh Portal	Developed by International Centre for Climate Change and Development (ICCCAD) and Nature-based Solutions Initiative (Oxford University)	http://www.nbsbangladesh.info/
IUCN	IUCN and Nature-based Solutions Publication on "Core Principles for Successfully Implementing and Upscaling Nature-based Solutions"	https://www.iucn.org/commissions/commission-ecosystem-management/our-work/nature-based-solutions https://www.sciencedirect.com/science/article/pii/S1462901118306671
IWA - TNC	International Water Association and The Nature Conservancy: Building nature-based, resilient water systems	https://iwa-network.org/learn/NbS-the-role-of-water-regulators-wod/
UN Environment Programme (UNEP)	NbS Contributions platform NbS Compendium NbS Example Initiatives	https://www.unenvironment.org/NbS-contributions-platform NbS Contributions Compendium NbS Example Initiatives

UNESCO	Digital Library: UN Water Report on NbS	https://unesdoc.unesco.org/search/7b4cf926-8c81-4480-8263-9f7b5419ca39
Wetlands International	Systems approaches are key to scaling up nature-based solutions	https://www.wetlands.org/publications/the-nature-based-solutions-for-climate-manifesto-developed-for-the-un-climate-action-summit-2019/
World Bank - Deltares	Implementing nature-based flood protection: Principles and implementation guidance	https://openknowledge.worldbank.org/bitstream/handle/10986/28837/120735-REVISED-PUBLIC-Implementing-nature-based-flood-protection-web.pdf?sequence=5&isAllowed=y
WUR (Wageningen University Research)	NbS Water Management and NbS activities	https://www.wur.nl/en/show-longread/Nature-based-solutions-for-water-management.htm https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Programmes/Biodiverse-Environment/Nature-based-solutions.htm
WWF	Working with Nature to Reduce Climate Risk in Europe	https://wwf.panda.org/wwf_news/?359040/World-Wetlands-Day-NbS http://www.landscapefinancelab.org/

6.11 Participants of experts workshops / expert consultations

Mekong delta (online workshop dd 13 November 2020)

1 Trang Vu (UU);
2 Hans Middelkoop (UU) (chair);
3 Annisa Triyanti (UU);
4 Haomiao Du (UU);
5 Dries Hegger (UU);
6 Carel Dieperink (UU);
7 Mandy Paauw (UU);
8 Vincent Schippers (UU);
9 Frances Dunn (UU);
10 Sitar Karabil (UU);
11 Murray Scown (UU);
12 Monica Lanz (UU);
13 Mark Drew (WWF);
14 Marc Goichot (WWF);
15 Tom Bucx (Deltares);;
16 Marcel Marchand (Deltares)
17 Sepehr Eslami Arab (Deltares).

GBM delta (online workshop dd 13 November 2020)

1 Marjolein Sterk (WUR);
2 Reinier Schrijvershof (WUR);
3 Tom Bucx (Deltares);
4 Hans Middelkoop (UU);
5 Mark Drew (WWF);
6 Marc Goichot (WWF);
7 Suresh (WWF India);
8 Haseeb Md. Irfanullah (private consultant Bangladesh);
9 Ratul Saha (WWF India);
10 Jasper Griffioen (TNO);
11 Jantsje van Loon (WUR);
12 Bertram de Rooij (WUR).

Ayeyarwady (expert consultation, December 2020)

1 Frank van der Valk (WWF);
2 Salai Thura Zaw (WWF);
3 Charles Selestine (WWF);
4 Jeremy Stone (Mercycorps);
5 Jonthan Bartolozzi (Mercycorps);
6 Tjitte Nauta (Deltares);
7 Tomek de Ponti (WUR);
8 Judit Snethlage (WUR);
9 Tanya Huizer (Arcadis);
10 Wim van Driel (ex WUR, ex Delta Alliance).

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