Paving the way for scaling up investment in nature-based solutions along coasts and rivers

How to finance and accelerate implementation of nature-based solutions

EcoShape

Contents

Building with Nature represents a paradigm shift that places the understanding of natural processes and systems at the heart of the approach to create Nature-based Solutions (NbS) in hydraulic engineering along coasts and rivers.

To enable Building with Nature (BwN), the characteristics of nature-based solutions have to be carefully considered throughout the development process. This white paper discusses costs, benefits and risks of NbS, as well as suggestions on how to finance and accelerate investment in NbS in hydraulic engineering in emerging countries. Over the past ten years there has been a growing recognition of the potential of Nature-based Solutions to help cope with the challenges of sustainable development, climate change and the biodiversity crisis. In the context of hydraulic engineering, the number of NbS projects that are actually implemented around the globe remains limited despite intentions to do so by governments, developers and banks. Projects that do get implemented typically have a strong pilot character[1], as institutional processes and legal arrangements remain geared towards conventional approaches. To achieve the required fundamental change, we recognize there is a gap to bridge between scientific and engineering communities, public authorities and the financial world.

The way forward

Building on practical experience in nature-based solutions in hydraulic engineering over the past 12 years, we discuss the way forward in scaling up investments in NbS. We provide insight in the advantages and disadvantages of NbS compared to "conventional" engineering solutions. We set out the barriers to a widespread uptake of NbS in public and private investments and follow up with suggestions on how these barriers could be overcome. Finally, we discuss what innovative financing models can attract more private investment in NbS.

Roadmap

In order to create a more favourable investment climate for NbS in hydraulic infrastructure, government and development finance institutions should put effort in creating a more enabling regulatory environment, demonstrating feasibility, earmark funding for NbS in the transition phase and increase efforts to blend in private investments. The private (financial) sector can enhance investment through (co)developing financial instruments such as blue (impact) bonds and integrated contracts/PPPs to share risks and operational efficiencies. Project proponents can contribute by supporting the use of blended finance and engaging more actively with the private financial sector. Furthermore they can help convince both public and private investors of the viability and attractiveness of NbS by putting further efforts in demonstrating (cost) effectiveness.

	Conventional solution	Nature-based Solution
Flood protection	• Breakwaters • Dikes • Seawalls • Groins • Concrete or rock embankments	• Mangroves • Coral reefs • Oyster beds • Seagrass beds • Sandy beaches and dunes • Shingle beaches • Salt marshes and other wetlands • Floodplain restoration
Port infrastructure	• Breakwaters • Dredging of navigation channels and basins • Quays and other conventional banks	• Design of breakwaters and dredging strategy to make use of natural currents to reduce sedimentation or to direct the flow of sediment to salt marshes and sandbanks • Vegetated revetments of conventional banks • Foreshores in the form of a sandbank, salt marsh or mangrove • Creation or restoration of coastal ecosystems (salt-marshes, mangrove, reefs, dunes) to compensate for the losses caused by the port development • Creation of new habitats by trapping (dredged) sediment

1 Out of 9 NbS projects that EcoShape was involved with, 6 were initiated as a pilot with knowledge development as one of the main project objectives with corresponding innovation (co) funding; 3 projects were funded and designed as part of mainstream infrastructure planning.

1. Building with Nature to create Nature-based Solutions in hydraulic engineering

Conventional engineering solutions for flood risk protection and port infrastructures typically present a strong contrast with the dynamic landscapes they occupy. The increasing need for further flood protection and coastal adaptation in response to climate change, as well as the increasing demand for port expansion will likely result in further pressure on natural environments along coasts and rivers, if these demands are to be met with conventional solutions. Decision makers face the challenge to deliver hydraulic infrastructure that provides better services to society as a whole, while enhancing the natural environment and increasing climate resilience. Building with Nature is a design philosophy that accomplishes this by integrating the services that nature provides into engineering practice in an inclusive way[1].

1.1. The status quo

The growing recognition of the NbS concept's promise to the challenges of sustainable development, climate change and the biodiversity crisis is recognized in recent pledges and activities from e.g. the World Bank[2], the Asian Development Bank[3], and the Inter-American Development Bank[4] to support and stimulate the role of NbS in infrastructure planning. NbS are also embedded in the EU's Green Deal, the EU's Green Infrastructure and Biodiversity Strategy[5], and pledges from 70 countries as part of the UNs' decade of restoration which kicked off in 2020[6]. Despite this increasing popularity of NbS, the number of projects actually implemented around the globe remains limited, with the majority of infrastructure investment still targeted towards conventional solutions[7]. Projects that do get implemented typically have a strong pilot character.

1.2. Trends and opportunities

Flood protection along coasts and rivers

With increasing urbanization, coastal development, sea level rise and extreme weather events, the economic rationale for (public) investment in coastal and fluvial flood risk protection across the globe is increasing. The required investment for coastal protection alone is estimated at $103 billion - $215 billion per year between 2015 and 2100, including maintenance of existing and new infrastructure[8]. Current public investment in coastal protection around the globe falls far below this objective [9]. Global investment needs and spending levels in fluvial flood risk protection are unknown.

Port development

Increasing globalization, the shift to a bio-based economy and sustainable energy, and the increasing size of container ships[10] stimulates re-development and expansion of existing ports. Investments in port expansion and development of new ports are focused in emerging economies in eastern and southern Africa and Asia[11]. Opportunities for integrating the building with nature approach arise during development of ports in new locations (site selection), expansion of existing ports (designing structures and port layout) and in maintenance of existing ports (e.g. dredging strategy and re-use of dredged sediment)[12].

Ecosystem recovery

The value of natural capital along coasts and rivers is increasingly being recognized, not in the least for their contribution to flood risk reduction. With continuing degradation of ecosystems around the globe, the potential market for ecosystem restoration grows as well, spurred by environmental regulations. According to Bendor et al. (2015), the global 'restoration economy' is a $25 billion industry, providing 220.000 jobs. A significant part of this work ($9 billion annually) relates to restoration and management of aquatic, riparian and wetland environments. The BwN approach presents opportunities to design NbS that integrate ecosystem restoration with other purposes.

Integrating NbS in flood protection and port development

The table on page 4 presents examples of conventional infrastructure and their nature-based alternatives in the context of coasts, rivers and ports – of course a hybrid solution merging them may also be attractive. Opportunities for applying the BwN approach can be found during project identification, development and design and maintenance phases of projects[12,14]. Nature-based Solutions are of particular interest in emerging economies: in a context of limited budgets, a vulnerable environment, large infrastructure development needs, and a wide range of development objectives, NbS can deliver the highest impact.

Box 1

Cost and cost-effectiveness of NBS

Based on an analysis of almost 1000 coastal restoration projects, the median costs of the restoration of mangroves was found to be about US$ 9,000 per hectare (2010 price level). Restoration costs were 30 times lower in developing countries (US$ 1,200 per hectare) compared to developed countries (US$ 39,000 per ha). Among coastal habitats, mangroves have the lowest restoration costs per hectare. The restoration of other ecosystems (coral reefs, seagrass, oyster banks and salt-marshes) is much more expensive due to the greater technological complexity and typically smaller scale of projects. Coral reefs have the highest restoration costs with a median value of almost US$ 170,000 per ha[1].

A meta-analysis of sixty-nine studies by[2] covering five types of coastal habitats world-wide (coral reefs, mangroves, salt-marshes, seagrass beds and kelp beds), shows that these habitats reduce wave heights significantly, particularly in low-hazard conditions. Coral reefs reduce wave heights by 70%, salt-marshes by 72%, mangroves by 31% and seagrass/kelp beds by 36%. In combination with engineered structures, they can reduce both the chance and impact of breaching[3].

Aside from being effective, mangroves and salt-marshes can also be two to five times cheaper than alternative submerged breakwaters for the same level of protection. Mangrove projects in Vietnam are three to five times cheaper than a breakwater, and salt-marsh projects across Europe and the USA vary from being just as expensive to around three times cheaper. Water depth is a crucial factor in cost-effectiveness: at higher depths breakwater construction costs significantly increase, and nature-based solutions can be highly cost-effective[2].

In an assessment of cost-effectiveness of coastal sand nourishment schemes in Portugal and the Netherlands and find that in particular in areas with high population density and an easily accessible sand source, sand nourishment is a cost-effective alternative to hard coastal protection, where it should be noted that cost-effectiveness depends on the time scale under consideration and scale of the design[4,5].

1 Bayraktarov, E. et al. The cost and feasibility of marine coastal restoration. Ecol. Appl. 26, 1055–1074 (2015).
2 Narayan, S. et al. The Effectiveness , Costs and Coastal Protection Benefits of Natural and Nature-Based Defences. PLoS One (2016) doi:10.1371/journal.pone.0154735.
3 Zhu, Z. et al. Historic storms and the hidden value of coastal wetlands for nature-based flood defence. Nat. Sustain. (2020) doi:10.1038/s41893-020-0556-z.
4 Brown, J. M. et al. The effectiveness of beach mega-nourishment, assessed over three management epochs. J. Environ. Manage. 184, 400–408 (2016).
5 Stronkhorst, J., Huisman, B., Giardino, A., Santinelli, G. & Santos, F. D. Sand nourishment strategies to mitigate coastal erosion and sea level rise at the coasts of Holland (The Netherlands) and Aveiro (Portugal) in the 21st century. Ocean Coast. Manag. 156, 266–276 (2018).

Box 2

Ecosystem services and benefits of wetlands

The table below presents an overview of the types of economic benefits (ecosystem services) created by wetlands[1]. The total economic value of an ecosystem is comprised of use values and non-use values derived by people from an ecosystem. Use values involve some human interaction with the ecosystem whereas non-use values are placed merely on its continued existence.

Use value			Non-use value
Direct use value (provisioning and information services)	**Indirect use value (regulatory services)**	**Option value**	**Existence value**
• Fish • Agricultural and forestry products • Wildlife • Fuelwood and peat for energy • Recreation & tourism • Transport	• Nutrient retention • Flood protection • Storm protection • Shoreline stabilisation • Groundwater recharge • External ecosystem support • Micro-climatic stabilisation	• Potential future direct or indirect use	• Biodiversity • Cultural heritage • Bequest value

Evidence base economic value of wetlands

Based on a meta-analysis of over 300 studies and articles, de Groot et al. (2012)[2] estimate the value of ecosystem services of 10 main types of ecosystems. The two most valuable ecosystems per hectare on earth are coral reefs and coastal wetlands (tidal marshes and mangroves) with an average economic value of respectively US$ 350,000 and US$ 190,000 per hectare per year (in 2007 US price level). The most valuable ecosystem services of coral reefs are erosion prevention and storm moderation (US$ 170,000 per ha per year) and tourism (almost US$ 100,000 per ha per year). The value of coastal wetlands mainly derives from nutrient recovery and breakdown (US$ 160,000 per ha per year). A range of other services (including fish nursery function, storm moderation and erosion prevention) each contribute between US$ 4,000 and US$ 10,000 per hectare per year. These values are averages with a sometimes very large bandwidth. The value of ecosystems varies in function of local conditions, especially for coastal wetlands.

The value of mangroves in Phillipines and India

A study of the coastal protection services of mangroves in the Philippines estimates that the existing 250,000 hectare of these ecosystems prevent or reduce flooding for more than 600,000 people every year (1 in 4 of whom live below the poverty line) and avert damages equal to 1 billion US$ per year in residential and industrial property. If the area of mangroves were restored to their extent in 1950, then an additional 270,000 people would benefit and 450 million US$ of damages would be saved[3]. A study of mangroves in India found that they improve the efficiency of fish production: one hectare increase in mangrove area leads to an increase in total marine fish production of roughly 1.86 tonnes. Given India's total mangrove forest area of 4.66 million ha, this corresponds to a total annual production of around 8.67 million tonnes (23% of India's total national fish production) at a total value of US$ 1.13 billion (KaviKumar et al., 2016)[4].

1 Barbier, E. B., Acreman, M. & Knowler, D. Economic valuation of wetlands. Ramsar convention Bureau (1997).
2 de Groot, R. et al. Global estimates of the value of ecosystems and their services in monetary units. Ecosyst. Serv. 1, 50–61 (2012).
3 Menéndez, P. et al. Valuing the protection services of mangroves at national scale: The Philippines. Ecosyst. Serv. 34, 24–36 (2018).doi:10.1371/journal.pone.0154735.
4 KaviKumar, K. S. et al. Valuation of Coastal and Marine Ecosystem Services in India : Macro Assessment. (Madras School of Economics, 2016).

2. Nature-based Solutions as an attractive alternative

NbS can have various advantages compared to "conventional" grey infrastructure: they can be cost-effective, limit negative externalities, provide co-benefits and are more flexible. If and to which degree these advantages materialize depends on a case by case basis. In many cases, a hybrid alternative combining the two strategies may be most attractive.

Cost-effectiveness

Depending on the local circumstances and desired protection level, NbS or hybrid green-conventional solutions can achieve the same flood risk reduction benefits as conventional infrastructure at a lower lifecycle cost (for an overview of evidence, see Box 1). Particularly in locations with a relatively low flood protection goal (e.g. 1/5 to 1/100 year event), NbS can be cost-effective. NbS are not always cost-effective: while NbS generally have a lower lifecycle cost, their effectiveness is also lower as more dynamics and variability is introduced.

From negative to positive externalities

Conventional infrastructure is typically designed for a single purpose, without - or only to a limited degree - taking externalities such as biodiversity loss, social consequences and increased climate vulnerability into account. By occupying space and affecting natural processes they often destroy or impair ecosystems. Building with Nature takes the social and natural system as a starting point, reducing negative environmental externalities and instead purposefully generating positive externalities - (co-benefits) - through increased stakeholder engagement.

Co-benefits – Ecosystem services

NbS create a wide array of co-benefits for nature and society: they deliver ecosystem services. These "services" are benefits for humans derived from healthy natural environments, e.g. fish production, CO_2 storage, aesthetic quality of landscapes and recreation opportunities. To illustrate this, Box 2 includes a description of benefits and many goods and services produced by coastal wetlands (salt-marshes, mangroves) and the economic values derived from them. Coastal ecosystems are among the most valuable ecosystems on the planet. In most cases, the economic value of restoring such ecosystems significantly exceeds investment costs and leads to a high economic return on investment, as demonstrated by our pilot project in Indonesia (see Box 3) and climate change adaptation options in the Fiji Islands (Box 4). These co-benefits can also help attract co-investment from non-conventional sources [15].

Flexibility

Uncertainties on climate change, e.g. in rate and magnitude of sea level rise, can complicate decision making on large-scale infrastructure investments[16]. For example, a breakwater can be costly to remove if future insights or changing circumstances change functional requirements. In this light, solutions that are flexible and adaptive to changing circumstances are attractive and prevent lock-ins: NbS are typically more flexible than conventional infrastructure.

The table on page 4 shows which benefits have been derived from EcoShapes' Building with Nature projects in comparison to their conventional alternative.

> *Nature-based Solutions are typically more flexible than conventional infrastructure.*

Box 3

Pilot project in Demak, Central Java, Indonesia

Caused by a combination of sea level rise, subsidence due to groundwater extraction, river canalization and clearcutting of mangrove forests for rice cultivation and aquaculture, the north coast of Java sees increasing coastal erosion and flooding with about 30 million people exposed. Additionally, habitat destruction, loss of freshwater influx and progressing salinity intrusion increasingly inhibit productivity of rice cultivation, aquaculture and fisheries.

Protecting the long, low-lying, muddy and largely unprotected coastline of northern Java with conventional hard infrastructure would be very costly and would fail to bring back the economic, environmental and social benefits that healthy mangrove coastlines would offer. A more holistic and long term solution is needed that addresses both the root causes of the problem, while taking into account the economic and social well-being of the inhabitants.

In the 'Building with Nature Indonesia' project a large-scale application of Building with Nature techniques was piloted along a 20 km stretch of eroding coast. The, project was designed to halt land loss, bring back mangroves and revitalize aquaculture. To reconcile aquaculture productivity with mangrove conservation and restoration the Bio-Rights financial incentive mechanism was introduced. Project costs are $5 million.

Restoring and protecting mangroves in the area will reduce the flood extent: without coastal protection, subsidence and sea level rise are expected to lead to an increased flood extent of up to 6 km by 2100. Additionally, the project protects and increases local revenue streams from aquaculture, as well as provides additional ecosystem services such as nursery of aquatic organisms and brushwood production. The present value of mangrove restoration (using discount rate of 5%) benefits of ~$6,5m per village far outweighs the projects costs of $ 0,5m per village (Hakim, 2017)[1].

1 Hakim, L.L., 2017. "Cost and Benefit Analysis for Coastal Management: A Case Study of Improving Aquaculture Practices and Mangrove Restoration in Tambakbulusan Village Demak Indonesia" MSc Thesis, Wageningen University, The Netherlands

Box 4

Cost-benefit analysis of NBS and hard infrastructure options for climate change adaption in Lami Town, Fiji Islands[1]

Due to climate change the frequency of extreme weather events leading to storm surges is increasing in the Fiji Islands. To protect Lami Town from the impact of storm surges two sets of actions are proposed. The hard infrastructure option includes the construction of a 7 km long seawall, building drainage ditches along roads (83 km), dredging the river and reinforcing riverbanks. The NbS involves replanting mangroves (64 ha), replanting the riverbanks (32 ha), reducing coral extraction and reducing upland logging. The key cost and benefit parameters of the two options are shown in the table below (values are expressed in in millions of Fiji dollars and refer to the present value over 20 years with a discount rate of 3%).

The results of the cost-benefit assessment is presented below. The hard infrastructure option has the highest net present value due to its higher effectiveness and should be selected despite the higher benefit-cost ratio of the NbS option.

	Hard infrastructure	NBS
Avoided damage	87.0	40.6
Ecosystem service benefits	–	11.6
Avoided damage	87.0	40.6
Net present value (NPV)	67.7	47.4
Benefit-cost ratio (BCR)	4.5	10.9

1 Rao, N. S. et al. An economic analysis of ecosystem-based adaptation and engineering options for climate change adaptation in Lami Town, Republic of the Fiji Islands : technical report. (Seretariat f the Pacific Regional Environment Programme, 2013).

EcoShape Project	Description BwN solution (NbS)	Conventional alternative	Benefits from Building with Nature
Mud motor	Use dredged sediment to enhance salt marsh development	Dredging and 'dump' dredged material in water bodies impacting water quality, or remove it as waste product	Beneficial use of dredged sediment to create nature
Houtrib Dike	Sandy foreshore in front of a dike	Stone dike reinforcement	Improves natural value, cheaper and more effective (under certain circumstances)
Marconi	Salt marsh development with dredged sediment	Dredging and 'dump' dredged material or remove it as waste product	Beneficial use of dredged sediment to create nature, knowledge development and improve the coast of Delfzijl
Clay Ripening project	Use dredged sediment from the Eems-Dollard to make clay which can be used for local dike reinforcement	Dredge the Eems-Dollard and 'dump' dredged material or remove it as waste product, and buy clay for the dike reinforcement	Improve water quality, stimulating regional economy, beneficial use of dredged sediment for clay production
Soft Sand Engine	Sandy shore protection, in the form of a sand engine	Stone dike reinforcement	Sustainable coastal protection that is adaptable to water level changes, improved spatial quality, and knowledge generation for larger-scale application in the strategy for the Frisian Ijsselmeer coast
Marker Wadden	Create island with local mud and sand to improve water quality and natural values	Do nothing	Improve natural value, improve water quality, provide recreation opportunities
BwN Indonesia	Use semi-permeable dams to promote mangrove restoration for coastal protection	Do nothing/stone protection structures (dams, groins)	More effective in trapping sediment, reduce coastal erosion and improve natural value
Hondsbossche Dunes	Building of a new dune coast with marine sand for coastal protection	Stone dike reinforcement	Coastal flood protection, improve natural value and create opportunities for recreation
Delfland Sand Engine	Use a mega sand nourishment for coastal protection	Use stone coastal protection constructions (dams, groins)	Use natural processes for long-term coastal protection, create recreation opportunities and reduce negative ecological impact of sand nourishment

Uncertainty and complexity

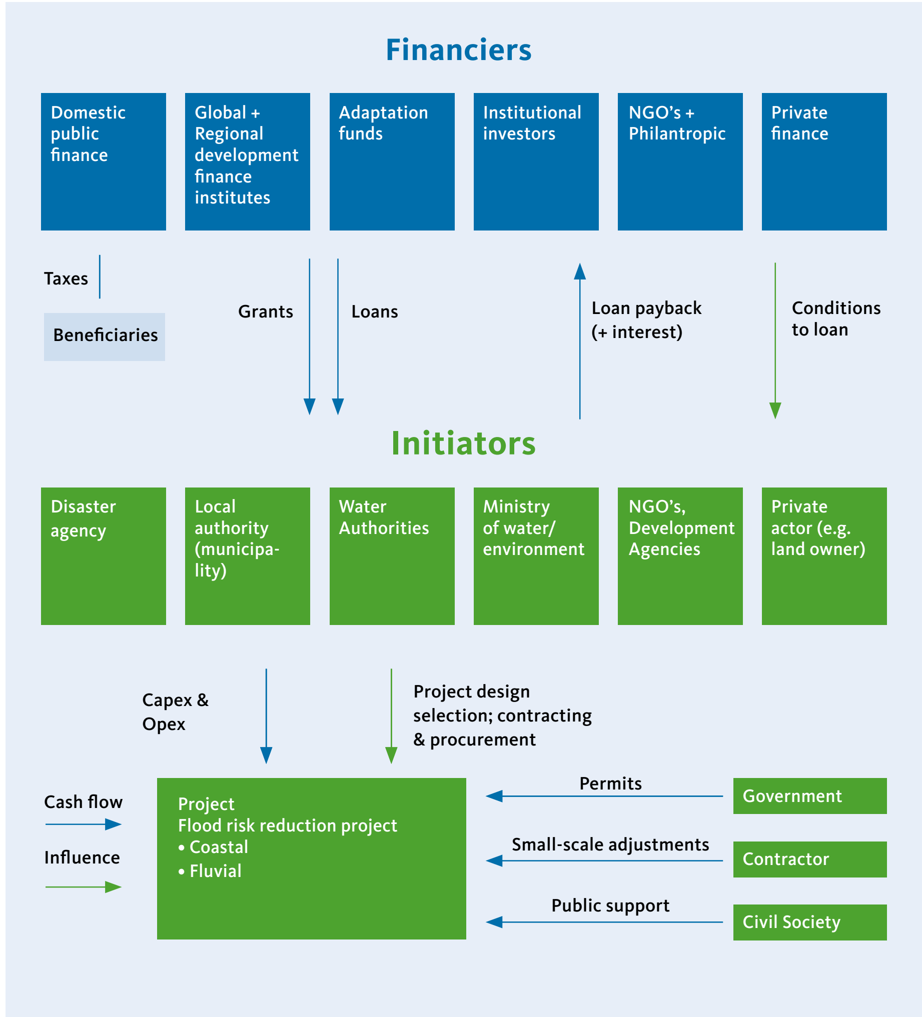
Due to their relative novelty in relation to conventional infrastructure there is still some uncertainty on their effectiveness. This uncertainty stems from the dynamic behaviour of natural processes (natural system), impact of interventions in the natural system (technical system) and economic, cultural, legal, political and institutional aspects regarding the problem and proposed solutions (social system). Across these sources of uncertainties, there are also three types of uncertainty: unpredictability, incomplete knowledge and ambiguity (different interpretations of a phenomenon between actors). Aside from the benefits described above, the broader scope and wider perspective that characterizes the Building with Nature approach may bring more uncertainty and complexity to the design and implementation phase.

Box 5.1

Institutional and financial playing field in flood protection & port development

Flood risk protection

Flood risk protection is typically a public good and therefore funded predominantly by public budgets[1]. As flood risk reduction projects have high up-front investment costs, some degree of finance is usually needed to raise the required capital. Particularly in emerging economies this can be difficult to find. In these regions development finance institutions, direct foreign aid, adaptation funds and philanthropic grants play a key role in providing loans, often complemented with technical assistance for developing projects. As such, these actors can play a key role in enabling and shaping investment in flood risk reduction through their wide-spread (public) client base and technical support services. Figure 3.1 gives an overview of actors, roles and cash flows in relation to coastal and fluvial flood risk protection.



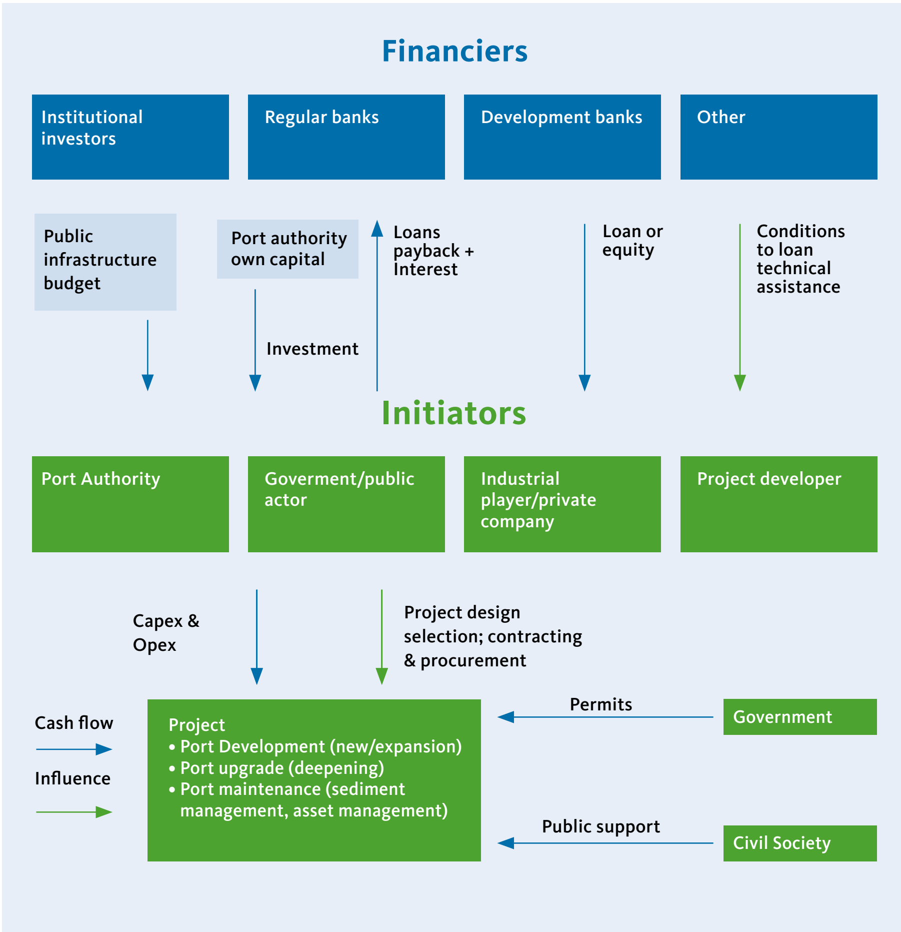
1 Pauw, W. . From public to private climate change adaptation. (Universiteit Utrecht, 2017).doi:9789402808414.

Box 5.2

Institutional and financial playing field in flood protection & port development

Port development

Port development is a typical commercial activity with a clear revenue model: the handling and storage of goods. Due to the high impact on the wider economy and the need for a good infrastructure, governments often play an important role in port development. The decision making on the design and maintenance of port infrastructure depends on the ports' ownership model. Across the globe the Landlord Port Model, with a public Port Authority managing the basic infrastructure is most common[1]. In this context, initiatives regarding new port development can be financed by own capital, or by attracting external financing from e.g. institutional investors, development banks or regular banks as there is a large revenue base. Regardless of the port ownership model, public authorities have to authorize the construction of the port and therefore can play a role in site selection and design of activities. The port authority is typically responsible for maintaining key infrastructure and dredging.



1 World Bank. Alternative Port Management Structures and Ownership Models World Bank Port Reform Tool Kit. http://siteresources.worldbank.org/INTPRAL/Resources/338897-1117197012403/mod3.pdf (2010).

3. Investment gap in coastal protection and natural capital

Although there is no structural tracking of global investment in flood protection[17], port development and coastal ecosystem restoration, there are estimates on current global public coastal protection investment levels. Current investment falls far below estimates of investment needs of on average $103 billion - $215 billion per year between 2015 and 2100. This range depends on the climate and socio-economic scenarios and includes construction of new and maintenance of existing infrastructure. Particularly low-income economies are unable to invest significantly in flood protection due to financial constraints and the need to invest in other priority areas[18]. If these investment needs are not met, global flood losses in the 136 largest coastal cities alone are expected to rise from US$ 6 billion per year in 2005 to US$ 1 trillion in 2050 as a result of population and economic growth, climate change and subsidence [19].

Some investments that contribute to coastal protection are labelled 'natural capital': e.g. restoration or protection of coastal ecosystems. The most recent comprehensive estimate of global spending on natural capital dates from 2010 and amounts to US$ 52 billion annually (see Box 5). The amount needed to conserve the natural ecosystems on the planet is estimated at US$ 355-385 billion per year[20]: the observed level of spending falls far below. For restoration and management of aquatic, riparian and wetland environments currently around US$ 9 billion is spent[13].

The call for private finance investments in infrastructure

Box 6 introduces the institutional and financial playing field in flood protection and port development. Key sources for investment in flood protection, typically a public service, include domestic government sources, bilateral and multilateral development finance institutions (DFI's) and, to a limited degree, private sector sources. As ports do have a clear revenue model (the handling and storage of goods), the role of the public sector lies mainly in regulation, and key funding and finance sources may be public or private. In response to the investment gap described above, there is an increasing ambition to use blended finance in (public) infrastructure investments. In this concept, public or development capital is used to mobilize additional private finance for investments related to the Sustainable Development Goals in developing countries. At present, private sector finance for flood risk protection - and climate adaptation in general - is very limited due to insufficient financial returns. Current private investment focuses on climate-smart agriculture, eco-tourism and water- and forest management[17,21]. The co-benefits provided by NbS may offer new opportunities for attracting private sector finance[15].

Box 6

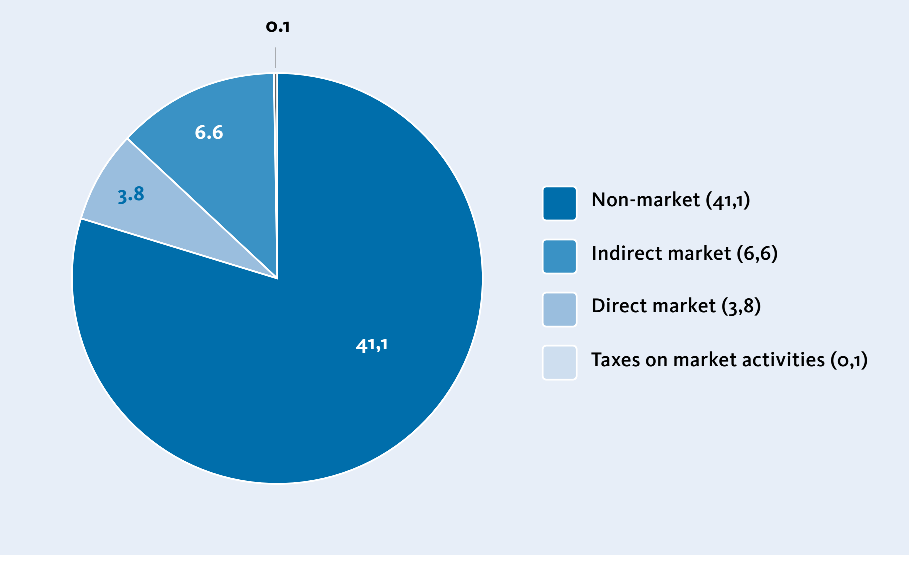
Global investments in natural capital

(billion US$, 2010)

Parker et al. (2012) analyse global investments in natural capital around the globe ($52 billion), and identify four types of funding:

- Direct market: natural capital investments or carbon offset markets, such as forestation projects financed by major GHG emittors under the Kyoto Protocol's Clean Development Mechanism
- Indirect market: markets for agricultural commodities produced in line with commodity standards for sustainable production (coffee, tea, wood, fish and shrimp)
- Taxes on market activities: taxes on polluting or biodiversity-impairing activities used to fund investments in natural capital
- Non-market: government budgets, official development assistance, agricultural subsidies tied to biodiversity practices and philanthropy.

The majority of funds invested in natural capital in 2010 (80%) was raised from public sources. 20% originated from the private sector through market mechanisms (US§ 10.5 billion) and philanthropy (US$ 1.7 billion). 80% of the funds was sourced in high-income countries, and 60% was also invested in these countries. The remaining 20% was transferred to low- and middle-income countries to supplement the 20% of funds raised there[1].



1 Parker, C., Cranford, M., Oakes, N. & Leggett, M. Little Biodiversity Finance Book - A guide to proactive investment in natural capital. (2012).

Box 7

EcoShape Experiences: embedding lessons learned from the Houtribdijk pilot project

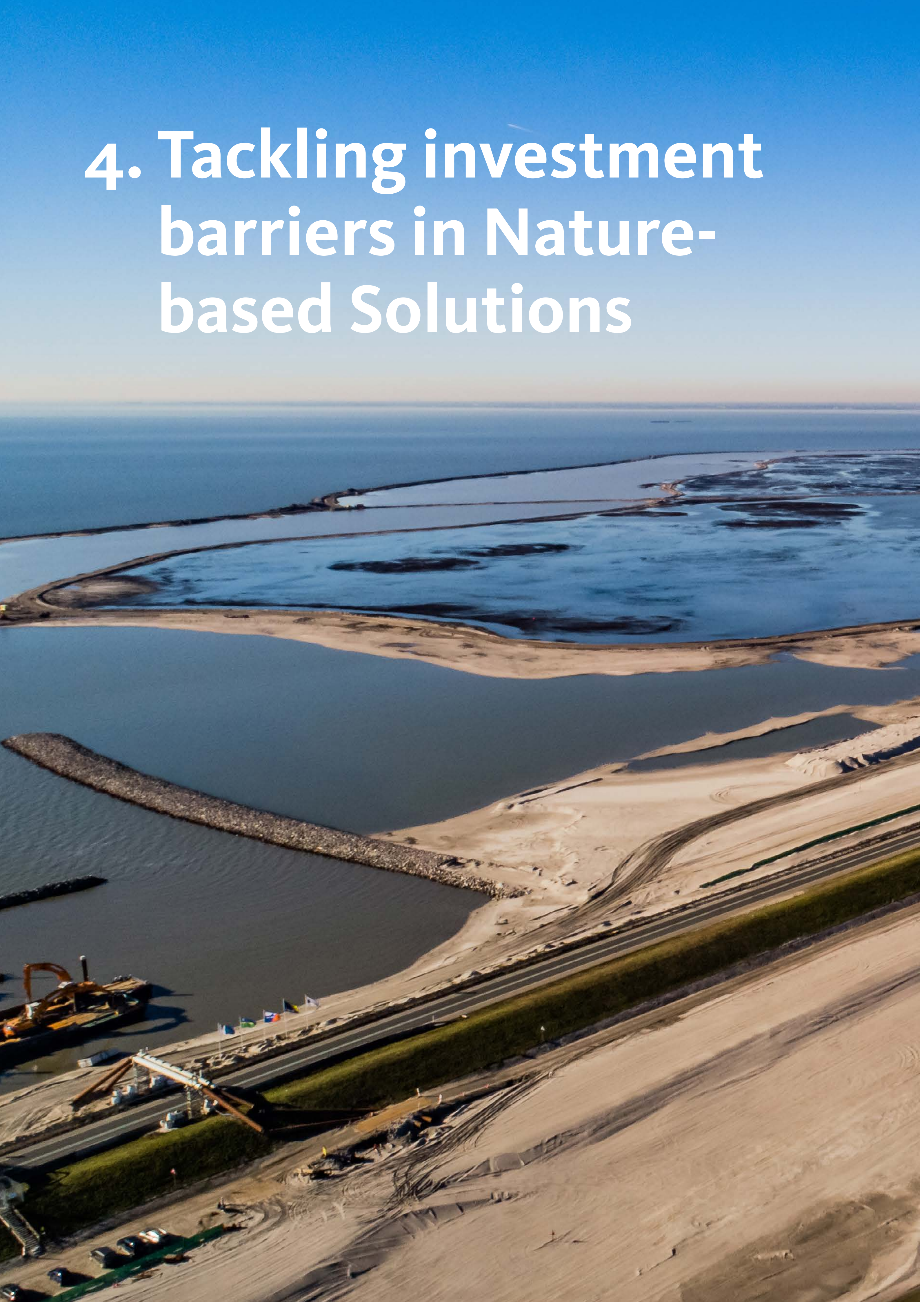
Short-term decision-making can hinder the adaptive management approach that is needed to learn from pilot projects for successful upscaling. In EcoShape's Houtrib dike project, the purpose of the pilot was to gain knowledge on optimal design of a sandy foreshore to reduce wave impact on the dike over the first 4 years after implementation. However, the first two years of the implemented pilot project already gave sufficient trust to the decision-making process that the final project would be feasible: the large-scale follow-up project was already being prepared, designed and commissioned during the lifetime of the pilot, before the monitoring and evaluation of the pilot was finished. Although in this case the short-term decision-making did not hinder the implementation of BwN, it could lead to sub-optimal designs and prevent learning from pilot projects for up-scaling.
The Houtribdijk also illustrates this: the large-scale follow-up project did not sufficiently consider how potential vegetation would develop during the implementation phase and maintained in the design and management plan of the project site. Also, due to the mono-functional scope of the initial project (the nature-based solution was selected on grounds of cost-effectiveness), the design did not account for potential additional benefits e.g. recreational facilities for kite-surfers.

Box 8

EcoShape Experiences – combining budgets for BwN

The variety of investors in EcoShapes' projects show that there can be a wide array of rationales to invest in BwN. An analysis of motives for investment in EcoShape projects show that flood safety was the primary motive for financial contribution to an EcoShape BwN project, particularly for the government (ministries, Rijkswaterstaat) and Water authorities. This is followed by knowledge development and nature development (governments and nature organizations/ funds). Other motivations, particularly for local authorities like provinces and municipalities, include providing opportunities for recreation, stimulation of the (local) economy, improving water quality, spatial quality and stimulating innovation.

4. Tackling investment barriers in Nature-based Solutions



Despite the attractions of NbS discussed in section 2, NbS remain undercapitalized in comparison to conventional infrastructure[22].

We identify two key reasons:

1. Current infrastructure investments are in the far majority conventional in nature. NbS is not main-stream in regular infrastructure investment planning as institutional incentives remain geared towards conventional infrastructure and authorities lack awareness and knowledge of NbS.
2. In emerging economies the investment gap in infrastructure in general is so high, it cannot be met by donor support[21]. The potential to attract private co-investment to ease the pressure on limited public infrastructure budgets is not capitalized.

In the following sections, we first discuss barriers and enablers for increasing public investment in NbS and then barriers and enablers for increasing the role of the private sector.

4.1. Scaling up public investment

Particularly in emerging countries, development finance institutions (DFI) can play a key role in supporting the mainstreaming of NbS in a countries' infrastructure planning throughout the project cycle. To some extent this is happening, e.g. through developing and mandating application of technical guidance[23] in certain loan conditions and offering support through technical assistance grants. However:

- the institutional set-up and internal incentives of DFI's and public authorities hamper successful implementation as short-term decision-making and planning horizons hinder the long term vision that is needed for NbS;
- there is still uncertainty about effectiveness and long-term costs; and iii) NbS brings along more complexity in the process, which is not always sufficiently addressed in grant conditions and project development process.

4.1.1 Aligning institutional incentives with NbS

Adverse incentives in institutional framework

The short-term and compartmentalized nature of public sector decision-making hinders the longer-term and integrated planning perspective needed to appreciate the benefits of NbS[24]. To illustrate, the primary driver of DFIs is the provision of (large and easy to process) loans. This is reflected in the institutional set-up and internal incentives of DFIs. A loan is much easier to process when focussed within one sector: hence the institutional alignment across sectors and the prevalence of single-sector programmes. Loan processes are typically aim for a relatively short-term project period, aiming for implementation within 5-7 years. This limited scope in time and objectives is also reflected in the way project alternatives are typically evaluated in mandatory analysis e.g. in cost-benefit analysis (CBA): these do not standard include ecosystem valuation, and typically value short-term benefits over longer-term benefits. For an integrated basin-wide or long coastal stretch Building with Nature approach more time and a wider project scope is required (see also Box 7). Furthermore, when implemented at a smaller scale, the lower required capital expenditures (capex) of NbS may fall below the loan threshold and thus be more difficult to finance. The institutional compartmentalisation is mirrored in most public authorities. Local enabling institutional frameworks e.g. ppp- legislation and municipal budget rules are also typically splintered, with the majority of economic power centered with engineering/civil works departments rather than disaster management and environment[21]. In practice, this prevents optimization of infrastructure for a wider range of benefits.

Creating an enabling regulatory environment

To break this institutional lock-in, local authorities and DFIs should actively prepare an enabling regulatory environment that incentivizes NbS and disincentivize harmful activities[21,25]. This could include:

- setting policy goals on NbS or natural capital inclusion in infrastructure projects;
- stimulating coupling of public budgets in multi-purpose projects (see also box 8);
- raising awareness and building (technical) capacity in executing agencies and;
- reducing specific barriers for NbS in permitting procedures – at present, NbS can have a more complex permitting process2. Particularly in emerging economies, making BwN standard practice in natural disaster recovery efforts following the 'build back better' principle provides a key opportunity[21].

2 For example in the EcoShape Houtribdijk project, habitat regulations acted as a barrier for NbS. Any development in areas with a special habitat status is rife with regulations and requirements for compensation, increasing project costs and additional study requirements to rule out negative impacts. In this way, well-intended regulations can actually become a barrier for NbS, leaving a conventional solution as the only feasible alternative[36].

4.1.2 Uncertainty about effectiveness and long-term costs

Limited evidence base

Compared to conventional infrastructure the predictability the effectiveness and long-term costs of NbS solutions in hydraulic engineering is still limited. As traditional decision-makers which are typically risk averse, this reinforces the tendency of decision-makers to choose conventional infrastructure solutions: they see NbS as a new and therefore high-risk technology. Around the globe, there are decades of experience and international standards and processes which can be used in asset valuation for conventional infrastructure, which are not yet there for NbS[3] - although the recent Global Standard for NbS by IUCN is a first step in the right direction[26]. This sense of certainty regarding the performance of conventional solutions is not necessarily justified: uncertainty and risks associated with conventional infrastructure are increasing with climate change.

Dynamic character of NbS

The uncertainty surrounding performance and costs of NbS is partly due to the use of natural processes, which are innately more dynamic than conventional infrastructure. The survival rate of organisms in constructed habitats has a wide range due to the multiple factors that influence survival - in some cases up to 50% does not survive[27]. With experience such characteristics will become better known and easier to address in the design. However, at present this experience is still limited under project sponsors and contractors.

Despite ongoing research, there is still a lack of reliable data on the costs and effectiveness of NbS, and uncertainty on how their dynamic behavior will react under changing conditions like climate change. As existing NbS projects are relatively recent, they lack the long-term monitoring and evaluation that would give insight in the dynamic behavior of NbS under changing conditions. Evidence on performance and costs are also difficult to standardize as design characteristics and performance is particularly site-specific, due to the underlying nature of NbS. Experiences in one location cannot be transferred directly to another environmental setting, although the general concept can be copied[4].

Adopting an adaptive management and monitoring approach helps to mitigate performance risks.

Invest in feasibility assessment of NbS

To enable assessment of the viability of NbS in feasibility studies on equal footing with conventional alternatives, further expansion and formalization of the evidence base on feasibility of NbS, and a shift in evaluation practices is required at a strategic level[5]. At the project level, a sound decision-making process that provides a fair basis for NbS should include the following elements:

- Demonstration of the technical feasibility (effectiveness) of conventional and NbS (or hybrid) solution;
- Identification of social and natural uncertainties and management options to address them;
- Identification and quantification of the benefits and drawbacks of the NbS and conventional alternatives including adaptability and resilience.

To increase the evidence base of NbS, public authorities should fund application of strong monitoring networks of NbS to support (cost)effectiveness analysis across cases[25]. This will globally help support their uptake. To some degree this is already happening: NbS have been part of European Commissions' Horizon 2020 program for research and innovations, with already up to €180 million in demonstration projects and research projects on NbS. Up to the present, many pilot projects have focused on demonstrating the technical feasibility of NbS: in the future, additional attention is required on:

- demonstrating cost-effectiveness (cost-savings);
- quantification of uncertainty and risk and development of management perspectives;
- revenue generation concepts would be valuable in light of increasing the bankability of NbS projects[21]. At the project level, adopting an adaptive management approach in combination with monitoring can help address and mitigate performance risks.

3 For example, flood risk protection project in the Netherlands should meet safety levels for a certain time period. There are centuries of experience in optimizing dike reinforcement projects to this purpose. Performance of nature-based solutions is dynamic, and guidelines and evidence on how to manage them effectively and how to value their performance are largely missing.
4 For example, the type and origin of sand and design of the nourishment can differ between projects which affects the costs and performance of the NBS.
5 For example, lifecycle cost approach and ecosystem services valuation are not standard practice in current economic analysis and guidelines in the project definition stage.

Box 9

Examples of markets for natural capital

Compliance carbon emission trading: The imposition of a cap on emissions of greenhouse gases along with the establishment of emission trading markets has generated substantial investments in measures that reduce greenhouse gas emissions, including through NbS. Targets go beyond emissions from industry or transport: several UN climate treaties recognize that ecosystems are potentially vast GHG emission sources or sinks. Emissions from Land Use, Land Use Change and Forestry (LULUCF) have to be included in national level reporting by developed countries. Conservation and enhancement of forest carbon stocks (e.g. by reforestation) is recognized as viable carbon sequestration measure under the Clean Development Mechanisms (Kyoto Protocol) and Paris Agreement.
Voluntary carbon markets: Besides the compliance markets, voluntary carbon markets have developed. These are not driven by emission ceilings and - targets as agreed in UN treaties, but by voluntary targets adopted by private actors, e.g. to compensate for activities like flying. Voluntary markets have been a valuable testing ground for new types of emissions reductions and sequestration, e.g. NbS, linking to biodiversity and community benefits.
Blue carbon: In the context of hydraulic engineering, blue carbon, the carbon stored in coastal ecosystems like mangroves, salt marshes and seagrass beds, plays an important role both as potential source and sink of GHG. Through their Nationally Determined Contributions, countries can specify if and how they will address emissions from ecosystems. Currently, GHG emissions caused by hydraulic infrastructure are thought to be related mostly to deployment of construction vessels and these are likely to be capped by the IMO and European Emission Trading scheme. However, the carbon footprint of hydraulic infrastructure may be more significant and complex as projects also impact the blue carbon balance. When these would be included, NbS may prove particularly interesting, because they can be designed to optimize ecosystem based carbon sequestration and avoid GHG emissions. At present, the blue carbon market is mostly active in the voluntary carbon market, stimulated by initiatives like the Blue Carbon Initiative and Blue Carbon Resilience Credit. Demand for carbon offsetting is growing, and blue carbon sequestered and stored in coastal ecosystems can help meet this growing demand[1].
Biodiversity offset markets: Similar markets could be developed in relation to biodiversity and habitat loss. Quite robust and comprehensive frameworks and formal requirements regarding 'no net loss' of biodiversity and/ or habitats are a prerequisite[2]. In essence, biodiversity offsets are an economic instrument based on the polluter-pays principle in which measurable conservation outcomes can be used to compensate for biodiversity loss from development projects (to be used only for residual biodiversity loss after steps have been taken to avoid and minimize this loss). In more than 100 countries there are laws or policies in place that require or enable use of biodiversity offsets. Existing approaches for biodiversity offsets include one-off offsets, common under regulatory programs and voluntary offsets, in-lieu fees in which a developer is required to pay a fee to an offset provider, and biobanking in which offsets can be purchased directly from a public or private biobank – a repository of existing offset credits[3].

1 Sapkota, Y. & White, J. R. Carbon offset market methodologies applicable for coastal wetland restoration and conservation in the United States: A review. Sci. Total Environ. 701, 134497 (2020).
2 Conway, M., Rayment, M., White, A. & Berman, S. Exploring potential demand for and supply of habitat banking in the EU and appropriate design elements for a habitat banking scheme. https://ec.europa.eu/environment/enveco/taxation/pdf/Habitat_banking_Report.pdf (2013).
3 OECD. Biodiversity Offsets: Effective Design and Implementation: Policy Highlights. https://www.oecd-ilibrary.org/environment/biodiversity-offsets_9789264222519-en (2016).

4.1.3 Complexity in design and implementation
Multi-purpose NbS projects are typically more complex than their mono-purpose conventional alternative. As NbS typically aim to address root causes of problems, they generally occupy a larger area, spanning both land and sea, and often cross jurisdictional boundaries (i.e. multiple municipalities or ministries). This brings additional complexity in project formulation and implementation stages, in terms of land ownership and stakeholder engagement. To be successful, the implementation of NbS requires active cooperation between many stakeholders, whose priorities and interest may not align, or may even conflict.

To overcome the barriers in implementation of NbS, project development should focus on bringing a broader set of expertises to the table than conventional infrastructure. When this expertise is not present within the organizations of public authorities, project sponsors and potential investors (e.g. in relation to evaluating risks, tendering and permitting procedures), partnership models for combining the required expertise need to be developed: cooperation is key to successfully deliver NbS.

4.1.4 Earmark funding for NbS to support transition phase
To support the transition phase towards a more enabling regulatory environment for NbS, a dedicated public fund that can be used to support the project development phase and leverage any additional costs or risks of innovative, multifunctional infrastructure investments like NbS would be valuable. This fund would stimulate public authorities to consider NbS alternatives to their projects, mitigate key financial or risk-associated obstacles related uncertainties, and provide executive agencies with the means to design and develop NbS projects, and as such become more familiar with the concept. Such a fund could be funded e.g. by dedicating a fixed portion (e.g. 10%) of public infrastructure budgets to NbS[21]. Over time, the function of the fund will become redundant as NbS is integrated in mainstream infrastructure planning.

4.2. Increasing the role of the private sector

Due to the public good character of primary services provided by NbS in hydraulic infrastructure and the lack of revenue streams, public sector funding will remain the mainstay of investments in NbS. However, to bridge the investment gap, there is a critical complementary and supporting role for private financing: attracting private finance will ease the pressure on public funding and finance towards achieving the development goals[28]. The private sector can invest in NbS directly, if there are sufficient revenue streams, or indirectly, by financing government-sponsored projects: this can offer various benefits in terms of budgeting, risk sharing and operational efficiencies[6]. The increased development of green and blue financing instruments demonstrates a large interest of private investors to invest in natural capital and NbS. However, the development of private financing of NbS in hydraulic infrastructure is hampered by a lack of bankable projects and uncertainty about costs, effectiveness, and implementation risks[7,21,25,29].

4.2.1 Increasing the pipeline of bankable projects

Lack of bankable projects
NbS often lack sufficient revenue from goods and services, particularly in the short term, to make the project attractive for private investors. And revenue components that are possible, e.g. carbon credits (see also box 9) lack the track record that would make them acceptable for investors[21]. Even if there would be sufficient revenue, NbS projects often have a relatively low investment value (compensated with higher maintenance costs later on) as they require simple techniques and can be realized with local workers, whereas financiers typically favour large projects with lower average due diligence[7] and transaction costs, for instance, financiers only consider investments of at least US$ 25 to 50 million.

6 A good example of such a private/public partnership is the Kleirijperij project in the North of the Netherlands. In this project, the private investors have taken some of the initial risk, and the public sector covers for the bigger (but less likely) portion.
7 Due diligence of conventional infrastructure is easier at present as these projects are more standardized and familiar. Also, due diligence costs strongly depend on the size of the project: they are relatively high for projects with a low investment value as often the case in NBS.

Box 10

Blue Bonds
A “Blue Bond” label communicates to the public that the project will contribute to the development and preservation of marine and coastal ecosystems. This increases the visibility of the project, the project sponsor (the issuer of the bonds) and the buyers of the bonds. Many investors (e.g. institutional investors, impact investors, sustainable investment funds) have targets with respect to the part of their funds that must be invested in sustainable projects. By buying blue bonds they can achieve these targets. The strong demand for financing opportunities in green and blue projects often results in more advantageous financing terms for the issuers of blue and green bonds.

The first blue bonds have only been issued a few years ago and the market is still very small. The market of green bonds is by now 13 years and has reached a size of US$ 500 billion in outstanding bonds. The same rapid growth can be expected for blue bonds. The establishment of a reputed “Blue Bond” label and certification system (as exist for green bonds and climate bonds) is an important enabling factor for the development of a blue bond market.

Investments financed through blue bonds must be aimed at promoting the implementation and achievement of sustainable development goals[1], in particular SDG 14 (Life Below Water) and related SDGs that contribute to good governance of ocean and coastal habitats, improve marine and coastal ecosystems, reduce carbon emissions or strengthen resilient livelihoods of people who depend on oceans and coastal ecosystems in a changing climate (in particular SDG 6 Clean Water and Sanitation; SDG 13 – Climate Action; and SDG 15 Life on Land).

The Seychelles Blue Bond was the first bond explicitly advertised as “blue”. It was launched in October 2018 by the Republic of the Seychelles for an amount of USD15 million with a maturity of 10 years and a coupon of 6.5%. Under the Seychelles bond, the proceeds from the transaction will be used to support the expansion of marine protected areas, improve governance of priority fisheries and the development of the Seychelles’ blue economy.

In January 2019, the Nordic Investment Bank issued a SEK 2 billion (US$ 200 million) blue bond to protect and rehabilitate the Baltic Sea. Through the Baltic Sea bond, the issuing bank will support lending to waste water treatment and water pollution prevention projects, storm water systems and flood protection, protection of water resources, protection and restoration of water and marine ecosystems and related biodiversity (wetlands, rivers, lakes, coastal areas and open sea zones).

1 Roth, N., Thiele, T. & Unger, M. von. Blue bonds: Financing resilience of coastal ecosystems - Key points for enhancing finance action. 1–70 (2019).

Furthermore, due to low financial capacity during the project development phase, (e.g. government-sponsored) projects that would in theory be viable are sometimes not presented, structured and executed in a way that is investable by private financiers[29,30][8]. A bankable project must include a clear and secure investment vehicle, financial details and project related risks. Despite willingness of private financiers to invest in NbS, the lack of a pipeline of bankable projects means this potential is not capitalized at present.

> *The implementation of legally binding targets on the conservation of the environment would create strong incentives for investments in natural capital.*

Stimulate the development of bankable projects for private sector

To meet the needs for blended finance in order to achieve the sustainable development goals particularly in lower- and middle-income countries, the number of bankable projects must be increased. A key enabler for the development of bankable projects are experienced and qualified project teams and sufficient budgets for project development. In practice, emerging countries typically have about 10% of the required budget for project development available. More technical assistance grants or subsidies More technical assistance grants or subsidies, to be used for project development in cooperation with private financiers, would be a valuable step in preparing more, and better, bankable projects. Preferably these are result-based and specifically targeted at NbS in hydraulic infrastructure, would be a valuable step in preparing more, and better, bankable projects.

Generating new revenue streams: creating markets for natural capital

In the area of renewable energy most of the investments are – after a transition phase with initially public investment - carried out by commercial firms, as there is a financially feasible business case. In some cases natural capital has an immediate economic and financial return. In that case the private sector has an incentive to invest in the conservation of natural capital, as is the case in the partly privately funded insurance scheme for Cancuns' coral reef[31]. However, in the majority of NbS projects this is not the case – benefits and revenue streams take time to develop and may be non-excludable and difficult to capitalize. Creating new markets for natural through imposing regulation will generate new revenue streams that open up the market for private (co) investment in NbS. Under the Clean Development Mechanism[9] the demonstrated carbon sequestration of investments in natural capital (such as forestation or sustainable agriculture projects) could be converted in tradeable carbon credits. Sale of these credits could provide an additional financial revenue for some NbS projects in aquatic infrastructure (in particular in salt marsh restoration, mangroves and seagrasses). Initiatives such as the Blue Carbon Initiative and Blue Carbon Resilience Credit[10] are working on developing and formalizing this for the voluntary market. Similar markets could be developed in relation to climate adaptation and natural capital, e.g. through trading resilience or adaptation credits, biodiversity offset and habitat banking[32,33] (Box 9).

For example, if infrastructure developers (in aquatic or terrestrial environments) would be obliged to compensate the impact of their projects on the natural environment, a natural capital development sector would emerge, developing e.g. ecosystem services and biodiversity credits for sale to companies and government agencies that need to offset their negative impact on natural capital.

To facilitate the emergence of such markets, the implementation of legally binding targets on the conservation of the environment – e.g. through compensation requirements - would create strong incentives for investments in natural capital. Ideally this is combined with mandatory implementation of natural capital accounting standards to facilitate calculation of the required compensation, as well as developing sound metrics and certification systems in relation to the tradable assets (credits). The imposition of emission ceilings for greenhouse gases and the establishment of emission rights markets provide a good example: this has generated substantial investments in projects that reduce greenhouse gas emissions.

8 In some cases it may also be that the incentive to seek private (co) investment of finance is not there, or not strong enough: for example, the majority of EcoShape projects are financed by public funds. In some cases (e.g. Marker Wadden project), it was tried to realize private co-financing, but often that resulted in very low amounts only.

9 The Clean Development Mechanism was established under the Kyoto Protocol and therefore ceased to be effective upon the entry into force of the Paris Agreement in 2020. A similar mechanism is provided by article 6 of the Paris Agreement, but not yet practically implemented.

10 See https://www.thebluecarboninitiative.org/ and https://www.climatefinancelab.org/project/blue-carbon-resilience-credit/ for more information.

Combining revenue streams in integrated projects

The proponents of NbS often build the investment case on their capacity to fulfill multiple functions and to generate multiple co-benefits: demonstrating NbS are strategically attractive. However, co-benefits do not necessarily translate into revenue streams, and if they do, additional efforts are needed to bring these revenue streams e.g. from ecotourism, fisheries or non-timber forest projects, into the project structure[11]. New ways to bundle such similar or sub-projects under a single, secure investment vehicle should be developed[21,29,30]. For example by combining them into hybrid infrastructure clusters, which can be absorbed by formal public investment planning processes, and translated into a number of financially viable or even bankable deals using a blended finance approach[34].

Box 11

Washington DC Water Environmental Impact Bond

In 2016, the DC Water and Sewer Authority (DC Water) issued a US$ 25 million Environmental Impact Bond (EIB) to finance the installation of a set of green infrastructure elements (bioswales, permeable pavements, green roofs and rain barrels) in order to slow surges of stormwater during periods of heavy rainfall[1].

The EIB is structured to incentivise innovation by sharing risk between DC Water and private investors. DC Water was interested in testing green infrastructure as an alternative to the construction of water tunnels. However, it was not allowed to invest public funds in a project with an untested effect. The risk-sharing EIB enabled DC Water to try out an innovative approach and test whether the green infrastructure will absorb stormwater in a less expensive and more environmentally friendly way as the conventional alternative.

The expected return of the bond under the base case is 3.43%. If the green infrastructure is more effective than expected, DC Water will pay investors a bonus "outcome payment" of US$ 3.3m, increasing the return to 6.4%. If runoff reduction falls short of expectation then the investors will pay a "risk sharing payment", reducing the return to 0.5%. Outcome payment will follow after monitoring period is finished, in early 2021. The range of the expected percentage reduction in stormwater runoff was determined in a feasibility study, and confirmed by an independent engineer selected by the investors. The actual percentage reduction, determining the pay-out under the EIB, is calculated by comparing the post-construction and pre-construction stormwater runoff. An independent validator confirms the results of the assessment.

1 North, J. & Gong, G. DC Water Environmental Impact Bond. 5 (2017).

11 For example, in the BwN Indonesia project a wide project scope, encompassing benefits for coastal protection as well as from aquaculture and fisheries has been considered from the early project development stage.

BOX 12

Private investments – experiences from Pevensey Bay[1]

In the late 1990s, the Environment Agency decided to upgrade protection of Pevensey Bay, a 9km stretch on the south-east coast of the UK, through tendering a long-term contract for coastal protection from 2000 to 2025 with specified performance levels as an alternative to upgrading existing groins or building a hard structure such as a sea-wall. The tender was won at a value of £30 million by the Pevensey Coastal Defence Limited (PCDL), a special purpose vehicle consisting of a consortium of four dredging and construction companies and financed with shareholder equity investments.

Efficiency gains and risk sharing

Ex-ante assessments of the efficiency gains achieved through this construction carried out by the Environment Agency estimated 15% savings of the PPP over traditional public provisioning: this The PPP contract defines that protection is provided for events up to the 1/400 year event. The costs of maintenance vary with weather and are shifted onto the private partner up to the level of 1/50 year events. Between 1/50 and 1/400 year events, the costs of repair are shared.

For the private construction and dredging companies, the contract was attractive due to the flexible service delivery terms which allowed integration of shingle supply to the bay with other projects, lowering operating costs. The long-term nature of the contract also allows efficiency gains over time with progressive insight about the project site.

1 Popovici, O. Financing flood protection measures in developing countries: Are private investments feasible? Experience from Pevensey Bay Coastal Defence Project in UK. (TU Delft, 2013).

Promoting financial instruments for NbS in hydraulic infrastructure with NBS

Private financing of government-sponsored projects can offer various benefits in terms of budgeting (relief of short-term budget constraints), risk sharing and operational efficiencies[12] and thus accelerate/ scale up overall investment. Attractive avenues for crowding in private finance are blue (impact) bonds and integrated (performance) contracts.

Blue bonds

In their most simple form blue bonds are like ordinary bonds: a government or DFI provides a loan, and banks, institutional investors or private individuals subscribe to this loan. In a blue bond, the proceeds of the bond must be used for investments in marine and coastal ecosystems (Box 10). This label of "blue bond' constitutes an additional attractiveness for a large class of investors who wish to achieve a non-financial impact. These investors may accept a slightly lower return, resulting in cost savings for the project sponsor. Blue bonds offer more value if, in addition to a label, they allow government project sponsors to share risks with the private sector. This is the case with impact bonds, like the DC Water Environmental Impact Bond described in Box 11. In this bond, the pay-out of the bond to investors partially depends on the environmental performance of the project. This performance-dependent pay-out was instrumental in allowing the water company to opt for a NbS with less certain outcome than its conventional engineering alternative.

Performance contracts and integrated contracts

The performance and environmental impact of NbS often depends on good operation and maintenance of the project. In the case of the DC Water Environmental Impact Bond the contractor was therefore responsible for the construction and the first year of maintenance, during which the effectiveness of the green infrastructure is evaluated. It is even more advantageous to extend the maintenance responsibility of the contractor to a substantial part of the lifespan of the project, and to give the contractor a financial stake in the project. This was done in the Public Private Partnership (PPP) for the flood defence scheme in Pevensey Bay (see Box 12). This PPP offered two important benefits to the British Environmental Agency, which commissioned the project:

- the flood protection performance is contractually guaranteed at a fixed price during the entire contract period (25 years);
- the involvement of the contractor in the design of the project resulted in several cost-saving innovations that likely would not have been found in a conventional procurement approach.

4.2.2 Uncertainty about effectiveness and costs and implementation risks

Uncertainty about the effectiveness of NbS (particularly under climate change) costs and 'greenness' of solutions, as well as a lack of risk sharing and/or risk reduction measures and corresponding difficulties in calculating risk-adjusted returns affect the bankability of NbS. Additionally, implementation risk due to higher complexity of NbS can make NbS a less attractive infrastructure investment for private investors. On the flip side, NbS are typically much more flexible and adaptive than conventional infrastructure – thus reducing the risk of sunk assets under changing circumstances and enabling continuous performance optimization. Capitalizing this potential does require continuous performance monitoring and maintenance, and the institutional capacity to do so.

De-risking projects

Thiele et al. (2020) recommend strategies to de-risk investments in NbS projects[21]. To reduce risk in project development, the evidence base of performance evidence must be increased, and, building on this, standards for implementation and maintenance provided. In the project implementation phase, innovative procurement models (e.g. short term v.s. long term, performance-based) and multi-party integrated delivery agreements can be applied to share risks. Pilots in applying innovative procurement or other risk sharing models would allow learning and further development of such models. Additionally, the creation of multilateral partnerships between companies, communities, governments, NGOs, finance institutions and insurance companies would promote knowledge sharing and capacity building, and stimulate combinations of various forms of capital for NbS[35].

Furthermore, there are various avenues to improve the viability of NbS as private investment (e.g. in a PPP construction), by increasing the credit profile of projects and/or their sponsor, e.g. public authority paying for public services. For example, the project sponsor can bring in collateral (e.g. physical assets or newly reclaimed land) to reduce financial risk for private investors. Another avenue is to provide guarantees to cover (a specific) NbS project risk or emerging country (political) risks, either by the (external) government or through insurance.

12 A good example of such a private/public partnership is the Kleirijperij project in the North of the Netherlands. In this project, the private investors have taken some of the initial risk, and the public sector covers for the bigger (but less likely) portion.

5. Nature-based Solutions advocates as catalysts of transition

NbS has many advocates among theNbS-project development community, consultants, contractors, NGO's and policy makers, for example in the EcoShape community. The role these proponents can play in scaling up investment in NbS should not be underestimated.

To help reduce uncertainty and risks associated to dynamic behaviour of NbS, consultants and the science community can support asset managers of hydraulic infrastructure by providing tools and advice for adaptive management practices which fit the dynamic character of NbS.

NbS project developers should increase efforts in making projects bankable through working with supporting facilities such as BNCFF and ASEAN ACGF, developing new public-private partnerships and including the financial sector more effectively in discussions about scaling up investments. A shared interest in learning each other's languages and value systems is a key part of this. Conventional infrastructure developers should widen their scope and see their infrastructure development as potential leverage to contribute to multiple development goals, rather than a mono-functional solution to a stand-alone problem.

Intermediaries such as NGOs can perform a key role:

- in bridging the information and knowledge gap between water sector actors and providers of funding and financing[30];
- act as broker by identifying and matching project pipelines with funding and financing sources
- support development of blended financing. They can also help clarify and flag social and environmental risks and opportunities on the ground. Additionally, they can support development and dissemination of information on the effectiveness and benefits of NbS and how to value them, as well as information about the actual risks of NbS, and how to mitigate these.

6. In conclusion

In conclusion, NbS in hydraulic infrastructure are essential in achieving the sustainable development goals, addressing the biodiversity crisis and solving the investment gap in coastal protection. However, despite pledges and ambitions from governments and development finance institutions to scale up investment in NbS, prevailing barriers significantly limit its widespread application. To create a more enabling environment for investment in NbS in hydraulic infrastructure, we outline the following roadmap.

To scale up public investment in NbS, governments and DFIs around the globe should:

- Create a dedicated fund to support the project development phase to leverage additional costs or risk related to the innovative character of NbS. Such fund will assist in the transition phase from innovation status of NbS towards mainstream application.
- Invest in demonstrating feasibility and viability of NbS, e.g. through funding strong monitoring and information sharing networks to expand and formalize the evidence base and promote a shift in more integrated and holistic project evaluation.
- Create an enabling regulatory environment that incentivizes NbS, e.g. setting policy goals on NbS in infrastructure planning, streamlining permitting and tendering procedures, and increasing technical capacity.

To increase private finance for NbS, governments, project developers and the financial sector should:

- (Co)-develop and promote financial instruments such as blue (impact) bonds and integrated contracts in which private financiers can easily invest;
- Increase the bankability of NbS projects, e.g. by creating funds for technical assistance to develop bankable projects;
- Promote new revenue streams from natural capital through establishing regulation (e.g. biodiversity offsets, habitat banking);
- Make an effort to combine existing revenue streams into larger integrated infrastructure projects;
- De-risk projects through application of innovative procurement and integrated multi-party project delivery agreements and enhancing the credit profile of projects and borrowers.

NbS proponents in engineering communities (e.g. project developers, consultants and NGOs) can play a key role in the transition towards more mainstream investment in NbS, by:

- Supporting the use of blended finance in NbS projects by working with supporting facilities such as BNCFF (Blue Natural Carbon Funding Facility), developing new public-private partnerships and e ngaging more actively with the private financial sector;
- Help convince both public and private investors of the viability and attractiveness of NbS by further efforts in demonstrating (cost-)effectiveness and providing tools to reduce or manage uncertainty in relation to dynamic behavior of NbS.

Call to action

With biodiversity levels in freefall across the globe, the consequences of climate change becoming more evident each year, increasing investment gaps in natural capital and coastal protection, the time to scale up public and private investment in NbS in hydraulic infrastructure is now. Emerging countries provide a good place to start: against a backdrop of limited financial possibilities, NbS offer a more attractive and feasible option to harmoniously blend population growth and infrastructure development with climate risk management and nature preservation.

More information

For more information about EcoShape, please visit www.ecoshape.org or contact info@ecoshape.nl.

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For more information about NbS in hydraulic infrastructure order our book 'Building with Nature, Creating, implementing and upscaling Nature-Based Solutions'.

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EcoShape
EcoShape is a public-private foundation of 11 parties including consultants, knowledge institutions, contractors and NGO's that aim to develop and share knowledge about Building with Nature through pilot projects and fundamental as well as applied research (valued at €70 mln in total) addressing flood safety, port development and ecosystem restoration in lower delta's.

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Photography

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