TECHNICAL
GUIDELINES #1

BUILDING WITH NATURE APPROACH

Building with Nature to restore eroding tropical muddy coasts


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TECHNICAL GUIDELINES SERIES

This guideline on the Building with Nature approach is part 1 of a series of Technical Guidelines on technical and socio-economic Building with Nature measures that, in combination, help to restore eroding tropical muddy coasts. They bring together experiences and lessons learnt from the Building with Nature Indonesia programme which restores eroding tropical muddy coasts. These guidelines are based on insights and lessons learnt during the implementation of a district scale pilot in Central Java as part of the Building with Nature Indonesia programme. By sharing our lessons learnt in these practical guidelines, we aim to enable replication by government agencies, the water and aquaculture sector and NGOs. Building with Nature measures need to be part of integrated coastal zone management and require a thorough problem understanding and system analysis.

AVAILABLE GUIDELINES

#1 Building With Nature Approach
#2 Systems Understanding
#3 Permeable Structures
#4 Associated Mangrove Aquaculture Farms
#5 Sustainable Aquaculture Through Coastal Field Schools

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Demak, Indonesia ©Cynthia Boll

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EXECUTIVE SUMMARY

Building with Nature integrates Nature-based Solutions into water and marine engineering practice. The essence of Building with Nature is to work with nature rather than against it by considering both engineering and ecological principles in the design process. To make nature the fundament of the solution, a paradigm shift is needed in in all aspects of project development.

Dozens of pilots and full scale projects in different parts of the world have demonstrated that Building with Nature offers opportunities for inclusive, environmentally sound, sustainable and climate resilient development, whether this is in coastal areas, cities or rivers. The Ecoshape consortium has contributed to this through its knowledge and innovation programme "Building with Nature". The approach is now being used in the Netherlands on a large scale for managing its extensive coast and rivers. Building with Nature has also been successfully applied in Demak, Central Java, Indonesia as the first large-scale international pilot of the EcoShape consortium. The methodology was subsequently replicated elsewhere in Indonesia by the government and its potential in other settings is being explored.

One of the main barriers to mainstream adoption is unfamiliarity with the approach. This guideline aims to help users to understand how to apply the Building with Nature approach and to choose and implement the best Building with Nature solution for their challenge.

The Building with Nature approach differs from conventional, single-purpose infrastructure because it demands detailed site-specific understanding of the natural, socioeconomic and institutional systems, as well as business cases and capacity building. It also includes adaptive management and maintenance based on monitoring.

Implementation of Building with Nature projects is not possible without transdisciplinary cooperation and active involvement of stakeholders. Together, the stakeholders follow a range of iterative steps and phases to develop a Building with Nature project. During each phase of project development, there are opportunities for integration of Building with Nature solutions, with maximum potential and flexibility in the initial stages of development. The earlier the approach is embraced in the project development process, the larger the potential impact.

In this guideline, the Building with Nature design and implementation process is illustrated with insights from our successful coastal protection and aquaculture practices in an Indonesian coastal district. Work alongside a multi-disciplinary consortium enhanced the resilience of both the mangrove greenbelt and the local economy. This multi-faceted approach brought together local expertise, employed some traditional skills and materials alongside advanced engineering solutions to restore coastal integrity, and has been described as innovative. We learnt that Building with Nature principles produced a solution tailor-made for the situation, and added considerable value throughout all stages of the project: from design through to implementation and maintenance. We argue that the methodology is very suitable across Indonesia and Asia.

1 INTRODUCTION

Studies have shown that economic development, poverty reduction, climate change adaptation and mitigation require a rapid increase in investments, particularly in water infrastructure in Asia (ADB, 2017). These challenges demand an innovative approach that aligns the interests of economic development with care for the environment (de Vriend, 2012). Observers increasingly argue that conventional built infrastructure, such as large scale dams and seawalls, cannot adequately protect populations from multiple threats, and may even aggravate environmental pressures. Hence, a new generation of infrastructure projects is necessary. Harnessing the power of nature, also known as green infrastructure, can sustain and enrich both humans and nature, if planned in harmony with conventional, grey infrastructure (Browder, 2019; GCA, 2019).

To address this challenge, several methodologies have emerged globally, for example Building with Nature (BwN, EcoShape), Engineering with Nature (EwN, USACE) and Working with Nature (WwN, PIANC), all geared to deliver 'Nature-based Solutions' (NbS) in the context of water-related infrastructure.

In this document we use the term Building with Nature. The essence of the Building with Nature approach is that infrastructure is developed to work in synergy with nature rather than in conflict with it, which requires a transformation in all aspects of project development. Building with Nature is a design philosophy rather than a specific solution, and represents a paradigm shift from minimising negative impacts to maximising positive impacts for society and environment. By including natural features in infrastructure design, practitioners can create multiple benefits for people and nature, while allowing flexibility and adaptability to changing conditions. Frequently, the lifecycle costs are lower than those of conventional engineering solutions (www.ecoshape.org).

Nature-based Solutions may involve different degrees of intervention (Figure 1), but the best results are achieved when existing ecosystem functions are preserved and conditions are created for them to support the objectives of the project. Restored or newly created ecosystems take time to mature and deliver ecosystem benefits.

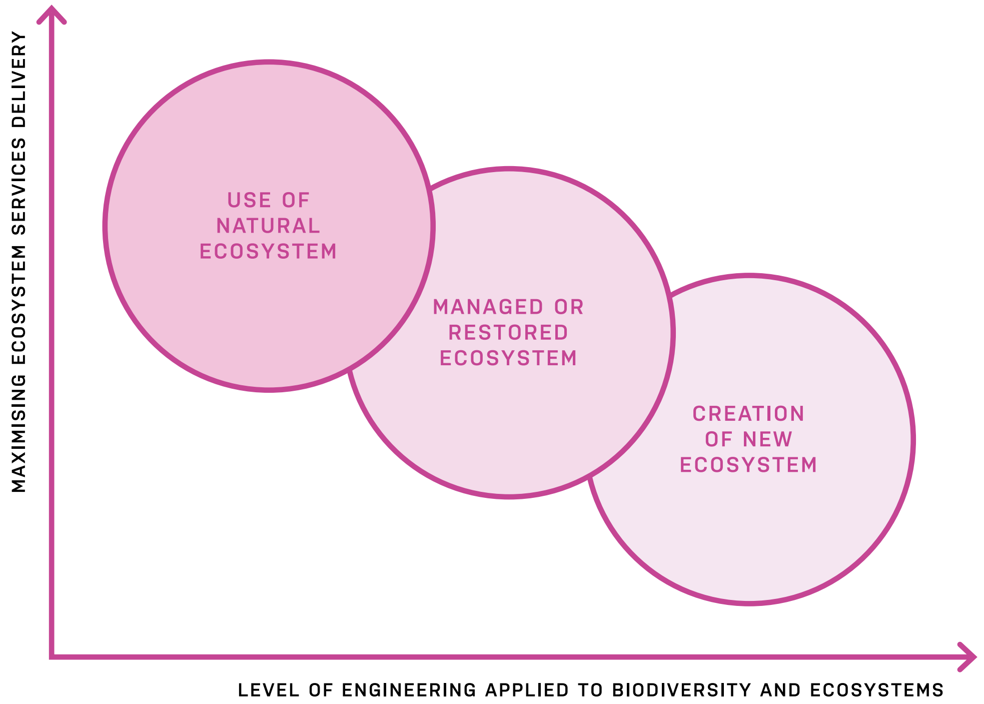

Figure 1: Level of engineering applied reduces ecosystem service delivery for Nature-based Solutions (adapted from Eggemont et al., 2015)

INITIATIVE	NETWORK	DESCRIPTION
Building with Nature (BwN)	EcoShape	A design approach that harnesses the forces of nature to benefit environment, economy and society, while developing water-related infrastructure.
Green Infrastructure (GI)	European Commission	A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services.
Nature-based Solutions (NBS)	World Bank	An approach that uses natural systems to provide critical services, such as wetlands for flood mitigation or mangroves to reduce the impact of waves, storm surge, and coastal erosion.
	IUCN	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.
Engineering with Nature (EWN)	US Army Corps of Engineers	Intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative processes.
Working with Nature (WWN)	PIANC	Promotes a proactive, integrated philosophy which focuses on achieving the project objectives in an ecosystem context rather than assessing the consequences of a predefined project design and focuses on identifying win-win solutions rather than simply minimising ecological harm.
ECO-DRR	PEDRR	The sustainable management, conservation and restoration of ecosystems to reduce disaster risk, with the aim to achieve sustainable and resilient development.
Working with Natural processes (WWNP)	Environment Agency (England)	Implementing measures that protect, restore and emulate the natural functions of catchments, floodplains, rivers and the coast.

Table 1: Similar concepts and initiatives

The Building with Nature approach can be applied to any water-related infrastructure challenge, whether in rural, urban or port areas; sandy or muddy coasts; lakes, estuaries or rivers. The specific design is, however, adapted to the local requirements and space available. Building with Nature solutions develop from transdisciplinary cooperation and active involvement of stakeholders such as government, local communities, experts, engineers and NGOs, preferably from the early initiation and design phases through to the implementation, operation and maintenance phases. It can be applied to large projects, as well as small-scale projects. Building with Nature fits neatly within integrated coastal zone and water resource management methodologies. In a global context, it contributes directly to the Sustainable Development Goals (SDGs) and commitments on Disaster Risk Reduction (DDR) and Climate Change Adaptation and Mitigation (CCAM).

Building with Nature is a participative approach to water-related infrastructure that makes use of, and improves ecosystem functions to benefit society.

This guideline aims to help users apply the Building with Nature approach and to design and implement the best Building with Nature solution for their specific challenge. The intention is to inform the development of government guidelines, the organisation of tenders and the design and implementation of water infrastructure projects. It is dedicated to the wide range of professionals and stakeholders involved, including national and local government, port authorities, project developers, consultants, designers and contractors, scientists and educators, NGOs and civil society. In addition, the guideline can be used by the international community working on Nature-based Solutions for water infrastructure. This guideline is largely based on the Building with Nature guideline by EcoShape (www.ecoshape.org), which is itself the product of knowledge and experience gained in multiple Building with Nature projects implemented between 2008 and 2020. The novel element in this guideline is that we discuss how large scale implementation of the Building with Nature approach in Indonesia followed a generic approach, illustrating that the approach is also relevant in other Indonesian and Asian settings.

Chapter 2 explains the background and characteristics of the Building with Nature approach in general. Chapter 3 outlines the generic process and introduces five steps that can be followed throughout project implementation. Chapter 4 demonstrates how the approach has been applied to halt coastal erosion in a densely populated area in Central Java and assesses how this generic approach can be replicated in Indonesian and Asian settings. Chapter 5 discusses the potential for bringing the Building with Nature approach into the mainstream. Chapter 6 introduces other initiatives that promote similar nature-based approaches.

2 BACKGROUND AND CHARACTERISTICS

2.1. BACKGROUND: A PARADIGM SHIFT

The essence of the Building with Nature approach is to work with nature rather than against it. This requires a paradigm shift in all aspects of project development. The relationship between water-related infrastructure and the environment needs to move from minimising negative environmental impacts, via neutrality by compensation, to optimizing positive impacts. Thus emerges the strategic objective of Building with Nature:

"To deliver engineering services while delivering and/or utilising ecosystem services." (www.ecoshape.org).

A paradigm shift: from 'building in nature', via 'building of nature', to 'building with nature'.

This paradigm shift is illustrated by looking at the development of water-related engineering in the Netherlands, which is home to EcoShape, the foundation at the heart of the public-private Building with Nature innovation programme, and link this to the Asian context. See box 1.

BOX 1: FACILITATING TRANSDISCIPLINARY COLLABORATION

Transdisciplinary and cross-sectoral collaboration is essential for successful and sustainable implementation of water infrastructure. Facilitating such collaboration was the main driver for the initiation of EcoShape. EcoShape is a consortium of 20 organisations, including government agencies, dredging companies, engineering firms, research institutes, and NGOs, that jointly develops and shares Building with Nature knowledge and experience. Members share the vision that multisectoral and public-private collaboration is key to drive innovation. Since 2008, multiple large and successful pilots have been implemented, through a wide variety of partnerships between EcoShape members and local stakeholders. Building with Nature is now widely supported within the Dutch water sector and embraced by a growing number of government institutions responsible for infrastructure and ecosystems. Knowledge has been developed via pilot and full-scale projects, by testing theories in practice. The knowledge base is being expanded and shared with the consortium and with the world through guidelines such as the present one, and those published on our website (www.ecoshape.org). A large pilot project, implemented in Indonesia, led to the set-up of the Building with Nature Asia initiative, which aims to accelerate adaptation by integrating Nature-based Solutions into water-related infrastructure in Asia, and by facilitating transdisciplinary and cross-sectoral collaboration. The Building with Nature Asia Initiative initially focuses on Indonesia, the Philippines, India, Malaysia and China.

Early infrastructural works in the Netherlands were implemented without an assessment of the potential environmental impact. In the 1970s, public concern about the natural surroundings increased, and legislation was introduced to ensure that environmental impacts are taken into consideration. As a consequence, attention was focused on minimising environmental impacts caused by infrastructure works: **building in nature**. Early examples of such projects in the Netherlands are the Afsluitdijk (completed in 1932) and the construction of the Flevo polders (completed in 1968). The Delta works, with the construction of the Eastern Scheldt barrier (completed 1986) as the presumptive pinnacle of impact minimisation, mark the end of this period, at least in the Netherlands (Van Koningsveld et al., 2008).

There is significant interest from the Indonesian government and other countries in these examples of the Dutch expertise in water related-infrastructure. Several exchange visits have taken place over the years. Elsewhere in Asia, numerous large infrastructure works have been built in nature, for example the land reclamations in Hong Kong, Singapore and other metropolises.

Figure 2: Eastern Scheldt barrier ©https://beeldbank.rws.nl, Rijkswaterstaat

Since the 1990s, Dutch environmental legislation has adopted the principles of *prevention, mitigation and compensation of residual effects*, stipulating preservation of existing natural areas and emphasising the precautionary principle. Compensation for any loss of nature, or **building of nature**, yields a neutral net result. As a consequence, impact minimisation is still predominant, but mitigation and compensation measures are also frequently seen. The Maasvlakte 2 exemplifies this approach, as the project was designed for a minimum environmental impact, while compensating for residual effects with nature regeneration. Similar trends are observed in Asian metropolises. In Singapore, for example, Environmental Impact Assessments have been required for development projects in the coastal and marine areas since 2004. Projects that incur damage to the natural environment are required to include mitigation, repair and compensation for damages. Environmental Monitoring and Management Programmes have arisen to provide an overarching framework for managing multiple development activities and ensure that impacts do not exceed pre-determined threshold limits. Moreover, this has enabled management agencies to take immediate action when threshold limits are violated. An example of such mitigation work is The Semakau Landfill – mitigation measures employed during construction protected adjacent coral reefs, conserved part of the island's intertidal habitat, included mangrove restoration and created coral nurseries (EcoShape, 2010; Hamid et al., 2009).

The next step in the development of water-related infrastructure is creating opportunities for development of new natural areas or restoring previously destroyed habitats, above that required for mitigation or compensation: **building with nature**. The guiding principle no longer is doing less bad, it becomes doing good proactively. Early examples are the Grensmaas project (2010 ongoing), where flood protection and gravel mining are combined with river restoration and nature development, and the strengthening of the Delfland coast (completed 2009), where habitat creation was used as a starting point for sustainable coastal reinforcement. In the Mekong delta (Vietnam) and in the Gulf of Thailand, projects are being executed to protect the coast and restore the natural coastal ecosystem (Winterwerp et al., 2020).

We can even think one step further, how to create opportunities for nature development: **building for nature**. Examples of projects where this has been applied are the Eastern Scheldt revetment project and the 'Living engineering' case studies: Eco-concrete breakwater structures and Harbouring Opportunities. Where natural processes have been used to assist the creation of a structure, this would be called **building by nature**. Examples of projects in this category are the Sand Engine Delfland (started 2011), where natural processes distribute sand from a large man-made deposit over shore, beach and dunes. An Asian example of this approach is, the Gorai Re-excavation Project, where dredging triggered natural river deepening, thus providing the Sunderbans nature reserve with fresh water and creating conditions for new economic activity around the river. The Building with Nature approach has also been applied in Indonesia to restore a rapidly eroding coastline, together with government and local communities and explored the potential in other Indonesian and Asian settings. Building for Nature and Building by Nature are both considered to be specific forms of Building with Nature.

Figure 3: Construction of permeable structures ©Nanang Sujana

2.2 THINKING, ACTING AND INTERACTING DIFFERENTLY

What can turn a Building with Nature project into a true success story is working not only with the surrounding natural system, but also with the social system, by inviting stakeholder participation at an early stage. Building with Nature applications share four primary characteristics: they are inherently dynamic, multi-functional, context-specific and innovative. A project may be initiated with any of the following aims: improving resilience of flood defences to climate change, sustainable marine port development, increasing effectiveness of ecological restoration efforts, or increasing connectivity and resilience in (delta) cities. The Building with Nature approach is very flexible, allowing a diverse range of pathways to completion. There is a multitude of concepts that can be applied to Building with Nature, but the exact manifestation of these concepts will differ for each landscape, purpose and societal setting. Shifting the infrastructure development paradigm towards Building with Nature requires not only a redefinition of what to do and what to aim for, but also how to do it: a change in thinking, acting and interacting.

Think differently

In many disturbed environments, man-made projects are an inherent part of the environment, providing a unique opportunity to induce positive change.

The Building with Nature design approach invites all parties to think differently and view the project form a new perspective. Evaluation of a number of successful Building with Nature cases has revealed that this new perspective is characterised by extending the **problem solving** approach of conventional engineering with an ecology-inspired and governance-sensitive **opportunity-seizing** attitude. From a project development point of view, this means **starting with the system in mind, not with the intervention**. Understanding the system enhances the understanding of the problem(s) for which solutions are sought.

'The system' in this case includes the natural (biotic and abiotic), as well as the socio-economic and institutional sub-systems. Equipped with system knowledge, the Building with Nature project developer and stakeholders interact to explore opportunities for win-win solutions. This requires an open mind, venturing to make use of creativity and a transdisciplinary approach. Throughout the development process, the Building with Nature designer should continuously rephrase the most fundamental project objectives. For instance, the common design objective *"Design a safe and cost-effective hydraulic infrastructure with minimal impact on the environment"* can be rephrased to *"Design a safe and cost-effective hydraulic infrastructure and optimise the mutual benefits to and of the environment"*.

Practical implementation requires involvement of different stakeholders such as policy makers, biologists, ecologists, economists and engineers to jointly address the project development challenge, looking for win-win solutions. The best Building with Nature designs go beyond delivering the primary functions for which the project was intended, they also provide added ecological and economic value. It should be noted that opportunities to add such value are present at any stage of a project. Obviously, the potential impact of Building with Nature is greater when the methodology is embraced early in the process. Nonetheless, it is never too late to start. Experience has shown that it is possible to refine the ecological features during construction or even maintenance phases. The Creating rich revetments concept, which has been introduced during large scale dike maintenance works, serves as an example.

Act differently

Natural processes can be used and stimulated to achieve an optimal and sustainable fit of a man-made project in its environment.

Most hydraulic infrastructure is regarded as a static element with a predetermined lifespan, designed to withstand a set of forecasted environmental conditions. The design process aims at finding the most cost-effective solution that provides the required functionality. Solutions that work with the ecosystem require more than that: they commonly serve more than one function and extend conventional design approaches to account for dynamic environmental processes.

Building with Nature design embeds the planned intervention into a dynamic environment. This means that the natural processes at work and the associated timescales must become part of the ultimate design. Sand Engine Delfland is a practical example of a project that aims to use natural processes to achieve a predetermined management objective. Conventional sediment nourishment regularly places large amounts of sediment at various locations along the coast. The Sand Engine project aims to apply one very large nourishment and allowing natural processes to gradually distribute the sediment into the coastal system. This idea was developed by studying the local system in detail and making a confident prediction about the behaviour of waves and longshore currents over a reasonable timeframe. As a benefit over the conventional practice of sediment nourishment, this innovative approach produces a more natural coastal profile, lower disturbance of the coastal ecosystem, the development of valuable habitat, an increased freshwater reserve in the dunes and potential recreational value.

The inclusion of natural processes in water-related infrastructure involves the introduction of uncertainty and potentially even risk – besides the creation of opportunities – because this is a novel approach. Adequately dealing with this uncertainty, by generating more knowledge, by including proper contingency measures or by introducing flexibility and allowing for adaptive management, is crucial to the feasibility of a solution. Taking a life cycle approach may help to create more efficient solutions.

Lesson learnt from the Sand Engine Delfland: investment in close monitoring, adaptive management, scientific supervision and a well-defined communication strategy with the stakeholder community are essential for a successful and sustainable solution with returns higher than the costs.

Figure 4: Zandmotor ©Rijkswaterstaat

Interact differently

Completion of Building with Nature projects can only be achieved through transdisciplinary collaboration and early, active involvement of the stakeholders.

Early and active stakeholder involvement is essential in any infrastructure development, and the Building with Nature approach promotes it successfully because it aims to deliver multi-purpose solutions and a range of social and environmental benefits. For example, a standard dike offers flood protection (single purpose), while a dike where the foreshore is covered in vegetation also enhances local fisheries and biodiversity (multiple purpose). Understanding each other's view of the challenges at hand is encouraged by involving all stakeholders early in the design process. Besides, early involvement fosters shared ambitions and ownership. Local stakeholders have knowledge of and experience with their immediate natural, social and/or institutional environment. The process of developing Building with Nature solutions offers individuals the opportunity to integrate their knowledge and ideas into the programme, thus making them co-owners of the solution. Moreover, the same process can easily accommodate an economic valuation of ecological opportunities and societal needs. Given the right team, Building with Nature solutions facilitate a proactive collaboration between all parties and disciplines involved. Box 2 below presents recent examples.

BOX 2: MULTI-STAKEHOLDER APPROACH

The Building with Nature Indonesia programme was initiated to enhance protection of local communities from land loss and flooding and to steer their economies towards inclusive, sustainable use of the (restored) coastal mangrove system. The programme brought together an extensive network of professionals with diverse expertise and interests. The participation of local governments, universities, and citizens was at the core of planning, implementation, and maintenance of coastal adaptation measures. In Demak, Coastal Field Schools enhanced farmers' capacity to manage resources by advising on sustainable aquaculture practices. Subsequently, a financial incentive mechanism called Bio-rights was introduced, which reconciled economic productivity with environmental conservation and restoration measures. Training and awareness programmes partnered with government and universities in order to scale up Building with Nature approaches.

Current compartmentalised governance systems may be unsuitable for this approach, thus changes may be necessary, even if time-consuming. Changing our attitude brings about a new kind of governance that allows for flexibility and nurtures the project from the outset. For example, institutional embedding of coastal zone management needs to be arranged between institutions, ministries and departments that all have their mandate in different aspects of the coastal zone or water management. This requires facilitation of policy dialogues, capacity building and training, joint learning and knowledge development in pilots, in addition to raising awareness.

In Indonesia, the Building with Nature initiative facilitated collaboration between national, provincial and district departments of two Indonesian ministries responsible for management of coastal and marine resources and for technical and large infrastructure, including coastal and river flood defences. The initiative focused on planning, testing and implementation of measures in the project and on the creation of an enabling environment for implementation of Building with Nature nationwide.

Figure 5: Roundtable discussion on Integrated water management planning Coast-2-City, Semarang. ©Yus Rusila Noor, Wetlands International

The engagement process needs to take a dynamic, adaptive approach because conventional ways of contracting usually lack the flexibility, and are less suitable for complex circumstances. In recent years, contracting has changed to combine two or more of the following: Design, Build, Construct, Maintain and Finance. In addition, early contractor involvement and alliance contracts enable comprehensive and innovative solutions by linking planning, design, construction and maintenance phases. These new contracting forms require involvement in and understanding of more project phases and disciplines than in conventional contracts that typically have a phase-by-phase focus. As an example, the Building with Nature project Hondsbossche dunes spanned the design, construction and maintenance phases.

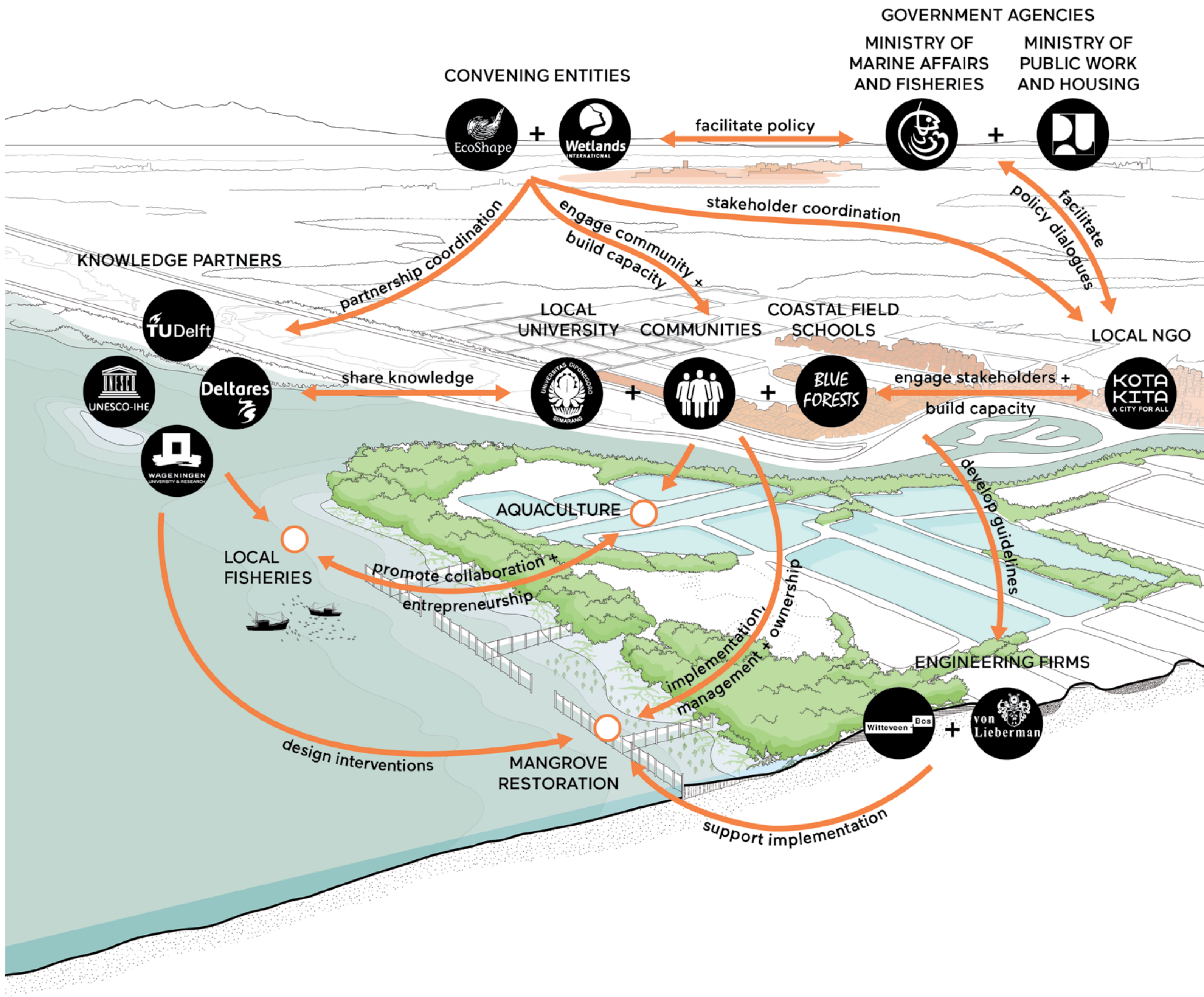

Figure 6: Organisation chart of the Building with Nature Indonesia project ©One Architecture & Urbanism

To ensure collaboration across sectors, public-private partnerships and multi-sectoral consortia or alliances are emerging as a result of tenders and funding programmes, such as the Dutch Sustainable Water Fund. Building with Nature Indonesia was implemented through a public-private partnership. The programme connected international expertise and experience with local and context-specific knowledge on engineering, aquaculture, ecosystems, capacity building and governance. Each partner brought specific knowledge, experience and skills and had a unique role within the project, as illustrated in figure 6 and the brochure 'meet the partners'.

2.3 CREATING AN ENABLING ENVIRONMENT FOR BUILDING WITH NATURE

The desire for and willingness to implement sustainable solutions is increasing, but all actors are still exploring ways to achieve this in practice. In the course of developing pilot projects across a broad range of landscapes and social settings, EcoShape has identified six overarching key elements, named 'enablers', essential for the implementation and popularisation of Building with Nature (Bouw et al., 2020). All enablers reflect the required changes in thinking, acting and interacting discussed above, and provide initial guidance for a range of practitioners. Additionally, they need to be considered when aiming to incorporate Nature-based Solutions on project, landscape or national levels. The six enablers are:

1. Technology and system knowledge
2. Multi-stakeholder approach
3. Adaptive management, maintenance and monitoring
4. Institutional embedding
5. Business case
6. Capacity building

Figure 7: Six enablers ©EcoShape

Building with Nature enablers help to frame key considerations at the start of any project and make the development process achievable. The context will determine the particular importance of each enabler in a project or initiative, even though all projects benefit from the consideration of all enablers. More detailed information on the enablers and other tools is available on EcoShape's online platform.

Technology and system knowledge

Building with Nature requires knowledge of specific solutions integrating water infrastructure technology and natural processes. In addition, knowledge of the local natural, socio-economic and institutional system is essential to design such a solution. Key aspects to consider:

- Large-scale system analysis, comprehension of driving natural processes and natural dynamics.
- Various Building with Nature instruments that suit different landscapes.
- Building with Nature design approaches and assessment tools.

Multi-stakeholder approach

Building with Nature can rarely be implemented by a single party. Building with Nature projects require stakeholder engagement from the start, throughout the design, implementation, operation and maintenance phases. Key aspects to consider:

- Cooperation between stakeholders and comprehensive, multifunctional approaches.
- Coalition building, co-creation and public participatory approaches to create shared ambitions.
- Stakeholder assessment and engagement.

Adaptive management, maintenance and monitoring

Building with Nature solutions are dynamic: they develop under changing climatic conditions. This requires an adaptive approach for management, maintenance and monitoring their performance. Key aspects to consider:

- Balancing initial efforts/investments (over-dimensioning) against adaptivity and resilience.
- Making maintenance strategies an integral part of the development process.
- Organisation and techniques for adaptive management and monitoring to deal with natural dynamics at various temporal and spatial scales.

Institutional embedding

Building with Nature should fit into the local institutional context, norms, and regulations. Additionally, policies and processes can be developed to support co-creation, partnerships, and funding schemes that support Building with Nature implementation. Key aspects to consider:

- Fitting Building with Nature in the existing context, norms, and regulations.
- Creating a policy environment that enables conservations laws and formal instruments to be addressed.
- Connecting with international enabling policies, including the Paris Agreement, Sendai Framework, AICHI targets, CBD, Ramsar and UNCCD resolutions and SDGs.

Business case

A sound and convincing business case is necessary to generate support and financing for the particular Building with Nature application. Key challenges are the wide range of avoided costs and co-benefits of Building with Nature solutions and the difficulties in quantifying those, due to the 'soft' benefits and the performance uncertainties associated with (natural) dynamics. Key aspects to consider:

- Defining an optimum business model by integrating conventional engineering and nature conservation expertise with financial knowledge.
- Improving estimates of maintenance costs and the additional services and benefits (including coastal access, fish production, carbon sequestration).
- Financing arrangement and pre-requisites (bankable value creation streams).

Capacity building

Capacity building among policy makers, industry managers and the local community is key, and takes place through education, training, and knowledge sharing. People who are familiar with the Building with Nature philosophy are more likely to support it and take part. This will help scaling-up and is critical for proper maintenance of Nature-based Solutions. Key aspects to consider:

- Increasing awareness of the philosophy and possibilities of Building with Nature.
- Involving the upcoming generation in Building with Nature through training and educational programmes.
- Creating Building with Nature communities around your project.

Figure 8: Strengthening Houtribdijk connection across Markermeer and IJsselmeer (lakes), the Netherlands © aannemerscombinatie Versterking Houtribdijk

3 STEPWISE APPROACH TO DEVELOP BUILDING WITH NATURE PROJECTS

3.1 EMBRACING BUILDING WITH NATURE IN THE PROJECT DEVELOPMENT CYCLE

Project development, although an iterative process, goes through a number of consecutive phases and can benefit from structured step-by-step guidance. The Building with Nature approach may be introduced in any project phase, but the earlier the approach is embraced, the greater the potential impact. Opportunities for integration of Building with Nature solutions exist during each phase, with maximum potential and flexibility in the earliest stages of development.

Numerous guidelines, standards and frameworks exist to facilitate project planning and development (Table 2). All these frameworks aim to consider the full range of possible interventions and select the optimal solution for the specific combination of problems and systems. Possible interventions include not only conventional engineering solutions and Nature-based Solutions, but also non-structural measures, such as zoning and early warning systems, to enable resilience in multiple scenarios. The Building with Nature approach focuses on project development and outlines five steps to be taken at every project phase (Section 3.2). Other guidelines and frameworks may integrate all phases in one framework, some start more broadly, or explicitly require a risk analysis or (social) cost-benefit analysis.

In this guideline, we distinguish the following consecutive phases of the project life cycle: 1) initiation phase, 2) planning and design phase, 3) construction phase and 4) post construction or Operations and Maintenance phase (Figure 9). Table 3 outlines how each phase of the Building with Nature approach differs from a conventional engineering approach.

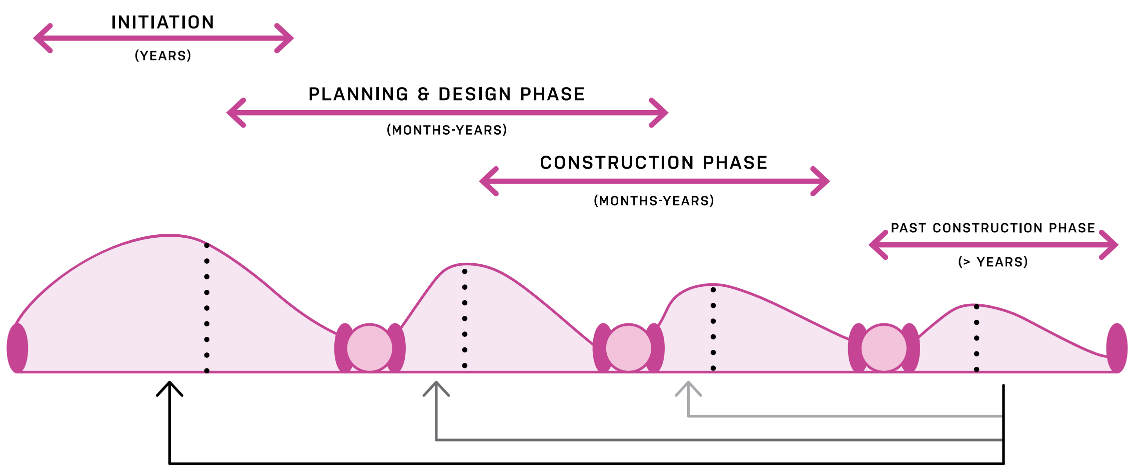

Figure 9: Overview of the project cycle and its phases. Possible overlap of the four project phases is indicated at the top. The iterative process of this approach appears as dashed lines at the bottom. Results within each process or subsequent processes can be input for later iterations. ©EcoShape

NAME	FIELD OF USE	AUTHOR	REFERENCE
Building with Nature	Building with Nature for water-related infrastructure	EcoShape	https://www.ecoshape.org/en/the-building-with-nature-philosophy/five-basic-steps-for-generating-building-with-nature-designs/
Implementing Nature Based Flood Protection	Planning of Nature-based Solutions	World Bank	https://openknowledge.worldbank.org/handle/10986/28837
Coastal engineering manual	Coastal engineering	USACE	Coastal engineering manual 2002 (EM 1110-2-1100, part V)
Global Standard for Nature-based Solutions	A user-friendly framework for the verification, design and scaling up of Nature-based Solutions	IUCN	https://portals.iucn.org/library/sites/library/files/documents/2020-020-En.pdf
Nature-based Solutions Handbook	A comprehensive guide to all relevant actors	Think Nature	https://platform.think-nature.eu/content/thinknature-handbook
Voluntary guidelines for the design and effective implementation of EBA approaches to CCA and DRR	CCA and DRR	CBD	https://www.cbd.int/doc/publications/cbd-ts-93-en.pdf
Making Ecosystem-based Adaptation Effective	Defining Qualification Criteria and Quality Standards	FEBA	https://pubs.iied.org/pdfs/G04167.pdf
Integrating Green and Grey - Creating Next Generation Infrastructure	Infrastructure	World Bank and WRI	https://openknowledge.worldbank.org/handle/10986/31430
CRIDA	Climate change adaptation	AGWA and others	https://agwaguide.org/about/CRIDA/
Framework of analysis	Integrated water resource management	World Bank	https://link.springer.com/content/pdf/10.1007%2F978-3-319-44234-1.pdf

Table 2: Overview of guidelines, standards and frameworks of project planning and development

PHASE	CONVENTIONAL APPROACH: SECTORAL, NARROW SCOPE	BUILDING WITH NATURE APPROACH: WIDER AND GREENER SCOPE
INITIATION PHASE: **Preliminary definition of the problem or opportunity and scoping of potential solutions.**	Project approach: characterised by a sectoral focus, limited and mono-functional problem perception and a tendency to jump to solutions. A narrow project framework is defined, according to the problem-owner's/ project-initiator's objectives or limitations, or authorities biased towards certain classes of problems and solutions.	System approach: the Building with Nature method takes a wider perspective, looks at large-scale temporal and spatial effects and defines multiple objectives. This approach strives for multi-functionality, such as nature, recreation and other ecosystem-dependent functions. Applying Building with Nature-principles as early as the initiation phase will have the largest influence on the outcome.
PLANNING AND DESIGN PHASE: **Development of strategies to achieve the objectives set out in the Initiation phase.**	Strategies focus on solving a narrowly defined problem within a given timeframe. Opportunities for adaptive management, incremental development and nature-inclusive designs are seldom considered.	Strives to utilise natural processes and stimulate nature development as an integral part of the strategy. Key questions are not only what the project can do for nature, but also what nature can do for the project. Special attention is given to longer term and incremental development, as well as to adaptive management. Ecosystem service provision may open doors to alternative funding sources.
CONSTRUCTION PHASE: **Elaboration of design and completion of construction work.**	Projects are optimised in this phase by minimising construction time, costs and risks. Delivering the required functionality within these constraints is preferred . Aspects considered are reuse of materials to reduce cost, cost-effective timing of construction activities, functional combinations with other projects, financial models, optimisation of operation and maintenance with design aspects. There is a tendency to use proven technologies in order to reduce risks.	Improves the cost-effectiveness of a project by ensuring embeddedness in the natural environment, taking advantage of natural processes and the creation of new opportunities for nature. Careful selection of materials and optimisation of the layout can yield significant advantages. This includes circularity and targeted use of sediments. Involvement of stakeholders in this refinement process may help to turn hesitation and opposition into enthusiasm and cooperation. Room for experiments and adaptive project development and management are vital elements. EcoDynamic Development and Design (EDD) can be used to optimise the work method and the selection of materials.
OPERATIONS AND MAINTENANCE PHASE: **Completed project in use, with maintenance performed as appropriate.**	Operations and maintenance are about keeping the structure performing as intended. Conventional approaches lead to similar interventions with little opportunity for adaptive management or incremental development. Such interventions are often more expensive than an incremental approach, and tend to have greater environmental impact.	Considers maintenance aspects early in the planning process, as this informs the design and can significantly reduce life cycle cost. It anticipates the possible need for adaptation to changes in system dynamics, environmental conditions or operation practices. Objectives and functioning are not fixed indefinitely, but leave room to seize new opportunities. Building with Nature does not focus on individual species, but rather respects natural system dynamics.

Table 3: Comparing the project phases of the conventional and Building with Nature approaches

3.2 FIVE BASIC STEPS FOR GENERATING BUILDING WITH NATURE SOLUTIONS

Analysis reveals that five steps are typically taken when developing Building with Nature projects (Figure 10). These steps represent a basic creative process that can be followed during any phase of the project (Figure 9). At the start of each iteration, the breadth of ideas and scope are wide, inviting outside-the-box thinking. In subsequent cycles, stakeholders agree to focus on what is likely to work in the specific setting. In steps 1 and 2, knowledge gleaned from monitoring and evaluation is acted upon, while steps 4 and 5 make use of adaptive management and maintenance. The five-step model is intended as a guide only – some Building with Nature projects may occasionally omit steps during some phases of the project process.

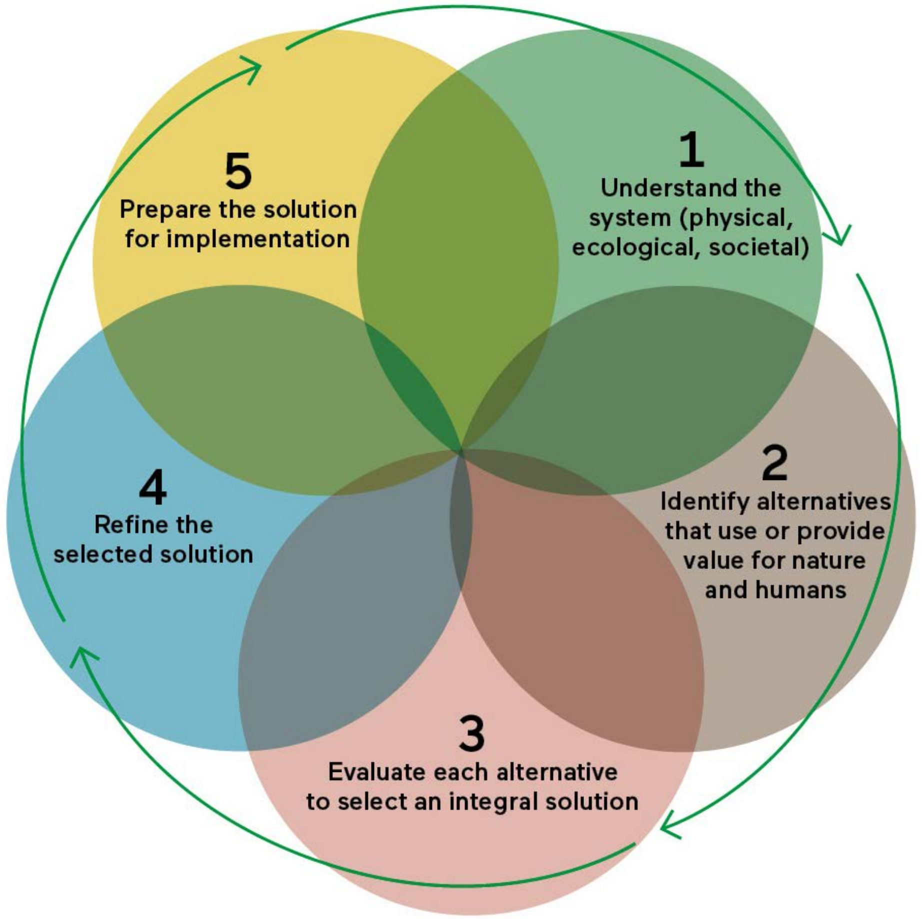

Figure 10: Five basic steps for generating Building with Nature solutions. ©Ecoshape

Step 1. Understand the system: natural, socio-economic and institutional

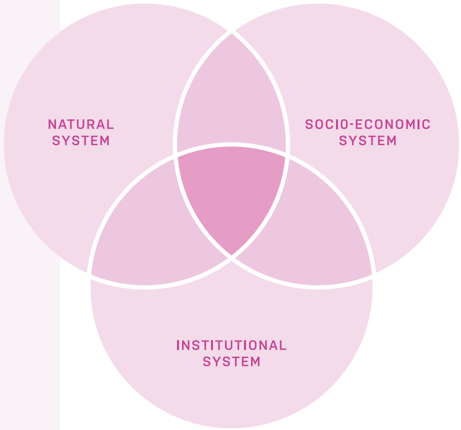

Figure 11: Three interdependent subsystems of sustainable development.

The process is initiated by examining the broader system in which our project is embedded – this is useful regardless of the type of infrastructure. In-depth knowledge of the natural ecosystem, the socio-economic system and the institutional context are crucial to help identify potential win-win solutions. Since natural systems operate at larger spatial and temporal scales than infrastructure projects, we need to consider the surrounding landscape, as well as any long-term processes in order to be able to address the root causes of problems and make use of ecosystem-wide opportunities. This implies that stakeholders from a wider area need to be involved. Additional information is available in the Technical Guideline '#2 System Understanding' as part of this series.

Consider the natural, socio-economic and institutional systems: Be clear about the primary objectives and recognise that finding win-win solutions allows flexibility in meeting secondary objectives. Note that a limited focus on your primary objective may restrict what you are able to consider. Adding secondary objectives will encourage thinking about other system characteristics, such as driving processes, other temporal and spatial scales, etc.

Information about the system can be derived from various sources: Building with Nature often involves low-tech designs that make use of high-tech system understanding. Therefore, it is important to consult experts and scientists. However, system knowledge is not the sole prerogative of scientists. Valuable site-specific information can also be found by:

- Talking to people with local knowledge (fishermen, harbourmasters, community elders, etc.)
- Delving into historical records to understand the evolution of the system, and building on historical expertise.

Think multifunctional: Remember to look for user behaviours and system functions beyond those covered by the primary objective.

Step 2. Identify realistic alternatives

The second step in the Building with Nature design process is to identify realistic alternatives that provide true win-win solutions, beyond mitigation and compensation. These alternatives should make maximum use of the system's potential (natural, socio-economic and institutional) while safeguarding or even enhancing sustainability.

Change your perspective: Building with Nature solutions turn a reactive perspective into a proactive one – problems are seen as opportunities to begin positive change. This may genuinely become an eye-opening experience. Such 'inverse' ideas commonly arise while answering the following questions:

- **Supporting the ecosystem:**
  - How can we support the functioning of the existing system (ecology, recreation, landscape)?
  - Larger scale: how can a project deliver benefits to the surrounding ecosystem?
  - Small scale: how can the project (with small adaptations) be more eco-friendly?
- **Utilising functions of the ecosystem:**
  - How can we better use local assets: tide, waves, currents, sediments, flora, fauna, economy, cultural values, traditional skills, etc?
  - Can local assets be utilised to lower construction and maintenance costs and simultaneously achieve greener solutions? Think how to reduce energy use, material required, or design multi-functionality, public-private partnership (PPP) solutions.
  - Can the system's dynamics be used as a positive rather than a negative factor? Can we find a way of harnessing natural forces and expected changes as a means to achieve our goals? A natural process may produce the desired change gradually, avoiding expensive engineering all-at-once.

Think about transdisciplinary solutions from the start: Involve academic experts, field practitioners, community members, business owners, potential donors and investors, decision makers and other stakeholders in the formulation of alternatives.

- Seek diverse contributions early in the design process and encourage collaboration. The most innovative and effective solutions emerge when heterogeneous knowledge is brought together.
- Encourage open-minded rationality, open to the unknown, the unexpected and the unforeseeable. Reject dogmatism, ideology and intolerance (see also Wikipedia: Transdisciplinary studies).

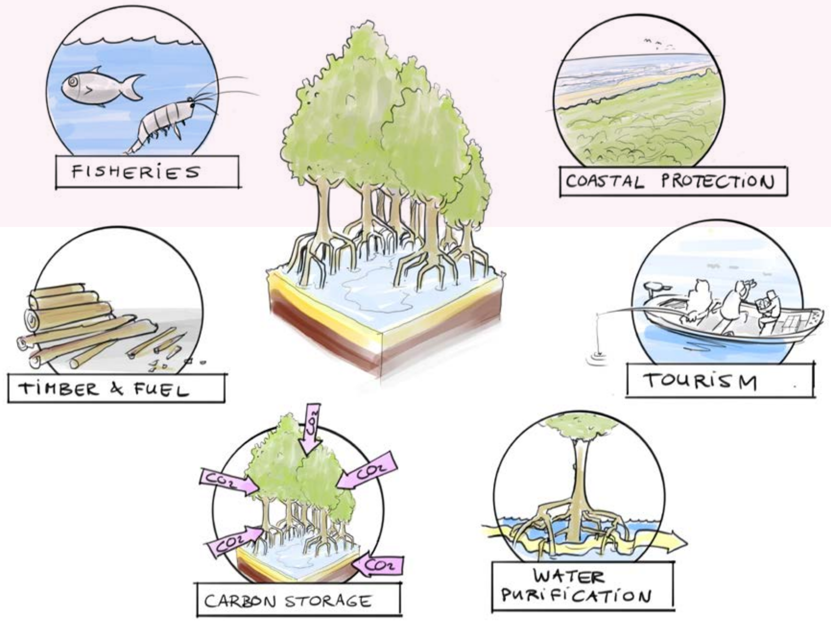

Figure 12: Mangroves perform a number of ecosystem functions, such as coastal protection, carbon storage, wildlife habitat, water purification and eco-tourism. ©Joost Fluitsma, Visual Thinking

Step 3. Evaluate alternatives and select a comprehensive solution

After identifying possible solutions, they are assessed and combined into complete alternatives. The merits of the Building with Nature alternatives are then compared to the conventional ones.

Improve value without increasing construction cost: When looking for win-win solutions, small adjustments to an existing design may produce better value at lower or equal cost.
- More for less is possible!

Embrace creativity: Innovative ideas can bring high returns. Test how they work in practice.
- Remember that, even though a solution may be innovative, its components may be based on conventional know-how. Again, think about transdisciplinarity!
- Tell the story of successful implementation.

Identify and manage uncertainties: Building with Nature solutions, by definition, work with natural dynamics and inherent uncertainties. Managing these is a normal part of the Building with Nature design process.
- Assess the risks related to climatic, socio-economic, and institutional factors and choose measures that effectively reduce risk.

Involve stakeholders in the evaluation and selection process: From Negative to Positive, from NIMBY (Not In My Back Yard) to PIMBY (Please In My Back Yard)!

Perform a (social) cost-benefit analysis: Take into consideration construction and maintenance costs alongside expected benefits. Compare the Building with Nature-solution with a conventional (usually mono-functional) one.
- Also look at social costs and benefits and ecosystem value (see figure 12). Nature valuation tools based on the concept of ecosystem services are included in the Building with Nature toolbox.
- Use life cycle analysis to seize opportunities

Step 4. Elaborate selected alternatives

The alternatives are developed further by adding detail. This includes any practical restrictions and institutional context.

Consider the conditions/restrictions of the project: Make sure that an innovative idea has enough practical detail, so that it could realistically be executed.
- Take construction into account (work methods, availability of equipment, etc).
- Identify important timing aspects (growing seasons, closure seasons, time for ecological components to evolve to desired state, etc.).

Improve your stakeholder network: Implementation always requires a range of actors and stakeholders.
- Effectively involve stakeholders across the planning, design and construction phases.
- Use existing examples as a source of inspiration. Share costs, expertise and ideas. Solutions should be of an 'open source' nature, they cannot and should not be protected.
- Tell your story to get support. If you have pursued an innovative idea, make sure you tell your story to the project team, stakeholders and the public. Think of access routes to a project, guided excursions, visualisations, information panels, press releases, media coverage, etc.

Step 5. Prepare the solution for implementation in the next project phase

Anticipate administrative bottlenecks and actively pursue inclusion in: requests for proposals, detailed design, project delivery plan, maintenance and monitoring schemes.
- **Translate solution to a technical design:** What is needed to implement the proposed solution (additional knowledge, available materials, sustainability criteria etc.)?
- **Translate solution to 'request for proposals' or contract:** How to reformulate the request for proposals (RfP) so that an innovative solution is generated?
- **Organise required funding:** Try to involve stakeholders in the search for funding.
- **Identify permit requirements:** As early as possible, seek the necessary permits and organise required input (expert knowledge, support by stakeholders).
- **Prepare risk analysis and contingency plans:** Building with Nature is inherently dynamic. Make sure the project takes this into consideration (adaptive execution, adaptive management).

More information about the steps in each phase can be found on the EcoShape platform.

Your understanding of the system will evolve during implementation; continuous monitoring and evaluation are needed to inform adaptive management and maintenance.

Permeable structures in front of Demak coast ©Witteveen+Bos

4 BUILDING WITH NATURE INDONESIA

In this chapter we demonstrate how this generic step-wise approach has been applied in Indonesia. Box 3 introduces the implementation project, and a detailed account has been published elsewhere. Sections 4.1 to 4.5 discuss how a large scale implementation of Building with Nature followed the five-step process. Section 4.6 summarises the five steps.

BOX 3: BUILDING WITH NATURE IN INDONESIA

Northern Java's deltaic shorelines suffer from severe erosion and related flooding hazards. Establishment of aquaculture ponds close to the coastline, accompanied by the removal of mangroves, has initiated a self-accelerating coastal erosion process. Land subsidence resulting from unsustainable groundwater extraction aggravates the erosion, which is further exacerbated by improper surface water management. At some places, the coast has retreated by hundreds of metres, even up to a few kilometres. As a result, over 30 million people in Java are at risk.

The Indonesian government has tried to rectify the situation by constructing breakwaters and seawalls (building in nature). These, however, have made the situation worse, because they have blocked landward sediment transport and prevented sediment deposition, a process that would have occurred among mangrove roots. These conventional solutions have been expensive to construct and maintain, but their biggest drawback has been that they cannot be upgraded to cope with rising sea levels caused by climate change. Furthermore, those conventional 'hard' structures never had the potential to bring the economic, environmental and social benefits of a thriving mangrove coastline. Restoring the mangrove belt by planting mangroves also failed, since the trees could no longer develop in the deeper waters.

A new, sustainable, inclusive and climate-resilient approach was needed to integrate natural ecosystem processes into engineering practice. Building with Nature was embraced after the initial successful experiment in 2012. The approach has now been applied to the restoration of a 20 kilometres long eroding coastal stretch in Demak district in Central Java, and has since then been replicated in multiple other districts by the government. The potential for Building with Nature in other settings in Indonesia and Asia is now being explored through the Building with Nature Asia initiative.

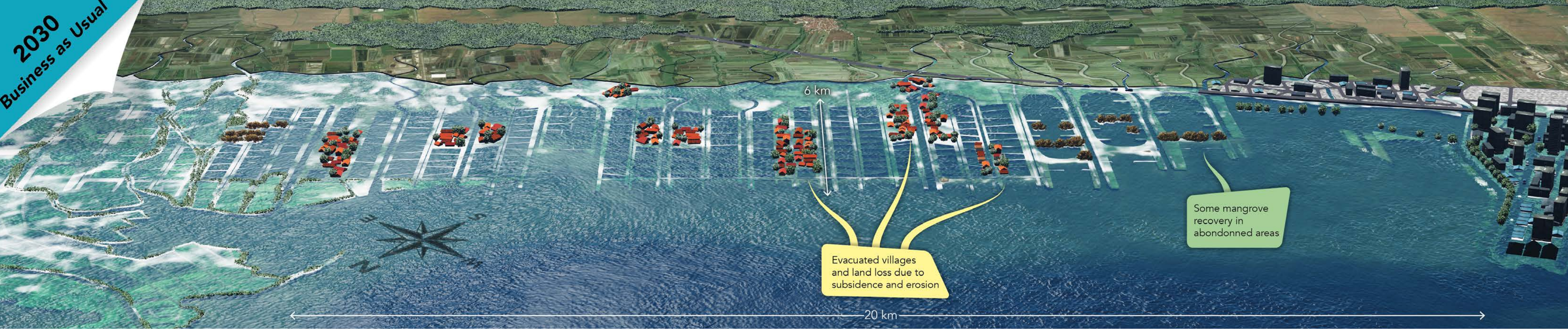

Figure 13: Visualisation of the Demak coastline in 2030, from Wulan Delta (left) to Semarang (right), under the business-as-usual scenario. ©Frederik Ruys

4.1 STEP 1. UNDERSTAND THE SYSTEM

The first step in the Building with Nature design process is identifying the root causes of the observed problems. In Demak, many of the environmental issues have underlying socio-economic factors. The entire coastline is at risk of flooding up to 6 kilometres inland, as illustrated in Figure 13. A baseline study was carried out to improve understanding of the natural and socio-economic system. A monitoring protocol was developed to ensure ongoing refinement of our system understanding.

The causes of coastal erosion and flooding in Demak were studied hydrologically and morphologically, detailing the impact of waves and currents on sediment transport. It emerged that the main causes of erosion are the removal of mangrove belts for aquaculture development, the construction of coastal infrastructure that disturbs sediment build-up from offshore sources, and river canalisation that impedes the dispersion of sediment within the system.

Figure 14: Aerial photo of Kendal (to the West from Semarang), North Java, Indonesia, 2016 ©Yus Rusila Noor

Unsustainable groundwater extraction was later identified as one of the root causes of land subsidence, which illustrates the importance of monitoring. While subsidence had previously been recognised as an issue, it was not immediately obvious that water extraction to supply a city and industries would be able to affect land levels more than 20 kilometres away along the coast. The revelation about the scale of land subsidence was made when monitoring poles, that had been placed in the intertidal area three years earlier, could no longer be found. It turned out they had sunk with the ground to below sea level, by as much as 30 centimetres within three years. The result of subsidence is not only depression of the land surface, but also the water levels become higher with waves becoming higher. A doubling of wave height quadruples the forces that cause erosion. In places like Demak, where the main type of sediment is fine silt, increased wave forces present a particular problem because fine sediment particles are easily moved. Consequently, it became clear that long-term landscape restoration would not be feasible if this subsidence continues. Conventional small-scale infrastructure would also not be able to address this issue. It was concluded that institutional changes are needed to provide alternative water supplies, so that groundwater can be conserved and land subsidence prevented. Building with Nature measures enhanced the resilience of the coastal communities and ecosystem in the shorter term and at a smaller scale, softening and delaying the impact of hazards and buying time to address subsidence. Adaptive management measures were put in place, for example communities were encouraged to express their needs in policy dialogues and were supported to reduce damage, adapt or transform their livelihoods.

The socio-economic baseline study identified that the main livelihood of rural households in the project area was fish farmer or fisherman (70%). Yet, lack of coastal safety (flooding and erosion) and a fragmented approach to water management have severely inhibited economic productivity. Moreover, draining fish ponds had become difficult, because of land subsidence. The ponds had been maintained in a conventional way, applying artificial food and antibiotics, with low productivity. Many ponds had been abandoned due to low profitability and/or erosion damage.

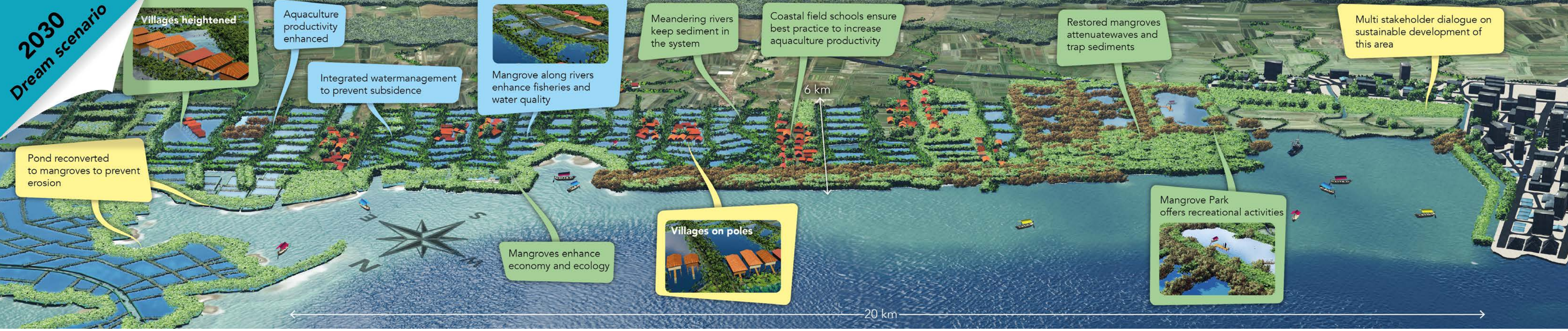

Figure 15: Visualisation of the Demak coastline in 2030, from Wulan Delta (left) to Semarang (right), under the scenario of mangrove ecosystem restoration, providing coastal protection and improving aquaculture productivity. ©Frederik Ruys

A policy review was conducted at local, provincial and national levels, in order to understand the institutional system and create a basis for outreach and policy dialogue. Its objectives were to ensure that the proposed project plan and design did not conflict with local policy and social customs, while developing a joint local vision on sustainable management and maintenance of the Demak coastline. It was revealed that existing regulations pertaining to coastal and river greenbelts, as well as to land ownership, do not allow infrastructure or agricultural development within 50 metres of the river and 100 metres of the coast. The law also states that when land is lost to the water, it becomes property of the national government. Meanwhile, discussions with the community suggested that new ponds were being built in the coastal zone, and in the mangrove greenbelt despite regulations, making it clear that implementation and enforcement were unsatisfactory. The formal involvement of local government was regarded as an effective way to overcome hurdles, such as land tenure and use rights. To align policies and plans, it was concluded that the project should focus on uptake of Building with Nature principles in the district masterplan and spatial plan, province coastal zonation plans and on national ministerial training programmes and guidelines. When we recognised the severity of subsidence, we initiated the development of a Regional Roadmap on Land subsidence in collaboration with Central Java Province and the Coordinating Ministry of Maritime & Investment Affairs.

4.2 STEP 2. IDENTIFY REALISTIC ALTERNATIVES

At the start of the project in Demak, a range of alternatives were considered, along with their advantages and disadvantages. Those included hard engineering and natural system restoration measures, as well as nonstructural measures for coastal safety and various aquaculture and mangrove management practices that have a potential to revitalise the local economy (see Tonneijck et al., 2015).

In Demak, hard infrastructure intended to protect the coastline from flooding, in practice has not only exacerbated erosion, but has also turned out to be unstable and expensive. Moreover, it has failed to support vital ecosystem functions such as fisheries, which the original mangrove belt had done. Communities suffered from extensive flooding, lost income and even evacuations. Most aquaculture farmers suffered low yields due to insufficient training, and used poor practices such as the use of chemicals that disturb the ecological balance. Stakeholders in the region acknowledged that a holistic and long-term solution was needed to address the root causes of the problem, alongside action to improve the economic and social well-being of the inhabitants. In line with this reasoning, we envisioned 'A safe and prosperous Demak district, where a mangrove greenbelt provides coastal safety and resilience, allowing communities to thrive, and, in turn, sustain the mangrove ecosystem they rely on', as illustrated in Figure 15.

At the start of the process of developing alternative solutions, it was acknowledged that mangroves provide numerous ecosystem functions, such as coastal protection, carbon storage, shelter for fish, habitat for birds, water purification and recreation. To be able to develop, mangrove saplings require a stable coast to settle in. The project therefore identified measures that put back in place ecological and socio-economic conditions that enable mangrove restoration, as presented in a design and engineering plan (Tonneijck et al., 2015). The proposals were developed at workshops and meetings with international and local experts, local communities and government officials, aiming to truly integrate socio-economic and structural interventions and create a win-win outcome.

4.3 STEP 3. EVALUATE ALTERNATIVES AND SELECT A COMPREHENSIVE SOLUTION

Evaluation of each potential solution was guided by estimates of its likely impact on the main objectives: reduce erosion, provide coastal protection and improve aquaculture productivity. Synergy between the components was deemed desirable and local communities contributed to the assessment. All ecological benefits were also included in the cost-benefit analysis. Any knowledge gaps were taken into account in monitoring programmes. Although the interrelatedness of measures challenged the design process, in the end it led to a more resilient outcome. The comprehensive solution developed at the start of the project is presented in the design and engineering plan (Tonneijck et al., 2015).

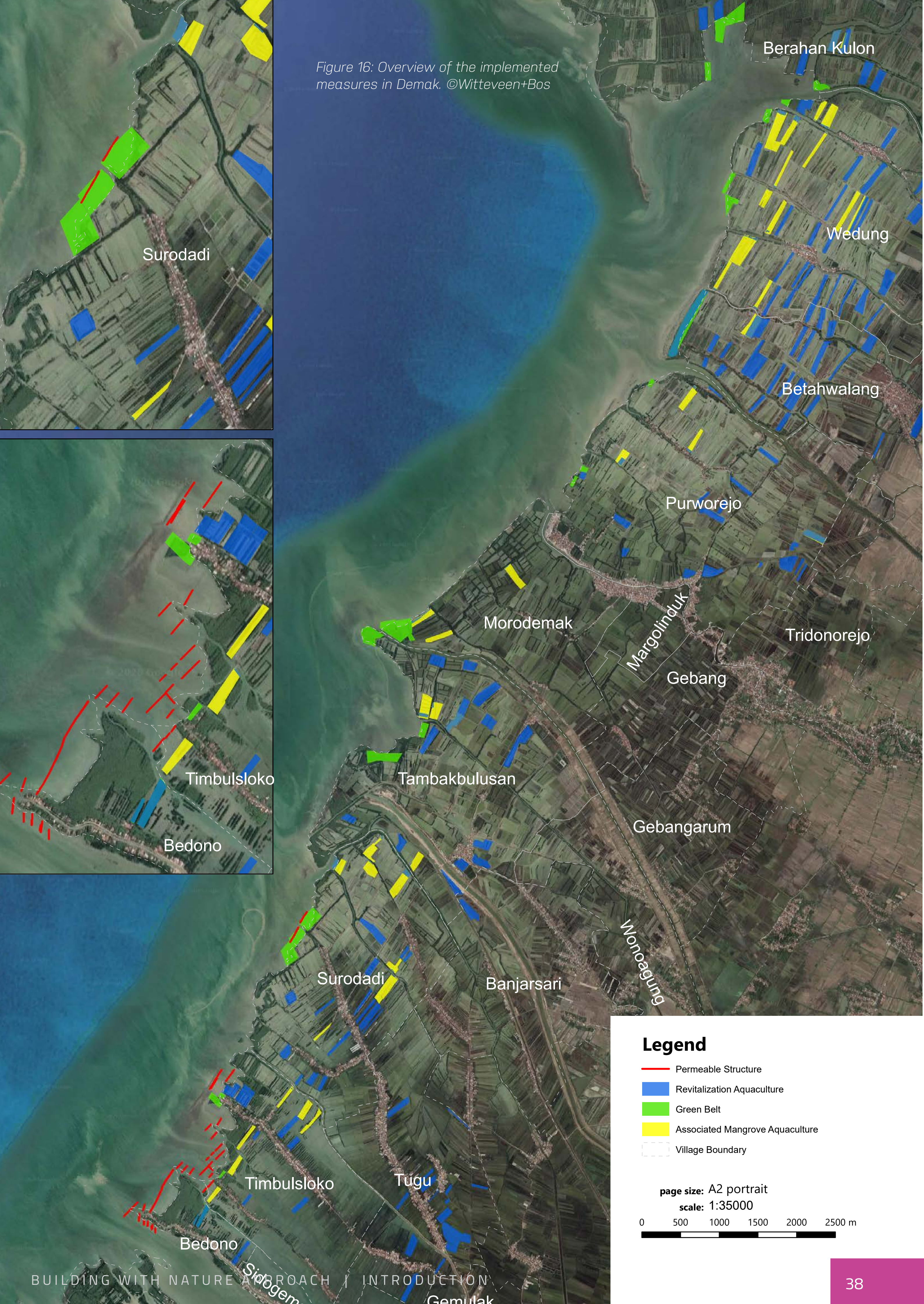

Figure 16: Overview of the implemented measures in Demak. ©Witteveen+Bos

An initial simplified cost benefit analysis clearly demonstrated that the proposed Building with Nature solution that the investment was economically sound. Net present value was computed using the official Indonesian discount rate of 7.5% over an infinite period of time and project costs of 8 million EUR. This cost included some activities not undertaken at the project site, e.g. global and national knowledge sharing, training, policy dialogues and communications. The benefits were estimated by comparing the reference situation (without the project) to project implementation. In the reference situation, coastal erosion would have continued and land would have been steadily lost, until aquaculture ceased to be viable and yields became zero. Conversely, in the scenario following project implementation, coastal erosion would be halted and aquaculture ponds revitalised, which could provide a net profit of about 5000 EUR/ha/yr. Assuming the project restored 300 ha, the annual yield could reach 1.5 million EUR. The net present value of this yield was estimated at 20 million EUR (7.5% over an infinite period of time). Other societal benefits, such as mangrove forest products like fruit and timber, nearshore fisheries, projected carbon values, and avoided damage, were not included in this quick analysis, nor was the impact of land subsidence. This simple socio-economic cost benefit analysis illustrated that the investments (8 million EUR) in coastal protection in combination with revitalisation of aquaculture ponds were economically sound, delivering benefits of at least 20 million EUR. This was recently confirmed by a full socio-economic cost benefit analysis, that also explored alternative future pathways and adjustments in the context of subsidence (Nieuwkamer et al., 2021). Note that full delivery of benefits requires mitigation of land subsidence.

4.4 STEP 4. ELABORATE SELECTED ALTERNATIVES

The identified bio-physical and socio-economical alternatives were further elaborated and mapped.

Bio-physical measures: permeable structures and pond conversion

Sediment balance had to be restored as a start of the efforts to stop erosion and regain a stable coastline. Various measures can be taken to increase the rate of sediment deposition and reduce the rate of loss. Conventional materials like rock and concrete reduce wave energy, but alternative, permeable structures made of bamboo or brushwood were explored here. These mimic the root system of mangrove trees and dampen waves, creating sheltered areas for accretion near the coast. Once the nearshore bed level rose sufficiently, mangroves were able to repopulate the coast, developing a natural defence that protected the hinterland from further erosion. This is a type of 'ecological mangrove restoration'. Creeks for tidal and freshwater flow were allowed to form between the permeable barriers, copying the natural system on a larger scale.

Permeable structures have been used for many years in the Wadden Sea along the Dutch, German and Danish coasts. Since they were new to Indonesia, it was not known what local materials would work and what their effectiveness would be. To handle the uncertainty, risks related to constructability, maintenance and durability were identified. Potential materials were selected together with the local communities, scientists and governments.

The permeable structures and their performance were monitored and evaluated, which made adaptive management possible. Based on data gleaned from the literature, several promising materials were initially selected for construction. During the first year, it became clear that shipworm damaged wooden and bamboo poles, which significantly reduced their lifetime. In subsequent years, the designs and materials were adapted and maintenance was intensified. Every year, new permeable structures were constructed, existing ones were repaired, and henceforward these two project phases formed a continuous cycle. The materials were locally sourced, easy to use and maintain, with acceptable lifetime and in good balance with life cycle cost.

More information is available in the Technical Guideline '#3 Permeable Structures' as part of this series.

Figure 17: Monitoring of permeable structures in Demak. ©Witteveen+Bos

Figure 18: Permeable Structures constructed by the Indonesian Ministry of Marine Affairs and Fisheries (MMAF) in Lombok in 2019. ©MMAF

During monitoring of the permeable structures, shellfish were found growing on the submerged parts. The local communities had started to collect and sell them. This unexpected additional benefit was further investigated to see if mussel cultivation can help finance the structures.

In areas where coastal erosion was not yet severe and ponds were still present up to the coastline, mangrove greenbelt restoration required restoration of hydrological connectivity. Here, it was important to know whether former aquaculture ponds received sufficient input of freshwater, seawater and sediment to serve as mangrove habitat. Where necessary, we performed targeted bund breaching to ensure that sediment-rich water could inundate and deposit sediment into the former pond, creating suitable conditions for mangroves to recolonise. Thus, the coastal green belt could be restored to protect the hinterland from erosion, wind and wave exposure and saltwater intrusion. Despite the known ability of mangroves to enhance fisheries, store carbon and deliver non timber forest products, it had been deemed impossible for farmers to give up their ponds for mangrove restoration, even when ponds were much degraded, showing that intensive stakeholder engagement can energise a paradigm shift.

Figure 19:. Degraded coastal pond converted to mangrove. Left photo: 5 March 2019. Right photo: 12 August 2019. ©Kuswantoro, Wetlands International

Socio-economic measures: sustainable aquaculture and other livelihoods

Alongside technical measures, the programme supported the integration of mangroves into sustainable aquaculture practice and developed other mangrove-based livelihoods that are environmentally friendly. Farmers received training through Coastal Field Schools to build their knowledge and confidence. Sustainable aquaculture interventions were developed, implemented and monitored with and by the farmers. This resulted in a selection of aquaculture activities, such as land and pond preparation which includes drying ponds, repairing dikes and sluice gates, providing compost and MoL (local micro-organism) to stimulate the growth of natural fish food and regular monitoring of water quality to ensure that water conditions are suitable for the growth of fish and shrimp. Two successful approaches introduced and tested by communities are:

Associated Mangrove Aquaculture Farms (AMAs) – in which part of the aquaculture pond is given up to make space for riverine mangroves. These areas readily fill up with sediment and allow natural recruitment of mangroves within one year. The mangroves on the edge of the pond act as water filters, so that higher quality water enters the aquaculture pond. The sediment captured by them protects the river bank and strengthens the pond dikes, thus reducing maintenance costs. To implement AMA systems, farmers set back the river dike and adjust the sluice system to create a mangrove greenbelt along the river. Monitoring showed that proper pond management is the key to success, for example opening and closing sluice gates at the right moment in time allows natural sedimentation. Farmers that gave up part of their pond were supported to improve yields in an ecologically sound way.

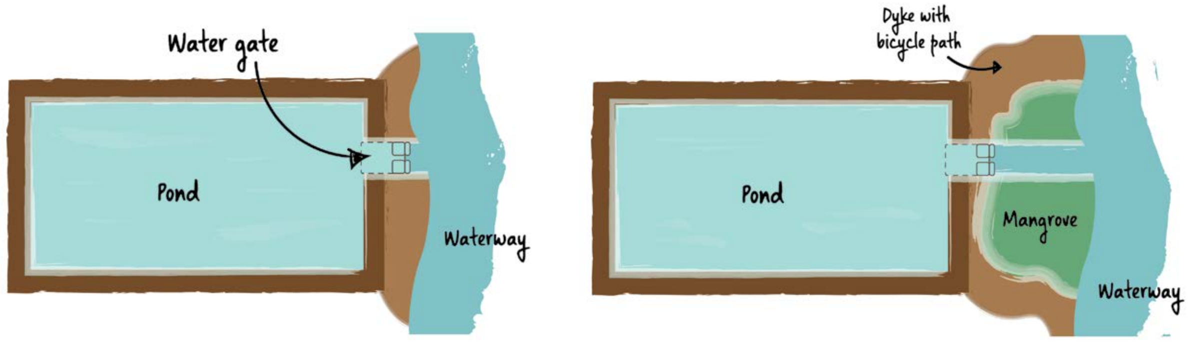

Figure 20: Overview of a common pond without mangrove (left) and a standard AMA for a single farm (right). ©Roel Bosma

Implementing Low External Input Sustainable Aquaculture (LEISA) - an aquaculture approach that applies the principles of good practice and environmentally friendly fish culture by minimising the use of external production inputs, especially those containing synthetic chemical compounds. The project demonstrated that applying a LEISA allows farmers to triple their income from milkfish and shrimp farming.

More information is available in the Technical Guidelines '#4 Associated Mangrove Aquaculture Farms' and '#5 Sustainable aquaculture Through Coastal Field Schools' as part of this series.

Figure 21: Water hyacinth that has been shredded and will be used as compost for LEISA practice. ©Cynthia Boll

4.5 STEP 5. PREPARE THE SOLUTION FOR IMPLEMENTATION IN THE NEXT PROJECT PHASE

The vision statement of the project implied that coastal safety measures needed to be intricately linked to socio-economic measures. That is why it was decided to introduce the Bio-rights approach, a financial incentive mechanism that reconciles economic productivity with environmental conservation and restoration (Wetlands International, 2009). In return for active participation in conservation and restoration measures, communities received financial and technical support to develop sustainable sources of income. Bio-rights agreements were conditional, meaning that payments would only be made subject to successful participation in restoration measures. This also motivated long-term interest in conservation work. The approach covered the costs communities faced on the journey of changing their current unsustainable practice (degrading the very mangrove greenbelt that they relied on for coastal safety) into long-term sustainable livelihoods.

Contractual agreements, witnessed by village officials, were set up with 10 community groups rather than with individuals. This ensured greater group cohesion and responsibility in implementing the agreement, and also allowed spatial spreading of measures. Some group members were involved mostly in mangrove restoration along coast and rivers, others were involved mostly in aquaculture revitalisation measures. Jointly the community group achieved both coastal safety and sustainable development targets.

To secure sustainable financing of measures at the local level, economic activities by community groups (aquaculture, alternative livelihoods and joint ventures) set aside some of the profits into a group savings fund that was used for mangrove rehabilitation. Joint venture activities included milkfish and shrimp aquaculture, developing tourism, compost production for aquaculture, and fish feed production from crab flour. To ensure embedding of local Building with Nature measures in local policy, the Bio-rights mechanism supported participants to enforce the measures in local bylaws and root them in community development plans. This helps to enhance village regulations and secure government support for sustainability beyond the project lifetime. By keeping

Figure 22: Community Group after signing of Bio-rights contracts. ©Wetlands International field team Demak

regular contact with local authorities, explaining the project, the upcoming activities and the results of the project, trust and support was built. Over the years, local government also allocated funding for the maintenance of the permeable structures, provided fish and shrimp seeds, and introduced regulations for the protection of mangrove rehabilitation areas and also the application of environmentally friendly aquaculture. The local government has also adopted the coastal field school approach as a part of their community capacity building programme. Such uptake clearly shows that our Building with Nature approach was genuinely suitable for the Indonesian setting.

4.6 REITERATION OF STEPS

The five steps of the Building with Nature approach form an iterative cycle. Monitoring and evaluation was used by the project team to inform project management and have resulted in adaptive management, seizing opportunities and addressing risks. Monitoring was also used by local communities, to inform their aquaculture and mangrove management decisions. Lastly, two research programmes have generated insight into coastal dynamics and aquaculture production systems. Monitoring and evaluation have contributed to system understanding.

Figure 23: Bio-rights meeting, Demak. 2020. ©Wetlands International field team Demak

5 EXPLORING UPSCALING POTENTIAL IN INDONESIA AND ASIA

There is a Building with Nature solution for every setting. Depending on the hazard and the natural and socio-economic constraints, Building with Nature solutions can be very different, each with its particular mix of green and grey infrastructure, and approach to risk reduction. Examples like the Building with Nature Indonesia programme can help to pave the way globally for integration of ecosystems into mainstream coastal infrastructure development. This is crucial as nations endeavour to build better flood resilience in response to climate change. We showed above that the Building with Nature approach has worked well in Demak, Indonesia. In this section, we explore the potential for replication of this particular Building with Nature solution, as well as the potential for implementation of different types of Building with Nature solutions in other settings in Indonesia and Asia.

5.1 POTENTIAL FOR REPLICATION ALONG TROPICAL MUDDY COASTS

Coastal erosion along muddy (former) mangrove coastlines is a problem throughout Indonesia and Asia, and as such there is great potential for replication of this specific Building with Nature approach. A recent risk mapping exercise showed that the flat low-lying coastal plain of Northern Java is very vulnerable to subsidence and sea level rise, and that 20% of the population of North Java can potentially suffer floods during an average storm surge (Willemsen et al., 2018). Conservation and restoration of mangroves in rural areas – e.g. by implementing Building with Nature - was flagged as top priority to maintain coastal integrity. In areas with severe subsidence, mangrove conservation and restoration need to be combined with other measures such as managed retreat or combinations of green and grey infrastructure, depending on the situation.

From 2015 to 2019, our government partner Ministry of Marine Affairs and Fisheries (MMAF) funded a marine spatial management programme to restore eroding coastlines with more than 23 kilometres of permeable structures placed in no fewer than 12 sites within and outside Java (of which 4.4 kilometres are in Demak). The investment was worth approximately 2.5 million EUR, with great uptake of the approach. In areas with limited subsidence, the structures worked as intended, trapping sediment and restoring a mangrove foreshore.

This approach is also applicable in other countries across the globe as (Winterwerp et al., 2020) shows.

Figure 24: Dr. Singgih Setyono, Secretary of Demak District during the workshop in NL ©Studio Dijkgraaf

Figure 25: Vision by Water as Leverage design team for Semarang. ©One Architecture

Government partner BINTEK (and its predecessor PUSAIR), which is the research department of the Ministry of Public Works and Housing (PUPR) developed and tested new permeable structure designs and developed guidelines. They secured 1.1 million EUR to monitor the impact of the structures and further improving the methodology. This resulted in a guideline on Hybrid Engineering (PUPR, 2018) which is to be accepted as a national guideline, allowing uptake at scale. The Ministry of Public Works and Housing is also developing river guidelines that specifically include Nature-based Solutions.

Both ministries have recognised the value of integrating nature into infrastructure design and encouraging active community participation, and are developing new government programmes to address coastal erosion. Indonesia's Mid-Term Development plans (RPJMN) for 2015-2019 and 2019-2024 use the term 'hybrid engineering' in reference to the use of permeable structures to restore mangrove ecosystems for coastal resilience.

5.2 POTENTIAL FOR REPLICATION IN OTHER SETTINGS

The Building with Nature approach can be applied to any water-related infrastructure challenge, whether in rural, urban or port areas, from sandy to tropical muddy coasts, and from lakes to estuaries and rivers - depending on the specific use requirements and space available. The potential for Building with Nature in Indonesia was explored by developing a conceptual design for the city of Semarang that directly borders the coastline in Demak, where the approach had already been adopted. The aim was to develop an integrated rural-urban coastal zone where mangroves were combined with a seawall. The design also included solutions to help industry transition from deep groundwater extraction to surface water use, thus addressing the root causes of subsidence. A plan to engage urban communities was also developed. The design received keen interest from the Mayor of Semarang and local authorities, who explored ideas further, demonstrating additional potential for Building with Nature solutions in a city environment (Beagen et al., 2019).

There is a lot of interest in Building with Nature from Indonesian knowledge institutes and universities active in engineering, water and coastal zone management disciplines. Project partners trained professionals from eight such institutions that have subsequently endorsed the approach and included Building with Nature in their curricula, reaching over 2000 students annually. Meanwhile, TU Delft has been running Massive Open Online Courses (MOOCs) on Building with Nature, featuring case material from Building with Nature Indonesia, helping train a new generation of engineers and ecologists to use the Building with Nature approach. More recently, we have also been providing webinars on Building with Nature for a broader Asian audience, showing that there is an appetite for new approaches in other countries, too.

Global and national recognition for Nature-based Solutions – including Building with Nature – is clearly on the rise. Building with Nature is in line with – and can strengthen – national policies, strategies, plans and guidelines, in particular those related to climate change adaptation, disaster risk reduction and sustainable development. Indonesia's country position to the UNFCCC, UNISDR and Ramsar convention, also mention Nature-based Solutions and ecosystem based adaptation.

Figure 26: The Building with Nature Indonesia team has welcomed many civil engineering and spatial planning students for a field visit to Demak, October 2019. ©Yus Rusila Noor, Wetlands International

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This guideline touches on many topics relevant for the implementation of the Building with Nature approach. Background information can be found in the following resources:

BUILDING WITH NATURE APPROACH

- Philosophy: https://www.ecoshape.org/en/the-building-with-nature-philosophy/
- Principles: https://www.ecoshape.org/en/the-building-with-nature-philosophy/building-with-nature-principles/
- Design guidelines: https://www.ecoshape.org/en/the-building-with-nature-philosophy/five-basic-steps-for-generating-building-with-nature-designs/

BUILDING WITH NATURE IN INDONESIA

- Project website: www.indonesia.buildingwithnature.nl
- Project brochure: Building with Nature Indonesia - reaching scale for coastal resilience: https://www.ecoshape.org/uploads/sites/2/2016/07/building-with-nature-in-indonesia-1.pdf
- Project leaflet: Building with Nature Indonesia – meet the partners: https://www.ecoshape.org/uploads/sites/2/2017/08/16.0745_EcoShape_Brochure_Indonesia_Consortium-Def.pdf
- Discussion paper: Mangrove restoration, to plant or not to plant?: https://www.ecoshape.org/uploads/sites/2/2017/02/16.0506-Wetlands-English-lowres_2.pdf
- Design and engineering plan https://www.ecoshape.org/app/uploads/sites/2/2017/08/Ecoshape-2015-Result-1-5-Design-Engineering-Plan-v7-0-LAYOUT-Nature-style_2.pdf
- Baseline assessment, Hardware plan and Monitoring plan (available upon request)

Bahamas coral reef ©Ter Hofstede-Van Oord

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Acronym or abbreviation	Description
ADB	Asian Development Bank
AGWA	Alliance for Global Water Adaptation
BINTEK	Directorate of Water Resources Engineering Development (Direktorat Bina Teknik)
BwN	Building with Nature
CBD	Convention on Biological Diversity
CCA	Climate Change Adaptation
CRIDA	Climate Risk Informed Decision Analysis
DRR	Disaster Risk Reduction
EBA	Ecosystem-based Adaptation
ECO-DRR	Ecosystems for Adaptation and Disaster Risk Reduction
EUR	euro
EwN	Engineering with Nature
FEBA	Friends of Ecosystem Based Adaptation
GCA	Global Center on Adaptation
GFDRR	Global Facility for Disaster Reduction and Recovery
GI	Green Infrastructure
IKI	International Climate Initiative (German international finance instrument)
IUCN	International Union for Conservation of Nature
km	kilometres
MMAF	Indonesian Ministry of Marine Affairs and Fisheries
NbS	Nature-based Solutions
NGO	Non-governmental organisation
NIMBY	Not in my back yard
PEDRR	Partnership for Environment and Disaster Risk Reduction
PIANC	World Association for Waterborne Transport Infrastructure
PIMBY	Please in my back yard
PUPR	Indonesian Ministry of Public Works and Housing
PUSAIR	Research department of the Ministry of Public Works and Housing
RfP	Request for Proposal

Acronym or abbreviation	Description
RPJMN	Indonesian National Mid-term Development Plan
SDG	Sustainable Development Goal
TEEB	The Economics of Ecosystems and Biodiversity
TU Delft	Delft University of Technology
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDIP	University of Diponegoro
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	Currently UNDRR: United Nations Office for Disaster Risk Reduction
USACE	United States Army Corps of Engineers
WRI	World Resources Institute
WwN	Working with Nature
WwNP	Working with Natural Processes

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