

DFS

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magazine

DREDGING FOR SUSTAINABLE INFRASTRUCTURE



Integrating dredging in sustainable development

Creating infrastructure
that benefits both people
and the planet.



Some 200,000 people live on the coast of Togo and Benin. Most of them depend on fishing. With sea level rising each year, coastal erosion has catastrophic consequences for their way of life and their survival. Read the full article on page 42.



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EDITORIAL

Sustainability in action



environment – physical, social and economic. This holistic approach is the cornerstone of the principles that guides the dredging community in creating value across all three pillars of sustainability.

The supporting articles showcase the practical applications of these principles. From the Benin submerged breakwater to the Delta21 project in the Netherlands, we see how dredging can be harnessed to protect coastlines, restore ecosystems and support economic development.

Welcome to the inaugural issue of *Dredging for Sustainable Infrastructure*. This magazine, born from the successful publications *Dredging for Sustainable Infrastructure* (2018) and *Financing Sustainable Marine and Freshwater Infrastructure* (2021), marks a significant milestone in our collective journey towards a more sustainable future. Both IADC (International Association of Dredging Contractors) and CEDA (Central Dredging Association) promote sustainable projects not only by making these publications possible but moreover explaining this working method in their conferences, seminars, courses and meetings.

I have been active in infrastructure projects involving dredging since 1986 and have witnessed that we have learned so much over the years. In the early days, we were only reactive to the environment, simply trying to reduce and mitigate negative effects. Today, having matured, we are more proactive, optimising positive effects that give benefits to all stakeholders. We have learned from numerous projects and pilot programmes, and also by sharing our experiences, and in turn have improved our overall skills. I strongly believe we must continue with exchanging knowledge to realise sustainable infrastructure and to reach the next level together.

For the coming three years, this new publication will alternative with IADC's technical journal, *Terra et Aqua*. Each issue will take a chapter from the DFSI book as its foundation stone and have supporting articles that show the philosophy put into practice. In the six years since the book was published, times and technology have changed and advanced. The aim is therefore to revisit and update the content, and bring it to the next generation in a more accessible format.

As we navigate the challenges of climate change, energy transition and urbanisation, the dredging community has a vital role to play in building a sustainable future. By adopting sustainable practices, embracing innovation and fostering collaboration, we can create infrastructure that benefits both people and the planet.

I invite you to explore the articles and get inspired in this issue, and to join us on this exciting journey towards a more sustainable future.

For this first issue, the theme presents the broad concept of how to integrate dredging in sustainable development. The essence of sustainable infrastructure lies in first understanding its total

Guest editor
Polite Laboyrie
International Director, Witteveen+Bos.



Integrating dredging in **SUSTAINABLE DEVELOPMENT**

Adapted from the second chapter of *Dredging for Sustainable Infrastructure* (2018), this article forms the foundation for this first issue and presents the concept of sustainability in relation to dredging projects. It describes the approaches and practices that are key to creating more sustainable solutions and infrastructure – a modern way of thinking about dredging.

The broad context

A dredge is a tool. For hundreds of years this tool has been used to shape and manipulate the interface between land and water in order to support a variety of human activities, including navigation, coastal protection, flood risk management, as well as residential, commercial, agricultural and hydro-power development. The use of dredging to achieve these purposes has always been guided by an understanding of the costs and benefits of applying the tool. However, in the last few decades the understanding of what constitutes costs and benefits has evolved substantially beyond the direct monetary costs of using the tool and the direct monetary benefits of what the tool was used to create.

This evolution was aided by the environmental movement over the past five decades, where the costs (in a broad sense) of applying the tool was expanded to include the negative environmental impacts that can be associated with dredging. Environmental regulations were put in place in an effort to minimise negative impacts on ecosystems caused by dredging activities, and for the last few decades dredging has been at the centre of a conflict, where the water meets the land, between groups supporting development and the environment. However, attitudes and approaches are changing.

The environmental regulations that have been put into place over the last 50 years

Today, a paradigm shift is being embraced – a move toward a holistic approach for integrating values for people, planet and profit.

to eliminate, reduce, or control the impacts of dredging on the environment, have produced a range of outcomes, both positive and negative. It is undoubtedly true that such regulations have helped to reduce negative impacts on the environment, in general. However, it is also true that the amount of environmental benefit produced by these regulations has not been systematically quantified, nor have the environmental, social and economic costs of such regulation been fully assessed (e.g. related to trade-offs and transferring impacts within the system). Today, a paradigm shift is being embraced – a move toward a holistic approach for integrating values for people, planet and profit.

The growing focus on sustainability
The international focus

An increasing amount of attention is being given to the concept of sustainability as an approach to informing social, environmental and economic development. In 2015, the United Nations (2015) published its SDGs, as a part of “The 2030 Agenda for Sustainable Development” (see Figures 1 and 3). These 17 SDGs encompass a

very broad range of interests, values, and objectives.

As a means for developing water resources infrastructure, the relationship of dredging to each of the 17 SDGs varies. For example, the use of dredging to construct efficient and productive navigation infrastructure is directly connected to SDGs 2, 6, 7, 8, 9, 10, 11, 14, and 15. As a tool used to provide coastal protection and infrastructure supporting flood risk management, dredging clearly supports SDGs 1, 3, 6, 9, 11, and 13, among others. In the future, one of the opportunities that should be addressed by the dredging and water infrastructure community is to incorporate these goals into the infrastructure development process, while effectively communicating how such projects support the SDGs.

The organisational focus

An example of organisational focus and application of sustainability in relation to dredging and infrastructure can be seen in the Environmental Operating Principles (EOP) of the United States Army Corps of Engineers (USACE). The USACE dredges approximately 250 million m³ of sediment

annually (including permits for dredging issued through its regulatory programme). This level of dredging supports a network of nearly 40,000 km of navigation channel and the associated ports, in addition to flood risk management and ecosystem restoration projects. In 2002, the USACE developed and published its EOP, which were subsequently updated in 2012.

These principles were developed and disseminated by USACE as a means of advancing its stewardship of air, water and land resources while protecting and improving the environment. These principles have been communicated within USACE and codified as a part of an agency regulation so that each of the more than 30,000 employees of the agency “understand his or her responsibility to proactively implement the EOP as a key to the Corps mission.” (Bostick, 2012). The USACE EOP recognise the relationship of infrastructure development to the three pillars of sustainability, the importance of considering the long-term, life-cycle implications of agency actions, and the essential need to openly engage the stakeholders and interests affected by its projects and programmes.

USACE environmental operating principles

- Foster sustainability as a way of life throughout the organisation.
- Proactively consider environmental consequences of all USACE activities and act accordingly.
- Create mutually supporting economic and environmentally sustainable solutions.
- Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments.
- Consider the environment in employing a risk management and systems approach throughout the life cycle of projects and programmes.

FIGURE 2
USACE Environmental Operating Principles.

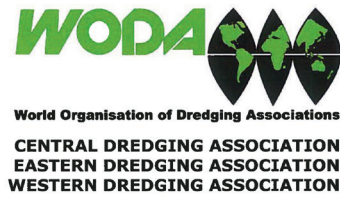
FIGURE 1
Sustainable Development Goals (SDGs) as published by United Nations (2015).

United Nations’ Sustainable Development Goals

Goal 01: End poverty in all its forms everywhere.
 Goal 02: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
 Goal 03: Ensure healthy lives and promote well-being for all at all ages.
 Goal 04: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
 Goal 05: Achieve gender equality and empower all women and girls.
 Goal 06: Ensure availability and sustainable management of water and sanitation for all.
 Goal 07: Ensure access to affordable, reliable, sustainable and modern energy for all.
 Goal 08: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
 Goal 09: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
 Goal 10: Reduce inequality within and among countries.
 Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable.
 Goal 12: Ensure sustainable consumption and production patterns.
 Goal 13: Take urgent action to combat climate change and its impacts.
 Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.
 Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
 Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
 Goal 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

FIGURE 3
The 17 Sustainable Development Goals (SDGs) are an urgent call for action by all countries – developed and developing – in a global partnership.





WODA PRINCIPLES OF SUSTAINABLE DREDGING

Dredging and dredged material management are essential if we are to maintain and improve our quality of life and economic well-being. This is achieved through the creation and maintenance of water-based infrastructure by navigation dredging and reclamation; enhancing environmental quality by beach nourishment or environmental dredging to remove contaminated sediments; providing flood control; producing minerals and construction materials, and supporting offshore energy production, including renewable energy.

By adhering to principles of sustainability that include working with natural systems to integrate these actions, the goals of environmental quality and economic prosperity can both be achieved.

WODA's objective is to achieve sustainable dredging through implementation of the following principles:

1. From the start and throughout each stage of a dredging project, social, environmental, and economic objectives should be systematically considered and integrated.
2. Development of a project design should identify how to work with natural processes and the site-specific characteristics of ecosystems to achieve the project's objectives, including understanding of the carbon footprint of a dredging project.
3. Project proponents, regulatory authorities and the broad range of stakeholders should be engaged at the earliest conceptual stage in the development of dredging projects. Active collaboration in the development of projects is the key to achieving maximum social, environmental, and economic benefits.
4. Scientifically based criteria, performance guidelines and environmental safeguards for dredging and dredged material management are essential to provide clear directions to project owners, planners and executing companies.
5. Dredged material management should be based upon a holistic and systematic understanding of the ecosystem and natural processes. Beneficial use of dredged materials, such as placement of sediment to nourish shorelines or to enhance or restore wetland ecosystems/marshes and upland habitat, should be given priority.
6. Dredging can be a key solution for remediation and restoration at historically contaminated aquatic sites.
7. Analysis of monitoring and assessment information before, during and after project implementation provides a basis for effective and sustainable project management.

Through the application of these principles of sustainable dredging, WODA believes that dredging will contribute to sound solutions that improve our well-being and protect our aquatic environment for future generations.

Anders Jensen
Chairman WODA Board of Directors

6 June 2013
Brussels, Belgium

FIGURE 4
WODA principles of sustainable dredging.

In view of the processes, variability and extremes associated with climate change, there is renewed motivation to consider the long-term sustainability of water infrastructure.

The sector-specific focus

In 2013, the dredging sector itself, through the actions of the World Organization of Dredging Associations (WODA) (which includes the CEDA, the Eastern Dredging Association (EADA), and the Western Dredging Association (WEDA), published its principles of sustainable dredging (see Figure 4).

The WODA principles reflect the importance of using dredging to create value across the three pillars of sustainability, considering the system-view of projects, including the ecosystem and natural processes operating within the system, and the role of engaging stakeholders (including project proponents, regulators, and the broader array of interests relevant to a project). Publication of the WODA principles has sparked a range of discussions and actions within the dredging sector in efforts to seek a balance between the economic development that is supported through dredging and environmental considerations and regulation.

Also, the recently published technical report "Sustainable ports: A guide for port authorities" (PIANC, 2014), from the port sector illustrates this shift towards an integrated and sustainable approach.

This guide is a joint report of The World Association for Waterborne Transport Infrastructure (PIANC) and International Association of Ports and Harbors (IAPH). It defines a sustainable port as "... one in which the port authority together with port users, proactively and responsibly develops and operates, based on an economic green growth strategy, on the Working with Nature (WwN) philosophy and on stakeholder participation, starting from a long-term vision on the area in which it is located and from its privileged position within the logistic chain, thus assuring development that anticipates the needs of future generations, for their own benefit and the prosperity of the region that it serves."

With regards to sustainable dredging it states the following aims: The Green Port goals related to sustainable dredging are primarily to keep the port's nautical access open, clean and safe. At the same time, the goals aim to:

- manage integrated dredging activities to create opportunities for improving environmental quality and at the same time creating or enhancing ecosystems;
- manage dredged material according to the philosophy of minimising quantity,

enhance quality, reuse with or without pre-treatment and long-term beneficial placement; and

- understand the local (and surrounding) environment and search for opportunities to use the natural processes including hydraulics, hydrology, geophysical, vegetation, benthos, etc., to maximise the efficiency of the dredging in both the short and long term.

Applying the concept of sustainability to water infrastructure development

The concept of sustainable development is based on the premise that the design for an action (in this case a development project that involves the use of dredging) will be informed by a full consideration of the values and costs of the proposed action across the three pillars of sustainability: society, environment and economy (see Figure 5).

The concept of sustainable development recognises the need to consider the full range of benefits and impacts related to human actions and the distribution of these benefits and costs across the social, environmental and economic domains. The relationships among these value

domains are reflected by the goal to take actions (e.g. develop projects) that will balance the distribution of benefits and costs so as to produce socially equitable, environmentally acceptable, and economically viable outcomes. This balance is achieved through active and consistent engagement with the stakeholders who will be affected by the proposed project, including government authorities, private sector interests, local/regional/national members of the public, and the special interest groups and perspectives that are relevant to the project.

In order to aid our discussion of sustainability in the context of infrastructure development and dredging we propose the following operational definition (in line with the definition proposed by Brundtland et al., 1987): "Sustainability is achieved in the development of infrastructure by efficiently investing the resources needed to support the desired social, environmental, and economic services generated by infrastructure for the benefit of current and future generations."

Here, we use the word infrastructure to refer to the diverse range of structures, features, and capabilities that are developed through the use of dredging (e.g. navigation channels and waterways, ports and harbours, levees and dykes), and nature-based infrastructure, such as islands, beaches and dunes, wetlands, reefs and many other forms of habitat. In practical terms, the sustainability of an infrastructure project is increased by:

increasing the overall value of the project through the range of services it provides; reducing costs associated with the project, where the word costs is being used in the broadest sense to include all of the monetary and non-monetary (e.g. environmental impacts) costs and resources consumed by the activity; and balancing the distribution of the value and costs among the social, environmental and economic domains over time.

Some practical implications for dredging

The importance of vision and value creation

For the vast majority of the history of dredging, the nearly exclusive focus of the activity was to generate the economic

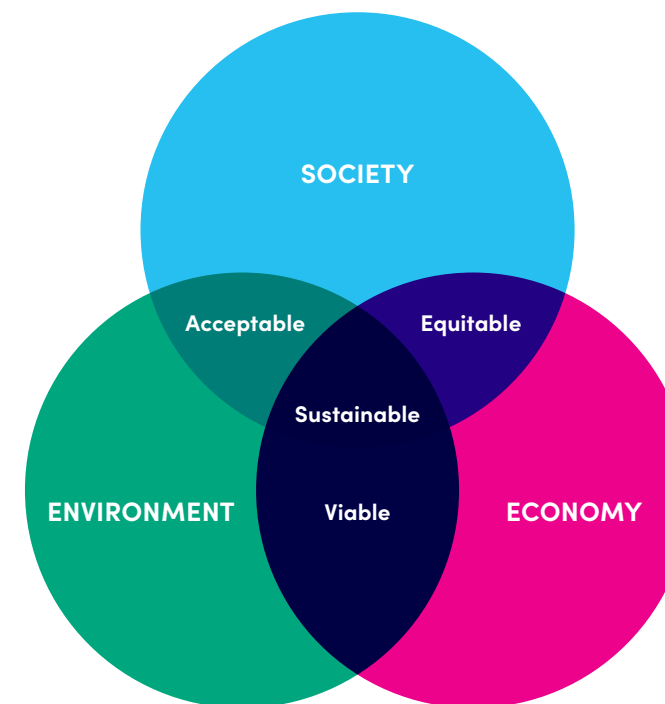


FIGURE 5
The three pillars of sustainability.

benefits produced by infrastructure. The incorporation of environmental and social factors (the other two pillars of sustainability) into the decision-making and governance process is a relatively recent development, mostly concentrated within the last 50 years. During the last few decades, significant technological and operational advancements have been made that have improved the dredging process in relation to the environment. That said, one of the biggest opportunities for increasing the overall sustainability of the water infrastructure sector is for project proponents, dredging contractors, and other stakeholders to invest more time and energy in up-front visioning to identify ways of creating more project value across all three of the pillars of sustainability. Such visioning will not diminish the importance of generating economic benefits from infrastructure, rather, it is more likely to reveal opportunities for creating additional economic value. By devoting more effort to identifying and developing positive social (e.g. recreational, educational, community resilience) and environmental (e.g. ecosystem services, habitat, natural resources) values, dredging and infrastructure projects will be able to avoid unnecessary conflicts with stakeholders while simultaneously developing a larger number of project proponents, advocates and partners.

Adapting projects to nature, rather than the reverse

Dredging is used to change or manipulate the physical structure of the environment to produce a feature or a function that nature did not and would not create on its own. For centuries, ports and waterway networks have been produced by creating a design for these systems and then imposing that design on the natural environment, with mixed results. Traditionally, designs were evaluated for their engineering performance and impacts on nature. Uncertainties related to performance and impacts were acknowledged to varying degrees. In the past, engineering was focused more on hydrology than ecology. In this historical approach, the engineering design and economic costs were dominant factors and effects on nature were secondary considerations. However, important lessons have been learned. Effects on nature and impacts in the coastal zone and rivers were underestimated or partly ignored in many cases. Lack of knowledge regarding sediment processes and the relation of these processes to local and regional geomorphology resulted in negative effects on engineering performance (e.g. higher than expected sedimentation in channels and reservoirs, erosion and scour around structures) and ecosystems (e.g. loss of habitat).

The ability to project long-term performance and effects was complicated by uncertainties. Hard structures, separating fresh and salt water and wet and dry areas (e.g. revetments, breakwaters, dams, walls, dikes etc.), were common engineering solutions,

in order to manage the hydraulics. Rivers were trained and dams were built to facilitate navigation, manage high water and flooding, and generate energy. In many cases these solutions have disrupted sediment processes, which have given rise to long-term effects and current, ongoing engineering and ecological challenges (e.g. shrinking reservoir capacity due to sedimentation, shoreline erosion, loss of coastal landscapes and habitats, etc.).



Change in coastal elevation at Horsey Island beneficial use sites between 1999 and 2015 (ABPmer, 2016, using UK Environment LiDAR data from 1999 and 2015).

Past engineering projects have certainly delivered major economic, safety and human welfare benefits. As time has passed and the infrastructure projects have “begun to show their age”, the adverse effects associated with these projects have become more and more visible, casting at least a partial shadow over the realised benefits produced by their construction. In view of the processes, variability and extremes associated with climate change, there is renewed

motivation to consider the long-term sustainability of water infrastructure.

Nature can be a stubborn and uncooperative collaborator when she is not adequately considered and consulted during the process of design. Winds, waves, and tides deliver force, water, and sediment against the products of our design with endless energy, which prompts us to spend our effort, time, and money reacting to nature’s onslaught. We have learned the lesson countless times that taming nature can be an expensive proposition. Integrating the concept of sustainability into our infrastructure projects will help us identify opportunities to cooperate and collaborate with natural processes, rather than seek to control and counter them. Working in this way we will adapt the port to the coastal ecosystem, the ship to the river, the local community to cycles of low and high water.

PIANC’s WwN philosophy incorporates this approach to navigation infrastructure development and the Building with Nature (BwN) programme in the Netherlands (De Vriend and Van Koningsveld, 2012, www.ecoshape.org) and the Engineering with Nature (EwN)[®] initiative in the United States (Bridges et al., 2014, www.engineeringwithnature.org) are implementing these practices across a wide range of water infrastructure projects. The opportunity and need to more directly incorporate nature into our infrastructure development process can be viewed at two different levels: the scale of the system the project is part of and the means of constructing and operating the project. Our infrastructure projects are part of a



The Sand Engine in the Netherlands – a result of the Building with Nature (BwN) programme.

system (e.g. an ecosystem), and the projects will both affect and be affected by the processes operating within that system. The more we are able to take these processes into account over the full life cycle of the project, the more sustainable the project can be. The more we use construction and operational methods, including dredging, that intentionally incorporate natural processes and materials, the more sustainable the project can be.

The new nature-based design philosophies draw attention to the opportunity and need to enhance natural capital, over the short and long term. As the concepts, techniques and tools supporting ecosystem services are implemented as a part of infrastructure practice, we will be able to communicate about sustainability more effectively within our project teams and with the broader community of stakeholders interested in our projects.

Taking the long view

Water infrastructure projects, due to the amount of investment they require, are long-term propositions. While the state of scientific and engineering practice continues to advance, there will continue to be uncertainties regarding the behaviour of natural and engineered systems over the long-term. Nevertheless, pursuit of sustainable infrastructure requires taking a broad and long-term view of a project's life cycle. Taking this broad, system view is necessary in order to determine whether the project can be expected to be sustainable over the long term, i.e. that the total value of the project over the three pillars of sustainability is judged to be sufficient in relation to the investment required to create that value. Performing such sustainability analyses could mean that some proposed projects will not be built, or that existing projects will be decommissioned and abandoned in favour of more sustainable projects. Some ports or waterways, for example, which cannot be efficiently sustained over time due to the effects of physical processes, coastal conditions, sedimentation, environmental impacts, etc., would receive reduced levels of investment in favour of ports and waterways situated in a more sustainable condition. When investment decisions are being made on the basis of the overall sustainability of the project, then we will know that the concept of sustainability has been successfully incorporated into the governance of infrastructure systems.

Three guiding principles of dredging for sustainability

Principle 1

Comprehensive consideration and analysis of the social, environmental and economic costs and benefits of a project is used to guide the development of sustainable infrastructure – Dredging is but one component of an infrastructure project, and any one piece of infrastructure functions as a part of a larger



Effect of environmental valve: valve off (above) and valve active (opposite page).

network of infrastructure as well as the surrounding ecosystem. Therefore, understanding the full set of costs and benefits of a project requires taking a system-scale view of infrastructure and the functions and services that infrastructure provides.

The costs (in the broad sense) of a project include all the resources, material, and negative impacts associated with executing the project and/or producing and operating the system over time. Likewise, the benefits generated would include all the values, services, and positive outputs generated by the project and/or system over time. Defined in this way, costs and benefits will include both monetisable and non-monetisable quantities.

While traditional economic analysis can be used to develop an understanding of the more readily monetised costs and benefits, for other values within the social or environmental domains different methods should be used to develop credible evidence about costs and benefits. Finally, one of the key opportunities for increasing the overall sustainability of water infrastructure is to seek opportunities to increase the



total value of projects by identifying and developing benefits across all three of the pillars of sustainability.

Principle 2

Commitments to process improvement and innovation are used to conserve resources, maximise efficiency, increase productivity, and extend the useful lifespan of assets and infrastructure – Innovations in technology, engineering, and operational practice provide opportunities to reduce fuel and energy requirements related to dredging and the operation of infrastructure. These same innovations can provide the means to reduce emissions (including greenhouse gases and other constituents) and conserve water and other resources.

By reducing the consumptive use of resources associated with dredging and infrastructure the sustainability of projects is enhanced. In addition, using better technologies or improvements in operational practice in order to extend the useful lifespan and functional performance of an asset (e.g. a navigation channel, an offshore island that supports coastal resilience), in a manner that lowers overall life-cycle

costs, will increase the sustainability of infrastructure.

Principle 3

Comprehensive stakeholder engagement and partnering are used to enhance project value – Stakeholder engagement plays an important, even critical, role in the governance of infrastructure projects. The level of investment and sophistication employed in the engagement process directly contributes to the degree of success achieved through the engagement. Early investment in stakeholder engagement should be used to inform the conception and design of a project.

Such engagement will provide important information about the values of interest to stakeholders and how those values can be generated by the project, in respect to the three pillars of sustainability. Furthermore, early engagement can help identify project partners who are interested in

Pursuit of sustainable infrastructure requires taking a broad and long-term view of a project's life cycle.

making contributions or investments toward particular values the project could produce (e.g. partnering with an NGO to perform ecosystem restoration as a part of the project). Pursued in this manner, stakeholder engagement can produce opportunities to increase the overall value of a project and to diversify the benefits produced across all three pillars of sustainability. This approach to stakeholder engagement is different to the historical use, which has been more focused on

reducing conflicts over project costs, which in the context of this discussion includes the negative impacts associated with a project (whether social, environmental or economic). For example, stakeholder engagement has been used as a means to proactively engage environmental interests concerned about port infrastructure, flood protection and dredging in order to minimise the risk of project delays and litigation. The information and knowledge that is produced through active and robust

stakeholder engagement provides a basis for increasing the overall sustainability of the project.

When the information leads to actions that increase overall project value, sustainability is enhanced. When these actions lead to reducing total project costs (including all monetary costs and non-monetary impacts), while producing the same level of benefit, the result is a more sustainable project and system. Likewise, actions that

increase project value (in terms of social, environmental, and economic benefits) for the same (or lower) costs result in a more sustainable project.

Traditionally, dredging projects have been focused on a narrow set of functions and outcomes (e.g. land reclamation, port basins and channels, coastal development, flood protection, pipeline trenches). A design was made and the effects on the environment and other functions were assessed, where possible mitigated, and, if needed, compensated. Stakeholders entered the project process late, during the permitting stage, where they were informed about the design, with limited opportunity to influence the design. This approach has frequently led to conflicts, project delays and frustration, for the developer as well as stakeholders. Increasingly now, more and more projects are developed in a manner that is more inclusive of stakeholder perspectives. At first, the focus on stakeholders was driven by aims to reduce the risk of project delays and lengthy procedural conflicts, but more recently this approach has evolved to include the mind-set of co-creation. In this mode of stakeholder engagement, values are created not only with regard to the primary motivation for the project (e.g. a particular set of economic outputs), but also to address stakeholder interests and values. This approach leads to value-added design and innovation, which will produce projects that are beneficial in regard to people, planet and profit (Elkington, 1997).

Practical examples

Environmental impacts can have consequences that affect other marine users. The livelihood of local fishing communities may be affected by

decreased fish stocks due to prolonged turbidity or deterioration of their fishing grounds. Coastal communities may be deprived from inhabitable land, cultural sites and natural wealth due to erosion or salinisation. Addressing these impacts is a requirement for project permits in many countries. Below are examples of dealing with these impacts.

Quantity of sand extracted

Between 1990 and 2023, dredged sediments were placed onto intertidal habitat to achieve both habitat restoration and coastal protection objectives at Horsey Island on the eastern coast of England. Sand and silt from capital and maintenance dredging at the nearby ports of Harwich and Felixstowe was used to create a mix of habitats including mudflats, marsh and a shingle spit to be used by nesting birds. The project has demonstrated that the environmental benefits can persist over decades. More case studies were collected by the CEDA Working Group on the Beneficial Use of Sediments.

Loss or degradation of marine habitats inside the dredging zone

For the extension Maasvlakte 2 of the Port of Rotterdam, 220 mln m³ of sand was Extracted between 2009 and 2013. The maximum extraction depth was 20 m below seabed, which is tenfold of the traditional limit. This reduced the directly impacted area from 110 km² to 11 km². Two sandbars mimicking natural sand waves were left behind after extraction to increase habitat heterogeneity. This is one of the optimisations researched in OR ELSE (recommendations for Ecosystem-based large-scale sand extraction) a consortium of 21 partners funded by the Dutch NWO programme.

Atafalaya River (USA).



Stakeholder engagement can produce opportunities to increase the overall value of a project.

Continuing with responsible dredging projects is key to sustainable development.

Nature-inspired design

In Atafalaya River (USA), Dredged sediment is placed in the middle of the river, just upstream a natural shoal, and contributes to the formation of an island. In 10 years, a 35 hectare island was created that hosts a rich wildlife habitat with access for recreation and a better aligned navigation channel.

Also prohibiting sand extraction in vulnerable habitats, has an inevitable impact on the livelihood of local communities. Even if these activities are illegal, they provide the means for survival of many of the local population. Any change in regulation to protect the environment should therefore be accompanied by measures to provide local employment.

These stakeholder impacts can be mitigated with the right regulations and ESIA procedure in place. In most projects, these regulations and procedures are beyond the scope and responsibility of contractors, but they can exercise due diligence and leverage and assist project owners with that responsibility.

A dredging project is short-lived and requires large deployment of human resources and equipment, often in little-developed areas. Yet it contributes significantly to the local economy in the form of: salaries for local workforce; local expenses (office, housing, transport, catering); local purchases and subcontracts (fuel, civil construction, fabrication, equipment rental); and

tax revenues (import duties, royalties, withholding tax, corporate tax, personal income tax on salaries).

The local content in the project budget can be improved by different incentives: onboarding and awareness training of local workforce with focus on health and safety, environmental care, diversity, equality and respect; training of local workforce when gaps are identified between required and available skills; selection and training of local suppliers based on labour and human rights, biodiversity, emissions, waste management and business ethics; advertisement of supply opportunities in local media; unbundling of contracts into units that are tailored to the local market; and engagement in local community projects.

Examples of these contributions are:

Stakeholder engagement

Port Philip channel deepening project, Melbourne, that involved the removal of 23 mln m³ of sediment of which 3 mln m³ was contaminated, was met with strong and continued opposition. The client and contractor formed an alliance contract to share responsibilities and risks, and also the communication effort, leading to successful completion of the project. Stakeholder acceptance of the project was a result of the accurate and transparent public communications which included public consultations, public hearings, a dedicated website, a 24-hour toll-free telephone number, weekly press conferences, media releases, mailing lists,

signage around the bay and notices to mariners. A vessel tracking system and online video data was used to prove that the operations proceeded in accordance with the environmental management plan.

Rebuilding villages after a flood

Around 70,000 people suffered from coastal flooding and erosion hazards in Demak, Indonesia and entire villages have been swallowed by the sea. Many people have experienced a major loss in income, reaching up to 60-80% in some villages. Also, the agri- and aquaculture sectors which are key economic engines in Indonesia have suffered multi-billion dollar losses. A project was launched to support the villagers through Building with Nature. The strategy for the area

was to restore the sediment balance and through that, the mangrove habitat by constructing permeable brushwood dams, in the near future, these dams will be overgrown by the mangrove forest. The results of the current BwN activities in the Demak district are encouraging. Sediments are indeed being trapped, restoring the coastal sediment balance and the mangrove habitat locally. The first mangrove seedlings have naturally established.

Sustainability for dredging practice: From philosophy to action

Dredging is connected to several SDGs, such as those related to navigation, coastal protection, and flood risk management. The dredging industry is increasingly

recognising the need to incorporate these goals into the infrastructure development process and communicate how projects align with the SDGs.

Climate change continues, energy transition is a fact, the growing world population calls for more sustainable cities and the need for food will increase. The demand for dredging will only increase, therefore, continuing with responsible dredging projects is key to sustainable development. The industry will continue to advocate for sustainability and promote dredging for sustainable infrastructure along with conducting more research on the topic to better projects that truly contribute the UN Sustainable Development Goals.

Construction of permeable dams by local contractor under supervision of the BwN team. On-the-job training is an important part of the BwN approach.



Check out the book *Dredging for Sustainable Infrastructure*.

Nature-based Solutions in Benin

A stakeholder partnership

In early 2018, the Government of the Republic of Benin awarded Jan De Nul a design and build contract to protect a 5-kilometre-long stretch of coastline near the town of Avlékété.

The project fits into the government's plan to turn the local coastal zone, which includes a lagoon, sandspit and beaches, into tourist hotspots. Yet the persistent oceanic swell and chronic erosion required an intervention.

This is the perfect starting point for a nature-based structure that offers multiple ecosystem services. Its long-term effectiveness, however, hinges on the support of its end users.

Stakeholder engagement was therefore central to the project.





Fishermen preparing their nets for “pêche à la senne de plage”.

Designing a submerged breakwater

Beach erosion is a well-known phenomenon along the West African coast. The consistent, monodirectional oceanic swell induces sand transport along the coast from west to east. Climatic change, sea level rise and human-made structures, such as river dams, groynes and breakwaters, disrupt this process. The breaking waves that drive this process also impose hazards to those wanting to swim or launch boats into the sea. These are just two groups who would therefore benefit from a milder wave climate.

Despite this general understanding of coastal processes, there is very little measured data available about the sand transport and its effects on the coast. Local knowledge institutions and researchers were contacted to assist in an extensive investigation into the driving forces and effects of existing structures. The groynes previously built perpendicular to the beach have proven to be inefficient in reducing erosion on Benin’s beaches. We therefore sought inspiration in nature’s most effective wave breaking structures: coral reefs. These natural structures combine three key functions that groynes do not provide: 1) they absorb wave energy; 2) they redirect it perpendicular to the coast; and 3) they host a rich ecosystem.

The concept design that resulted from this investigation consists of a submerged breakwater parallel to the coast at 150 metres off the existing low-water coastline. Its location and height were optimised in line with the depth and reach of the installation vessel. Its shape was finetuned with numerical and physical models in the Braunschweig Hydraulic Institute. The breakwater has two ingredients: a 1 to 500 kg foundation layer and a core of 1 to 3 tonnes of locally quarried rock units. These characteristics form

a structure that does not hinder the open sea view and reduces the incoming wave energy on average by 60%. The swimming conditions score 3.8 on the Beach Safety Rating (Short and Hogan, 1994), a method adopted by the World Health Organization. This score corresponds to the 20 percentile of world’s safest beaches.

Local stakeholders

While the design concept may provide a solution to the project requirements, it affects the activities of the local fishing community. Local fishermen traditionally deploy long nets parallel to the coastline and retrieve them from both ends by pulling from the beach (“pêche à la senne de plage”). Another technique used is to deploy nets from canoes and retrieve them from the water (“pêche à la pirogue”). The economic situation of the fishing community is also precarious because of the steady decline of fish stock in Benin’s coastal waters.

To facilitate good relations with the community, we appointed a community relations officer who organised information and awareness committees. The purpose of the breakwater was explained and the benefits were highlighted: 1) The large rock units and the voids between them will create a new biodiverse and abundant ecosystem that can boost fish stocks; and 2) the mild wave climate at the leeward side of the submerged breakwater will attract recreational swimming and snorkelling, facilitating economic development, in particular ecotourism.

At first, the local fishermen were sceptical towards the breakwater construction because its presence would make the “pêche à la senne de plage” impossible and increase the sailing distance

for their canoes. However, through continuous conversation, the fishing community became aware of the nature-related benefits. The fishermen shifted towards fishing with nets set out and retrieved from their canoes. Those who did not or could not shift their methods were financially compensated and provided with new land for use, allowing them to pursue alternative livelihoods. This comprehensive approach ensured that the needs and concerns of all stakeholders were addressed.

The benefits of a living biodiverse and bio-abundant reef extend beyond the local community. It is compliant to the sustainability objectives of the Ocean Panel (see www.oceanpanel.org) and the Green Globe Certified coastal resorts (see www.greenglobe.com).

Construction phase

The project started with a field survey that provided input data for the Environmental and Social Impact Assessment (ESIA). The ESIA was supervised by Antea group and ACL Consultants. The monitoring programme, set up in collaboration with the Benin Institute for Halieutic and Oceanographic Research (IRHOB) and the University of Abomey-Calavi (UAC), included a wide range of environmental and water quality parameters. 34 different benthic species were identified (mainly molluscs). In general, the impact assessment described the naturally occurring biodiversity of the benthic diversity to be low. Fish, sea turtles and marine mammals were described but not quantified.

The breakwater was built in three seasons, taking advantage of the mild climate between November and April. Starting in November 2018, 2 km of breakwater were installed in the first season. In the second season, the breakwater was extended westwards by another 2 km. The third season, completed in April 2021, saw 5.2 km of breakwater installed. In addition, sand was reclaimed on the eroded beach leeward of the constructed breakwater at the end of the second and third season.

Social impact actions

Taking advantage of the facilities during construction, the following three social impact actions were undertaken.

Rock Bujumbura

In 2019 and 2020, our installation vessel Pompei was mobilised with a special cargo. The Belgian not-for-profit organisation Rock Bujumbura collects and repairs musical instruments that have fallen out of favour and gives them a second life in Rwanda, Togo or Benin. Our transport and technical department joined forces to safely package and store instruments onboard Pompei and our project team delivered them to three local music academies.

Beach cleanup

With the slogan “a leap day is a day won”, we organised a beach cleanup on 29 February 2020. Waste grabbers, shovels, rakes and reusable baskets were provided to 150 volunteers, who covered 48,000 m² and collected 4.5 tonnes of waste.

Terres Rouges

After three years, our project staff said goodbye to the local community. As a token of appreciation, we donated our living and office furniture to Terres Rouges, a Belgian organisation committed to psychosocial care of neglected children in Benin. The furniture is being used to expand their shelters and help facilitate the operation.

Environmental monitoring campaigns

While we had evidence of past projects that the breakwater would soon become a biodiverse habitat that lives up to expectations, its evolution remains invisible and difficult to access. We have therefore organised three environmental monitoring campaigns in cooperation with our local partners.

2020 campaign

The first environmental monitoring campaign was organised in early 2020, just before the start of the sand reclamation. Near the breakwater we monitored environmental and water quality parameters, gained a general understanding on fish diversity through baited remote underwater videos (BRUV), organised two dive inspections for video footage of the breakwater itself and collected sediment samples near the breakwater for benthic analysis. The most important development was observed at the

There should always be time for a bit of music. The special cargo of the Pompei consisted out of 52 musical instruments that were delivered to the local music academies.



seaward side of the breakwater where several species associated with rocky environments – sea urchins, sponges, soft corals, juvenile hard corals, lime algae, crabs, barnacles and eels – were observed.

2021 campaign

In 2021, the scope and method of the second monitoring campaign were slightly adapted based on the lessons learned from the first campaign. The dive inspections were carried out by a team of spearfishermen that were used to the waves and currents near the breakwater allowing them to approach it to collect scrape samples. Nets were set out to monitor fish diversity and abundance, and interviews were conducted with the fishing community.

Combining local knowledge with European expertise, about 50 different fish species were observed, next to sea turtles, soft and hard corals, molluscs, sponges, lime algae and sea stars. There was a general scientific consensus that the submerged breakwater contributed to a substantial ecosystem development in

terms of biodiversity and bio-abundance compared to the adjacent coastal stretches. The return of the considered disappeared commercial fish (including *Pseudolithos* sp or Cassava-drum), is probably the best indicator.

Interviews proved that the perception of the local fishing community had taken a turn for the better. The three main topics that were touched upon were: 1) adaptation of fishing techniques; 2) overall findings on fish catch before and after the breakwater construction; and 3) impacts of the breakwater on biodiversity and communities. The reappearance of commercial fish species convinced the community to see the nature-inspired design as a positive contributor. Their direct involvement in the fishing net surveys and close relationship with researchers of IRHOB also led them to have a better understanding and appreciation of the ecosystem benefits originating from the breakwater.

The increase in sea turtles nesting on the protected beach was considered as an added value for the planned

ecotourism services provided by the submerged breakwater.

2024 campaign

The monitoring campaign was repeated in early 2024 and extended with an eDNA analysis performed by the Flemish institute of fisheries (ILVO). In total, 76 unique fish species were identified. 11 species were listed on the IUCN red list as near threatened or higher of which five species were exclusively found near the breakwater. The benthic analyses revealed over 200 different morphospecies including a wide array of reef-building species. The research concluded a large gap in diversity between a sandy reference location and the rich ecosystem correlated with the breakwater.

Interviews with the local fishing community were repeated. Their statements reinforced our belief that commitment to nature-inspired designs had become deeply rooted in the community. During their daily excursions on the water, the fishermen witnessed the restoration of marine biodiversity. They mentioned in particular the increase of sea turtle

Researchers from IRHOB performed taxonomic identification of fish species captured along the breakwater during the monitoring campaigns.



Local stakeholders are our allies in making this project a long-term showcase for nature inspired design.

From each unique fish species captured along the breakwater, a small piece of fin was sampled for DNA barcoding.



nests on the protected beach. Prioritising transparent communication facilitated our successful collaboration on this project. Fishermen who frequently fished near the breakwater had adapted their techniques in such a way that fishing is possible again by using shorter nets and reeling them in onboard their canoes.

Workshop

On 26 June 2024, a workshop was organised in cooperation with the Benin Institute for Halieutic and Oceanographic Research (IRHOB) and the Benin Centre for Scientific Research and Innovation (CBRSI) to present the findings of the three monitoring campaigns. The 66 attendees included journalists, researchers, fishermen, teachers, authorities and NGOs. The outcome of the biodiversity surveys was presented and discussions were held about the ecotourism potential, the ecosystem services for fishermen and tourism, the conservation and preservation of the fish habitat and the collaboration between stakeholders and the industry. The workshop was picked up in the media with two television news items, a radio interview a newspaper article and an online video.

For many stakeholders, the deep dive into the ecosystem services provided by the breakwater (e.g. tourism development,

biodiversity enhancement, fisheries, coastal protection) turned out to be a revelation. The scientific institutions participating in the project found evidence in the presented findings that more data and understanding of the local fauna and flora would lead to better decisions, and a healthier, more sustainable and more attractive environment.

Future potential

The success of the workshop reassures us that we have reached the outcome that we aimed for: A solution that meets the client's requirements, contributes positively to the local biodiversity and that is endorsed by a large stakeholder community. This project also shows that a contractor can do more than abide the contract specifications and legal requirements. The initiatives described in this article – the musical instruments, the beach cleanup, the office furniture, the monitoring campaigns and the workshop – were outside of our contractual scope. We did it because we thought it was the right thing to do.

We all wish that this project can be a showcase for a nature-based solution for a long time to come, but we are aware that there are obstacles on the way. A change in development plans, short-term

economic gains, rivalry between political parties or between contractors, parasites or natural disasters, can all jeopardise and decimate this achievement. This is where the power of stakeholder management lies: now that the contractor has withdrawn from the project site, it is up to the stakeholders to stand ground.

Ruben Geldhof

Marine Environmental Department, Jan De Nul nv, Belgium



Jonas van Acker

Marine Environmental Department, Jan De Nul nv, Belgium



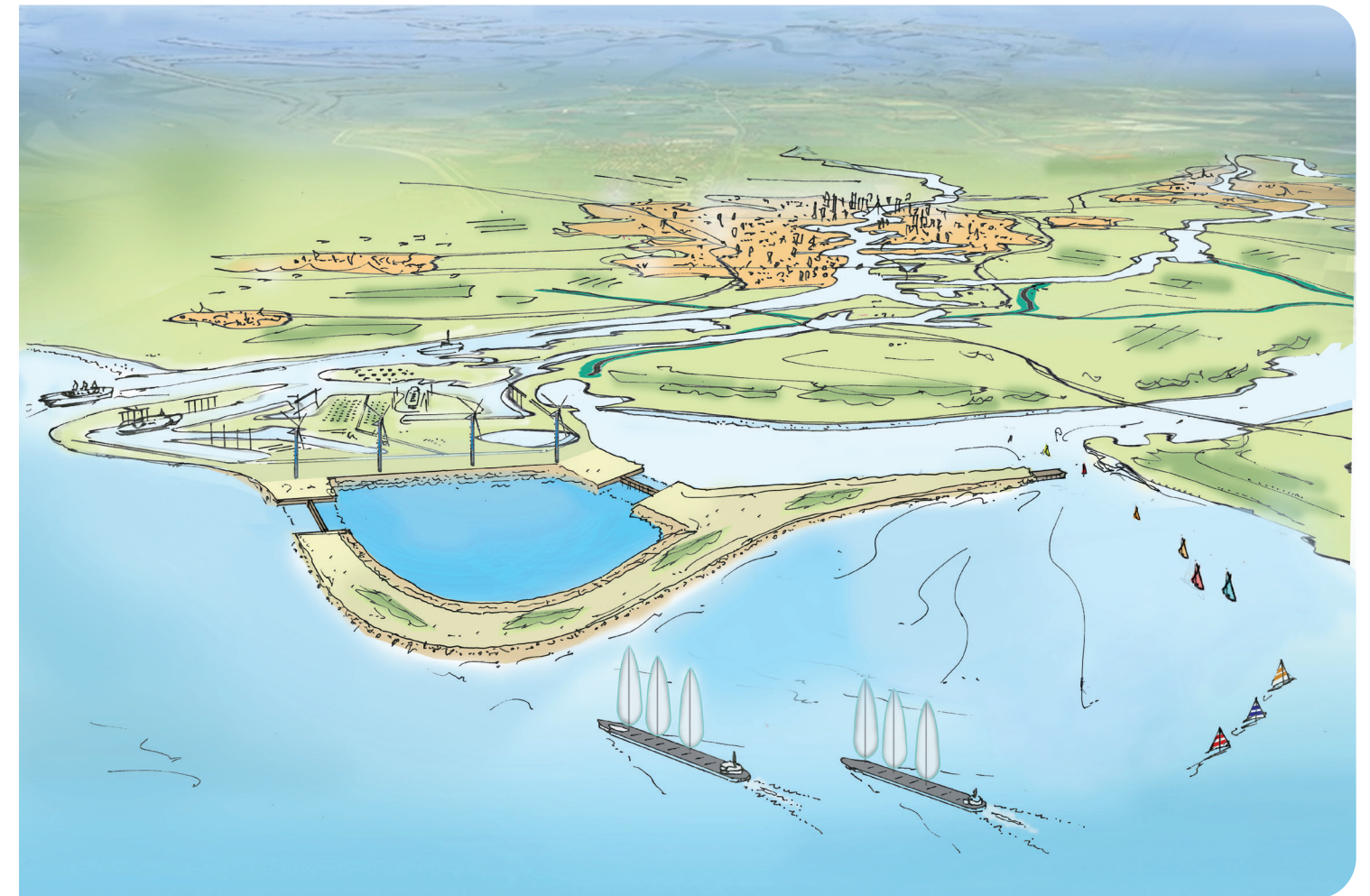
DELTA21

Combining flood protection,
energy storage
and nature restoration



Design by Esmée van Eeden, Delft University of Technology, the Netherlands.

Sustainability, innovation and collaboration are key to successfully facing today's global challenges of grid congestion and climate change. To combat these challenges, the Delta21 concept has been developed in the Netherlands. Located in the mouth of the Haringvliet estuary in the Dutch Delta, the project combines energy storage, flood protection and the restoration of nature. The concept could be elaborated upon and applied worldwide, inspiring governments, public bodies knowledge centres and developers to face climate change and move away from fossil fuels.



Bird's eye view of the lake that will be created by the Delta21 project at the Haringvliet estuary. Image © C Concept Design.

Building with nature through an integrated approach

The Delta21 project involves creating a 32-metre-deep lake in the Dutch Delta, which will be used to store approximately 34 GWh (gigawatt hours) of sustainably generated energy using the Pumped Storage Hydro (PSH) principle. Utilising pumps with a capacity of 10,000 m³ per second, the project will also improve the flood protection in the Dutch Delta. The strategic position of the site near Maasvlakte 2 (Rotterdam's new port area) in the offshore Delta also offers great opportunities to strengthen both biodiversity and the ecosystem in the mouth of the Haringvliet. It provides an outstanding example of the building with nature approach. The initiators of the concept, Huub Lavooij and Leen Berke, joined forces with several companies, educational institutions and public bodies for the development of this innovative concept.

The Delta21 concept consists of two basins. The 50 km² storage lake will

be the lower basin. Its different water levels will be interconnected with pump turbines, allowing for the generation of gravitational energy due to the differences in height. The North Sea will form the upper basin of the PSH system. The installed capacity could be increased from 2 to 12 gigawatts, allowing the surplus of generated energy to be stored. PSH is proven to be a mature principle that is responsible for 93% of energy storage worldwide.

Given the minimal height differences in the Netherlands, "low-head/high-volume" pump turbines will be used. The storage lake will also provide the possibility of discharging excess water from the river by means of pump turbines, preventing flooding in the hinterland and providing an attractive alternative to constructing dykes in densely populated areas.

The Delta21 concept also offers opportunities for building other eco-friendly solutions, such as floating solar

parks, wind parks, aquaculture and other opportunities to strengthen nature and increase biodiversity. The concept could be applied worldwide in flat areas, especially in densely populated low-lying coastal areas, with a demand for energy storage and flood protection where nature conservation is at stake.

The answer to energy transition challenges

The energy transition – the transition from conventional to sustainable energy – places great importance on the security of the electrical supply. The Delta21 concept allows for 34 GWh of energy storage. 2 GW of installed capacity could provide the storage or delivery of 34 GWh in 24 hours, corresponding to a maximum of 5 terawatt hours annually. According to TenneT, Transmission System Operator (TSO) for the Netherlands, this is approximately 10% of the required storage capacity for 2050. The storage capacity could easily and gradually be increased from 2 GW to 12 GW, allowing for the surplus of

Pumped storage hydro (PSH)

The principle of a PSH power plant is similar to a conventional hydroelectric power plant. The PSH plant foreseen for Delta21 will exchange water between the North Sea and the lower-lying storage lake. The water levels will vary between 5–28 metres, which is low compared to applications in mountainous areas. For that reason, the use of closed Archimedes pump turbines is foreseen. In times of high energy supply and low demand, the turbines will pump water from the lake into the higher North Sea. On the other hand, during times of low energy supply and high demand, water from the North Sea will be released to the lower storage lake via turbines, generating electricity. The water will remain in the lower reservoir until it is pumped back to the North Sea when energy supply is high and demand is low. As a result, the water level in the storage lake will vary between -5 and

-28 metres Mean Sea Level (MSL), whereas the bottom of the lake will lie at -33 metres MSL. During this process, 1,100 million m³ of fresh nutrient-rich salt/brackish sea water will be exchanged with the North Sea.

On the sheltered Haringvliet side, a series of Archimedes pump turbines will be located on a sand dune. The required number of 20-megawatt pump turbines will depend on the chosen installed capacity. The range of each pump turbine will be approximately 25 metres. The circular water screw will be made of a composite and have a diameter of 10 metres. The length of the screw will be approximately 80 metres. The Archimedes pump turbines will be very efficient (0.85–0.95% one way), sustainable, fish friendly, inexpensive and easy to maintain, with a life span of at least 60 years.

Large-scale energy storage is therefore essential for maintaining a sustainable energy supply.

generated energy to be stored as long as needed. At 12 GW of installed capacity and 4 hours of filling time, the storage lake could produce up to 30 terawatt hours per year. With 40 km² available for installing solar parks, wind farms and even aqua batteries at the bottom of the lake, an additional amount of energy could also be stored.

On a windless day, there is no energy generated from wind. However, if there is more wind and solar energy available than is used, we often throw that energy away. Large-scale energy storage is therefore essential for maintaining a sustainable energy supply. The energy storage lake in the Delta21 concept can make an important contribution to this.

Meeting increasing flood protection demands

The energy storage lake in the Delta21 concept offers a wonderful opportunity for temporary water storage and a huge pumping capacity during extreme weather events such as storms. The economically valuable downstream areas of the Rhine and Meuse in particular, are threatened by the combination of storm surges, high river discharges and rising sea levels. During heavy North Sea storms, the water level along the Dutch coast can rise 4-5 metres within a few hours. In those cases, the storm surge barriers along the Dutch Delta estuaries are closed to prevent flooding. However, the protective barriers also prevent the outflow of river water

into the sea. Due to climate change, sea levels are expected to rise in the coming decades. Additionally, the risk of rivers overflowing also increases as we experience more heavy rain throughout the European river basin, requiring drastic measures. Delta21 offers an attractive solution for this.

Facing environmental challenges

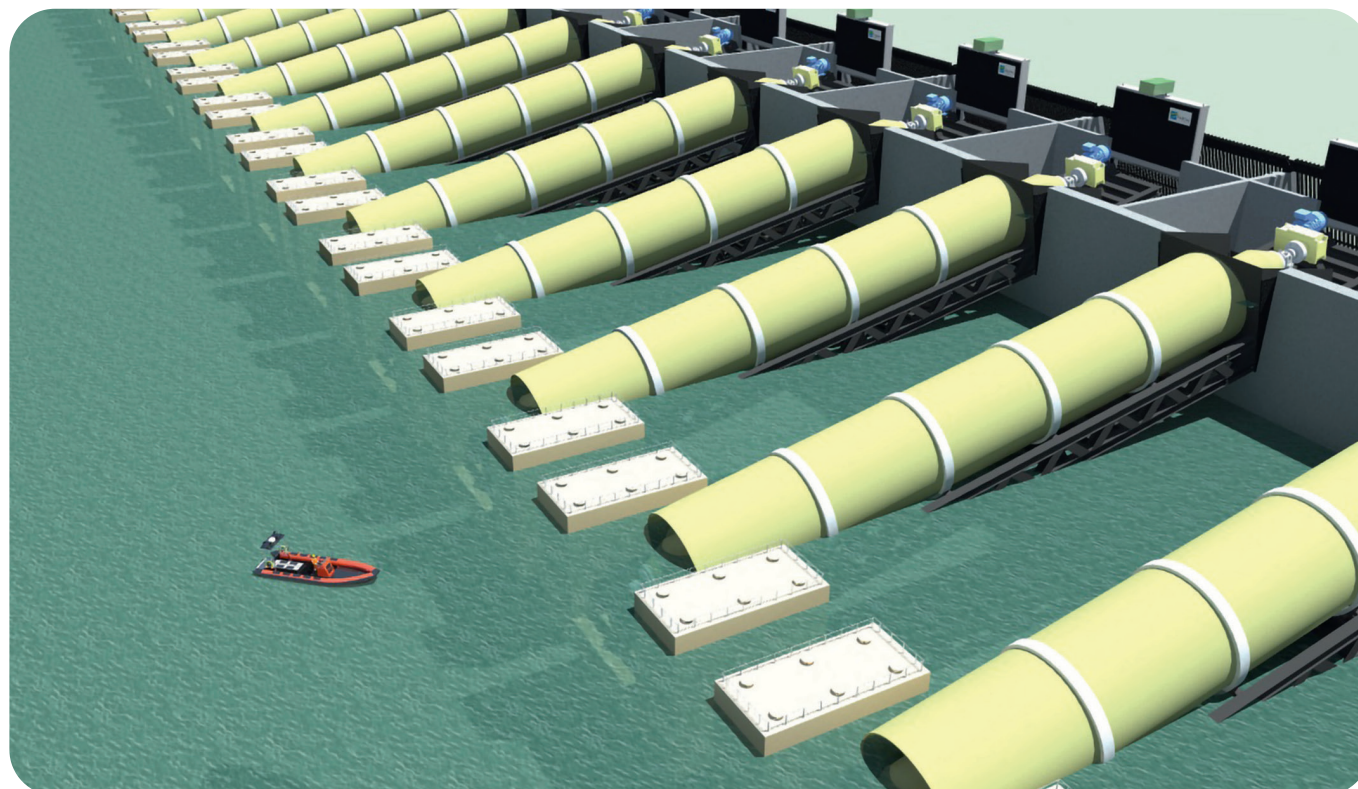
The mouth of the Haringvliet is under environmental pressure. Biodiversity in each of the four adjacent protected areas, Kwade Hoek, Duinen van Voorne, Voordelta and Haringvliet is slowly decreasing. Haringvliet used to be the main tidal estuary connecting the North Sea with the Rhine and Meuse, and was unique for its rich brackish water biotope. As part of the Delta Works, Haringvliet was cut off by a dam whose locks normally remained closed. Consequently, the Haringvliet estuary became a freshwater lake. Fish migration was strongly reduced and tidal currents weakened or even disappeared. This resulted in the sedimentation of the Haringvliet's mouth and had consequences on the brackish ecosystem and recreation.

Currently, the sea west of the Haringvliet dam (the Voordelta) is experiencing considerable silting up. Continuous dredging in the narrow channel is needed to allow Stellendam's fishermen to continue sailing. Even though some salt water has been allowed to enter Haringvliet since 2020, the measures have been insufficient to reverse the decrease in biodiversity.

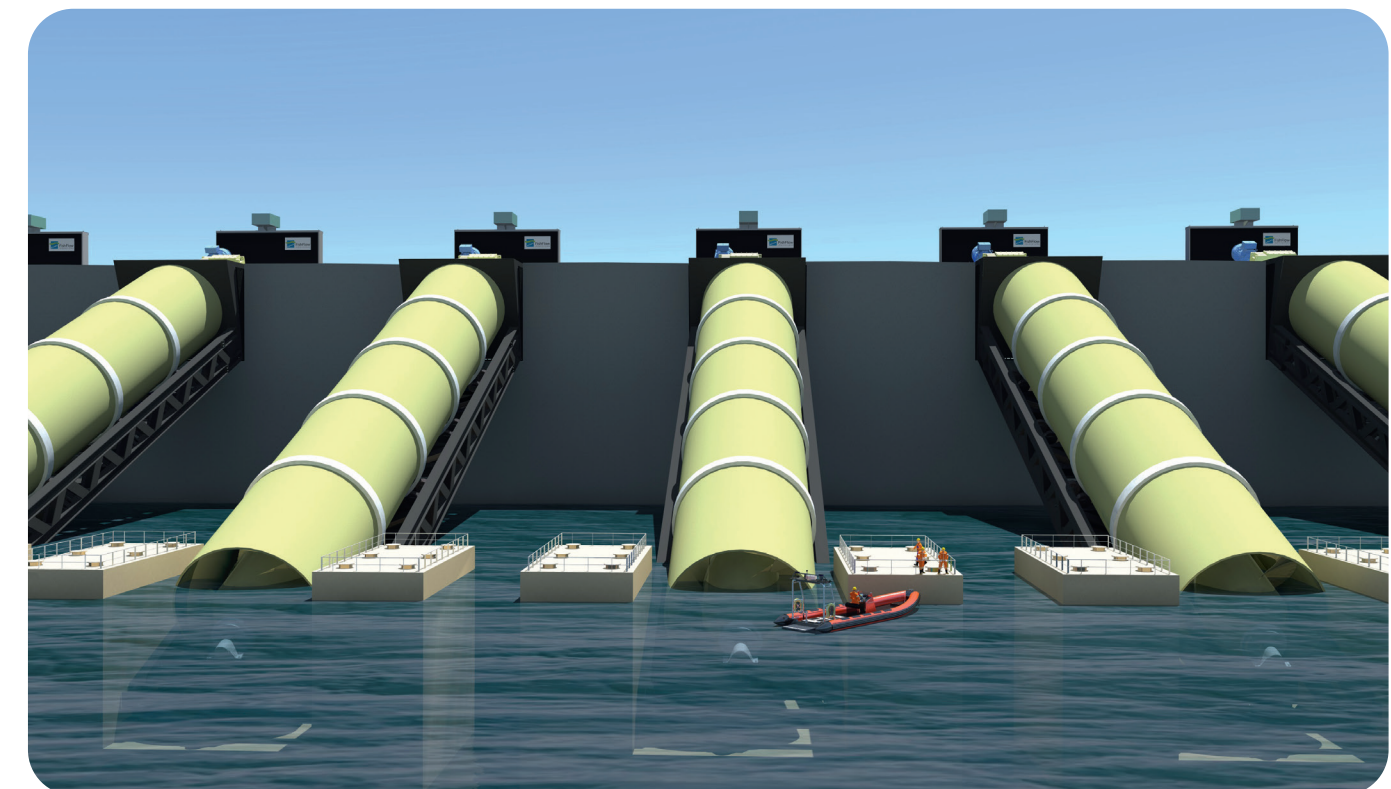
A simple and effective alternative

The question arises, where and when we will encounter the limits of building higher and wider dykes? Moreover, strengthening dykes has a major impact on the built environment. The Delta21 concept offers an alternative that is worth the calculation. The storage lake will be able to hold 1,100 million m³ of water. To put that into perspective, the Rhine discharges a maximum of 18,000 m³ per second, amounting to 65 million m³ per hour. This would mean the Rhine could flow into the storage lake for 17 hours before it is full. In addition, there would be more than a hundred Archimedes pump turbines functioning together as one mega pumping station.

In terms of water safety, the Delta21 concept is a simple and more effective alternative to continually raising and strengthening the dykes. For that reason, both the provinces and the water boards are looking into the benefits of Delta21 in the field of water safety with great interest.



Closed Archimedes pump turbines, developed by FishFlow Innovations, allow the safe passage of fish through the pump system.



Archimedes pump turbines. Images © FishFlow Innovations.

Causes and effects of biodiversity decline

The closing off of the Haringvliet estuary in 1970 by a dam as part of the Delta Works disrupted the existing nature and biodiversity in the four Natura 2000 protected areas and beyond. The decision to separate salt and fresh water by the Haringvlietdam had an impact on the biodiversity and fish migration between the North Sea and the Rhine and Meuse rivers. In addition, the consequent disappearance of tidal currents and waves caused sedimentation in the coastal morphology in the Voordelta and in the Haringvliet, negatively effecting navigation, as well as recreation and tourism. The salt spray caused by breaking waves, which

creates a number of unique salt-loving plants in the Voornse Dunes, practically disappeared.

As a result, sand is being transported along Kwade Hoek and the Hinderplaat is moving further towards Rockanje. The displacement of the Hinderplaat and the silting up create a major threat to the beach of Rockanje, as the siltation creates a sandy and mudflat biotope instead of beaches. The sedimentation also requires continuous maintenance dredging to keep the narrow, winding channel from the North Sea to Stellendam at a navigable depth.

For that reason, the Delta21 plan includes positioning a brackish tidal lake of approximately 50 km² in the shallow eastern part of Haringvliet's mouth in the Voordelta, allowing new brackish nature to emerge. Gullies, banks and creeks will transform the tidal lake into a rich natural habitat for flora and fauna. On the wind and wave sensitive North Sea side, the lake will be separated from the sea by dunes, offering opportunities for new and

extended biodiversity. The sand available from the deepening of the storage lake will be used to shape the dunes.

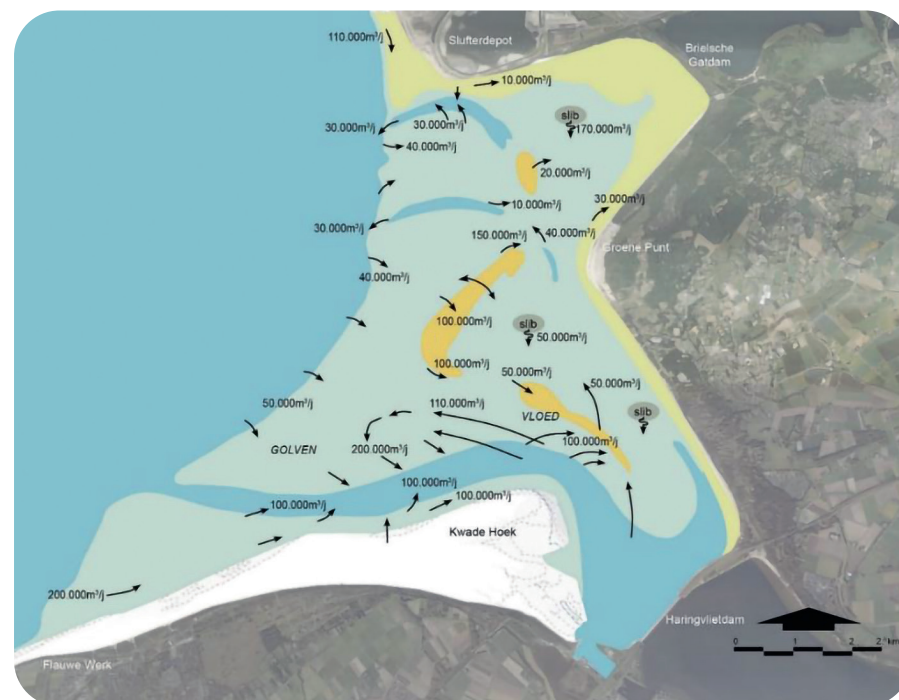
Restoring biodiversity and stopping sedimentation

Constructing the energy storage lake in the deeper part of the Haringvliet estuary would prevent Hinderplaat from moving further towards Rockanje. The silting up of the Kwade Hoek would

be stopped as well. To minimise silting, measures are being taken to direct the silt flow into a deep shipping channel that is to be constructed.

The shallow area between the energy storage lake and the Haringvliet locks also offers space for the 50 km² tidal lake in the Delta21 concept. The salt-brackish water in the tidal lake will partly restore the original brackish water

Gullies, banks and creeks will transform the tidal lake into a rich natural habitat for flora and fauna.



Current sedimentation process at the mouth of the Haringvliet. Photo © Arcadis.

biotope. Moreover, the tidal lake will be favourable for the migration of fish between the river area and the North Sea. The Delta21 concept plans to further support fish migration by constructing a fish migration river between the tidal lake and the Haringvliet.

Biodiversity will be stimulated by creating a row of dunes on the west side of the energy storage lake where breaking waves will provide the salt spray needed for unique salt-loving plants. Banks and channels will alternate in the tidal lake. Artificial reefs, terraces, floating platforms and other nature facilities in the energy storage lake will contribute to the restoration of the original biodiversity as well. The Delta21 concept offers plenty of opportunities for nature restoration, preventing the shore from slowly but surely turning into one large silt and sand plain.

Local demand for energy storage

The Delta21 concept is strategically positioned south of Maasvlakte 2, where TenneT already has an approximately 8-gigawatt transformation station available connected to the 380 kilovolt (kV) high-voltage network. However, large-scale storage is lacking. With a storage capacity of 34 GWh, the energy storage lake in the Delta21 concept will relieve the burden on both the TenneT transformation station and the 380 kV high-voltage network.

Maasvlakte is part of the port of Rotterdam, a 40% conventional energy port with an industry running mainly on conventional energy. The port sector attaches great importance to the design

of a sustainable energy hub with large-scale storage in the immediate vicinity. The Delta21 energy storage lake in the Haringvliet estuary could well serve as the sustainable energy hub for Rotterdam.

Business case

The construction costs for the energy storage lake amount to EUR 8 billion, based on 2023 price levels. Although the technical lifespan is longer, these construction costs can be amortised over a hundred years. In the existing access channel to Stellendam, there is room for a new 200-metre-wide/8-metre-deep navigation channel. This has not yet been included in this amount. The operating costs are comparable to the operating costs of a power plant, however, the operation of a power plant is much more complex. For the energy storage lake, only an operator is needed to switch on or convert the pumps and turbines.

The consultancy firm Horvat & Partners BV has validated the Delta21 design, our implementation method and the costs. CE Delft has investigated the quantitative merits of the energy storing of Delta21. The study shows that Delta21's levelised cost of storage (LCOS) is cost-competitive with favourable financing and sufficient full-load hours, all based on a depreciation period of 30 years.

Way forward

Since it has been determined to be technically and financially feasible based on proven methods, the "final step" is to convince politicians and the government. Various initiatives are underway to

achieve this. Several informal discussions are being held with the Dutch Ministry of Economic Affairs and Climate and the Ministry of Infrastructure and Water Management. They find the integration of solar and wind farms within the concept promising and advocate connecting the energy storage lake to the new nuclear power stations that may be built in Borssele, as well as the hydrogen factories to be built on the Maasvlakte. Huub Lavooij commented, "If we get the green light, one of the biggest challenges will be to immediately implement this project in its full extent. You cannot first 'practice' this on a small scale and then scale it up. But we will undoubtedly find solutions for this too."



Huub Lavooij
Owner Delta21 BV,
the Netherlands.



Dick van den Heuvel
Business Development
Manager, Van Oord,
the Netherlands.



Gerard Manshanden
Owner, FishFlow
Innovations,
the Netherlands.

Making strict choices

Co Verdaas, the Delta Commissioner in charge of all water safety measures, when presenting his Delta Programme in 2024, urged that we speed up and set limits on the use of space and water. He added, "That also means making stricter choices about where we do and do not build, where we create space to store water for dry periods, and where we reserve space for future dyke improvements." At this point in time, the emphasis of the water safety measures lies entirely on the dyke reinforcement programme.

TALKING HEADS

Lara Muller Director Public Sector, Invest International

Lara joined Invest International in January 2023 as Director Public Sector and is responsible for developing, financing and overseeing the implementation of large infrastructure projects in developing countries. Former head of public affairs at Boskalis, Lara was a permanent member of the EU's platform on sustainable finance for two years, advising on EU taxonomy and strategy. She also teaches creating shared value and sustainable finance at Nijenrode Business School in the Netherlands.



WHAT IS THE ROLE OF INVEST INTERNATIONAL AND HOW DOES IT MEASURE THE IMPACT OF ITS INVESTMENTS?

Lara Invest International has two activities in house. It provides loans and equity to Dutch entrepreneurs aiming to expand internationally and, on behalf of the Dutch Ministry of Trade and International Aid, it provides grants and sovereign loans to governments in emerging countries to realise public infrastructure projects. Founded in 2021, with 51% owned by the Dutch Ministry of Finance, its focus is on impactful, sustainable and innovative businesses. We get deeply involved in these businesses and support them not only with capital, but also with the knowledge we have about operating abroad.

We measure our impact primarily on SDG 8 and secondly on SDG 13. The creation of jobs is paramount, whether in the Netherlands as a contribution to the national GDP or in the partner countries we operate in. A lot of people think it's green impact, that it has to be sustainable, which for us is conditional. The aim for us investing in public infrastructure in emerging economies is really to create jobs. It's a critical step to help countries move from aid dependency to an equal trade position because we firmly believe that charity is not the solution. We need to help them stand on their own.

WHAT IS WETLANDS INTERNATIONAL AND ITS SCOPE OF WORK?

Pieter Wetlands International is a non-profit conservation organisation oriented at conserving wetland ecosystems for people and nature. Wetlands are a very broad category of ecosystems. They encompass all areas that have water, except for deep seas and large lakes. This includes, for example, mangroves, salt marshes, river systems, peatlands and seagrass meadows. More than 40% of global biodiversity can be found in wetlands, but they are also important for people. They protect our coasts against extreme events, they store large amounts of carbon, they provide fisheries, the list goes on and on.

We implement a large number of initiatives across the world. Some of these are conventional

It's not only about people thinking out-of-the-box but making the box bigger!



Coastal protection site in Beira, Mozambique, where Invest International and partners are working to safeguard the coast and 600,000 residents.

conservation projects where we protect ecosystems for their intrinsic value and to maintain their unique biodiversity. Yet most projects take an integrated approach where we aim to maintain the unique values of wetlands for local communities and the economy at large. Our core message is that truly sustainable development is impossible without putting care for our natural system at the heart of it.

HOW DOES THE ORGANISATION INTEGRATE CONSERVATION WITH INFRASTRUCTURE DEVELOPMENT?

Pieter In our programmes, we promote the adoption by the coastal and water engineering sector of Building with Nature (BwN). This approach promotes integral approaches to infrastructure development that maintain and build on the values of nature and incorporate the needs of local stakeholders. It has been promoted by the EcoShape consortium of which we have been a partner for many years. As an NGO, we add a complementary voice to the perspectives of partners from the private sector and academia within the consortium. We see our role very much as a convener and connector, fostering alignment of corporate, community and broader societal interests. The EcoShape programme offers a safe space where all partners are able to drive innovation jointly, without being restricted by the limitations of conventional projects.

However, we observe that many mainstream projects in the water and coastal engineering sector continue to have a far-reaching negative impact on ecosystems and local communities. For this reason, we are also working with marine contractors directly. In these collaborations, we support adoption of Building with Nature in day-to-day operations and contribute to resolving broader sustainability concerns.



Pieter van Eijk Programme Head, Deltas and Coasts, Wetlands International

Pieter leads the Deltas and Coasts programme, overseeing implementation of the strategy in over 20 countries, coordinating programme development and supporting implementation of projects on the ground. As a member of the EcoShape consortium, he works closely with engineering and marine contractors, promoting more sustainable approaches to coastal infrastructure development, in line with the Building with Nature (BwN) philosophy.

WHAT'S THE IMPORTANCE OF COLLABORATION BEYOND TRADITIONAL VALUE CHAINS?

Lara Current collaborations in infrastructure projects are often linear, with each party (governments, consultants, financiers, contractors) working in sequence rather than together. If we really want to move the needle, we need to have a more circular way of collaborating. Decisions taken early in a project have an impact throughout and if the fundamentals are wrong and misinformed, it can be a recipe for disaster.

And this is where the EcoShape consortium comes in to collaborate pre-competitively in an effective way. NGOs and parties that are responsible for the execution should be sitting at the table at the earliest stage of the process to support and work with financial institutions to get the right message across to the client before things are decided, designed and shaped. They bring invaluable environmental and social insights, which need to be engaged from the start. But also in terms of innovation, as we often see that contractors are continuously working on innovating their way of working and are often confronted with a tender set in stone with little room to offer alternatives.

IS BEING INVITED TOO LATE IN THE PROCESS A COMMON OCCURRENCE?

Pieter Yes, very much and Lara said it perfectly. In almost all cases NGOs are not seriously involved. They're considered stakeholders from a compliance perspective, often engaged only to show that there has been a participative process. We're usually brought in when the full design is already on the table, leaving little room for meaningful environmental or social improvements. You lose the opportunity to avoid a lot of potential negative

impacts and maximise the impact that you can create by developing an inclusive approach. Infrastructure projects can be sensitive by nature. There's a lot of money and interest involved. And many partners in the sector remain a bit hesitant to engage with NGOs. When we joined EcoShape in the early days, some people considered all NGOs as activists chaining themselves to ships and protesting, without realising that many operate as critical yet constructive dialogue partners. Luckily that is changing now.

DOES THE MISCONCEPTION ABOUT NGOS STOP COLLABORATION?

Lara It can and I think financial institutions are wary of NGOs because some are more into activism than into collaborative models. What I experienced with Wetlands International however, and this isn't always the case with NGOs, is that they find ways to engage without going to the press, without trying to harm reputations, and always try to solve things in dialogue. They proved themselves to be a great partner to work with. Critical, of course, but that's their role, as it should be.

HOW CAN INVESTORS AND NGOS WORK TOGETHER?

Lara I think Invest International and NGOs like Wetlands International have a unique opportunity to address gaps left by governments and companies. Governments often rely on narrow engineering solutions due to limited knowledge, while companies tend to wait to see what the client wants. I try to encourage companies to step out of that box and be more proactive in bringing new approaches to the table. It's not only about people thinking out-of-the-box but making the box bigger! It's also about relationship building. Building trust, being transparent. Being able to collaborate on

an equal level with stakeholders I think is the key. And I think it's the one skill that we need to future proof our companies, future proof our projects and to get nature-based solutions out there.

Pieter I agree, building trust is essential but often overlooked. You have to invest a lot of time. It's also about appreciating each other's complementary values. There's often a lack of understanding about the role and value of NGOs. Some view NGOs as either activists to be avoided or as ineffective talkers. When you really engage in a practical collaboration people start to appreciate our work. One of our partners from the dredging sector recently said, 'Thanks to our engagement with you, we now better understand what it really means to bring community perspectives on board and how you can engage communities directly in large-scale engineering efforts.' Our local knowledge, acquired through our global network of 20 offices, is also highly valued.

IS THERE A LACK OF KNOWLEDGE WHEN IT COMES TO SUSTAINABILITY?

Lara There's a huge knowledge gap from all perspectives about SDGs, about sustainability, about climate change and it's not something that can be tackled alone. We need to be smart and find efficient strategies to address it without constantly reinventing the wheel. I feel the nature-based solutions movement struggles with continually staying in the pilot phase. It's crucial to shift focus from just developing technical aspects to scaling up and leveraging processes to include diverse stakeholders. Collaborating with EcoShape, a neutral pre-competitive body, can facilitate bringing various parties together, including NGOs and companies, without explicitly highlighting their presence. We really need to standardise working together and to look for that collaboration strategically. A lot of approaches to nature-based solutions are being developed, piloted and matured. I think we should start developing, maturing and scaling up a collaboration approach together as an industry.

SUSTAINABLE INFRASTRUCTURE IS OFTEN SEEN AS MORE EXPENSIVE. HOW DO YOU CONVINC THE POLICYMAKERS OF THE LONG-TERM BENEFITS AND THE NEED TO INVEST IN SUSTAINABLE SOLUTIONS?

Lara The thing is it's hard to quantify. You know there are 250 methodologies to measure impact and still that doesn't convince people. However, showing a loss of 2 million euros from project delays due to local protests, that speaks volumes. Particularly when you can show that if they had invested 200,000 euros in dialogue, grievance mechanisms and local NGO engagement it would have been far more cost-efficient. Numbers talk

We use storytelling as a way to share our projects and to demonstrate the benefits of an integrated approach.

but they need to be presented in a context that decision-makers can understand and relate to. I consider nature-based solutions as much a social as an environmental approach to infrastructure, so not investing at the front end might be a "penny-wise, pound-foolish" strategy.

Pieter I don't think nature-based solutions are necessarily more expensive; they often offer a strong business case that's societal rather than financial. For example, a salt marsh dyke provides ecotourism benefits, boosts local fisheries, stores carbon and reduces flooding risks, benefiting many stakeholders. However, decision-makers must recognise and justify these broader benefits, which aren't always easily translated into financial terms. Connecting these benefits to international commitments such as SDGs can strengthen the case, showing how integrating social and environmental aspects can enhance infrastructure projects and meet broader goals.

WHAT CHANGES ARE NEEDED IN DEMANDING NATURE-BASED SOLUTIONS?

Lara The way we tender is one and it's the reason why we no longer engage in price-only tenders. With up to 50% of project value coming from grants, we want tenders to prioritise quality. We're now experimenting with requiring at least 40% of evaluation based on quality and conducting ESG pre-checks to exclude companies with poor environmental, social or governance records, including corruption. European dredging companies, especially Dutch companies, are top of their field in technical and environmental standards but need a fair competitive playing field. We're also considering mandating to have a nature-based solutions alternative in every tender and using a sustainable procurement toolkit to guide tender structuring.

HOW DOES WETLANDS INTERNATIONAL ADVOCATE FOR CHANGE?

Pieter Aside from engaging as a stakeholder in consortia around concrete projects on the ground, we also actively engage with umbrella organisations such as IADC. And through collaborations with development banks, such as the Asian Development



Trapping mud behind temporary permeable structures to stabilise the coastline and allow mangroves to seed and grow. @Wetlands International



Read about the valuation of externalities in maritime infrastructure projects.

Bank and the World Bank, we advocate for involving stakeholders from the outset, changing tender procedures and encouraging more inclusive designs. In calling for all these changes, we use storytelling as a way to share our projects and to demonstrate the benefits of an integrated approach. For example, as part of EcoShape, we coordinated a successful pilot project in Central Java, combining engineering with mangrove restoration and community engagement. The project demonstrated the effectiveness of nature-based solutions and won several international awards.

IS LACK OF VISIBILITY AND AWARENESS ABOUT NATURE-BASED SOLUTIONS A FACTOR?

Pieter Definitely and it's a frustrating one because I share Lara's sentiment that we have wanted nature-based solutions to take off much faster than is happening. Now in the Netherlands we see things slowing moving in the right direction, where the government is really stepping up to fund commercial projects based on pilot projects. Unfortunately, in the developing world we still see a big need to get things started.

The good news is that we also see some of the large development banks doing the same as Invest International, by specifically asking more for inclusive approaches. One of the things we're doing now within the EcoShape consortium is mobilising a programme called Building with Nature Asia. We want to develop pilot projects in five Asian countries that show, in different contexts, what these kind of nature-based solution approaches could look like.

But we don't just want to stimulate Building with Nature bottom-up. We also want to support policy reform, capacity building, knowledge development and raising awareness through overarching regional and national scales. Our hope is that this dual approach will address the barriers that currently prevent these projects from kicking off. Hopefully we can create a space where clients demand these kind of approaches and where project developers feel more encouraged

to actually actively propose them. Then we can connect the supply and demand, create a level playing field and move away from compliance and towards developing high-quality projects that both clients and developers are excited about.

HOW DO YOU CONVINCE GOVERNMENTS OF THE NEED FOR CHANGE?

Lara While we have to convince everyone that you should just do this because it's a smart thing to do it and it will boost the quality of your project, I think we need to steer away a little from the word sustainability. And instead talk about "healthy projects" and "healthy economy" because, for a lot of people, sustainability has become a political agenda that they don't understand anymore. I think by constantly promoting the green side of things, that perhaps we're not doing ourselves a favour. Perhaps we should really be focused on convincing governments and stakeholders that this is not about the moral thing to do, because ultimately that's a personal choice, but because it's the smart thing to do, both economically and qualitatively.

If we really want the nature-based solutions discussion to move out of the piloting phase and the very niche environment that it's currently in, perhaps we should also think how we sell it. And if we try selling it as being about quality, about having a "healthy project", we will avoid the lack of knowledge around what sustainability is and what it encompasses. It's a case of reframing the thinking.

Pieter I recognise the negative connotation some people have with the word "sustainability". They tend to think it's going to be expensive, that it's going to be complicated, it's going to delay things, we'll have to engage with all those consultants who tick their boxes. While compliance is important, you would create such a better atmosphere and a much higher quality project if you just turn things around entirely. Start understanding the system that you are working in. What natural values are in play, what does the hydrology look like and the sediment dynamics? How is the landscape governed? What does the economy look like and how do people live? Building this understanding and responding to the needs of local stakeholders without disrupting the natural system is the only way to develop a good design. And don't forget that nature is a key stakeholder in itself that is rarely being heard.

Lara To add another dimension to that, I think competitiveness is very important particularly from a business perspective. Not so much for governments, but for companies here within Europe that are really having to work extremely hard to remain competitive in a very difficult environment



Lara Muller and Bonaventure Kalou, Mayor of Vavoua, at the signing of a concessional financing package of EUR 300 million between Invest International and the Government of Ivory Coast.

WHAT DO YOU SEE IS THE MAIN WORK FOR INVESTORS IN THE FUTURE?

Lara I think for us as a financial institution, and partly as a governmental financial institution, we can do a lot by engaging with other international financial institutions, such as the World Bank and the Asian Development Bank, to discuss these matters and align more on how we tender projects and what our requirements are. How do we get the nature-based solutions in there? How can we work together, also with commercial banks, in order to align within the financial world on the necessity and the urgency? Also the methods we can propose as financial institutions to be adopted by the client receiving the money, which are generally other governments. It's often a world where our people have to spend a lot of time going backwards and forwards between ministry departments, that don't speak with one another. Again it comes down to trust. They don't trust each other so how are they going to trust us? We work in 44 countries. It just comes down to basic communication and putting things in place where people talk to each other and align on the same page.

dominated by state subsidised entities that compete on price. By incorporating this approach we're providing them with a way better competitive environment in order to differentiate themselves from the competition on the basis of the right arguments. And not one of price only.

WILL IT TAKE POLICY REFORM TO REALLY ACTION CHANGE?

Pieter For Wetlands International, there's a very large role related to our role as communicators. What we see works in society in terms of approaches, which things we see don't work and bringing voices from local communities and other stakeholders to the ears of the policymakers. And we're already doing that a lot, by sitting around the table with regulators and policymakers to make sure they take that on board. There are two ways in which we facilitate the process. First by bringing that information from society into the policy arena and secondly, what we see a lot in many countries, bringing together different ministries – that don't talk with each other and that pretty much compete with one another – around a single table. Surprisingly we can often have a strong role in working around those dynamics and frictions by quite literally just inviting them to come together. And it can be truly transformational.

And that's where, as an NGO, we're not bound by commercial considerations, by very specific requirements on what we should or should not do. In our projects, we have a freer role and can continue to make the box bigger.

Don't forget that nature is a key stakeholder in itself that is rarely being heard.

Communication skills and listening. Listening is another key skill to understanding people and what their position is. We benefit a lot from working with embassies. They're instrumental in helping us as they're the ones who have a relationship with the people of that country and with the government. We very much depend on them for their knowledge and network, as I know do a lot of entrepreneurs. So again, it's a case of let's not reinvent the wheel. We need those partnerships, with embassies, with NGOs, with contractors, and we need to start developing that way more strategically. We need to standardise it and integrate best practises because we surely don't need to keep reinventing the wheel.

It's also culture. Changing and developing intercultural and interpersonal skills. Hiring a different DNA within dredging companies that means not only the engineers and technical roles but more strategic communicators. There's a world to win for financial institutions there too and there's homework for us all.

We're also considering mandating to have a nature-based solutions alternative in every tender.

An aerial photograph showing a long, narrow beach stretching from the top left towards the horizon. The beach is wide and sandy, with some construction equipment and materials visible on it. To the left of the beach is the ocean with white waves breaking onto the shore. To the right of the beach is a coastal town with buildings, roads, and some greenery. The sky is blue with some clouds.

SAND MOTOR protecting coastal communities in Togo and Benin

The coastline of Togo and Benin moves between 1 and, in some places, even 10 metres every year. Land inwards, of course. Climate change is the cause: sea level rise leads to coastal erosion and that poses a direct threat to economic activities and life on the West African coast. “The inhabitants of this region depend primarily on fishing and tourism for their incomes and livelihoods. Thanks to this coastal protection project, they can benefit from the opportunities the beach and coastal environment offer them, now and in the future,” says Boskalis regional manager Pieter Boer.

Just imagine, you open the door of your home and your entire living room is covered with a metre of sand. Before the summer of 2022, this was the harsh reality for hundreds of coastal residents in Togo and Benin. Calculations by the World Bank, among others, show that coastal erosion amounts to more than 2.5 metres a year in Togo and as much as 4 metres in Benin. Locally, even more serious cases of up to 10 metres a year have been observed. In addition, along the entire West African coast, the number of flash floods due to increasingly turbulent weather, which in turn is caused by climate change, is rising drastically, affecting half a million people annually.

A total of some 200,000 people live on the coast of Togo and Benin. Most of them by far depend on fishing and, to a lesser extent, on arable farming. With long nets attached to their boats, fishermen sail out to reel them back in a few hundred metres away in the South Atlantic, hoping for a catch. But can the thousands of fishermen in the coastal region continue to do that work, and

support themselves and their families, when their homes are being devoured by the rising seawater? No. In other words, coastal erosion has catastrophic consequences for their way of life and their survival in the places where they have lived and traded for generations.

Sand motor

The dredging work that has been executed will preserve living conditions on a part of the Togolese and Benin coasts for decades to come. Even though that may sound unlikely, this is an accurate picture. With the construction of 15 new groynes, and the reinforcement of another six that were already in place, the project means that all the sand on the beach will be kept in place. In addition, the rock structures built at right angles to the beach mean that erosion will be less severe than in recent years.

Furthermore, with the help of Boskalis' trailing suction hopper dredger Willem van Oranje, the beaches have been raised with more than a million cubic metres of sand. Not only that, a sand motor

consisting of 6.4 million cubic metres of sand has been created on the Benin side of the border, and that sand will be spread along the coastline by the currents in a natural way. The Willem van Oranje made exactly 790 trips from the offshore sand borrow area to the coast for this nature-based solution.

Boskalis was awarded the contract by the governments of Togo and Benin, with funding coming from the World Bank. Discussions with Boskalis convinced both West African countries of the potential of the proposed dredging solution. Because strengthening this section of the coast by implementing a dredging solution means that coastal residents can rest assured that their homes will be protected for the next 50 years. Since only part of the beach was closed off during the work at any given time, and completed sections were immediately returned to the community, the social impact of the far-reaching work on the coast was limited. And the regular base for fishing, and therefore economic activity, was kept intact throughout the operation.



The sand motor under construction.

Fishermen on the beach in Togo.



The coastal protection project has given the region a huge boost.

Sand motor

The sand motor is a hydraulic engineering concept developed by Dutch dredgers Boskalis and Van Oord in collaboration with the Dutch government, universities and research institutes. It was introduced successfully on the Dutch coast between the Hook of Holland and Scheveningen 10 years ago. In Africa, it was used for the first time on a large scale in Benin. The idea behind it is relatively simple. A huge amount of sand is deposited with trailing suction hopper dredgers in a strategic location and the natural movement induced by the wind, waves and currents spreads it along the coast over time. That counteracts the coastal erosion resulting from the impact of the same elements. In short, it is a nature-based solution to a major societal problem.

Research has shown that nature-based solutions of this kind are increasingly seen as an effective solution for these and similar challenges. Because a sand motor not only preserves the natural environment, it also supports the local communities and economies that depend on protection for the coastline. However, one of the major challenges facing countries on the West African coast is funding. Working with an organisation like the West African Coastal Areas Management (WACA), supported by the World Bank, proves that governments, industry and international organisations can get together to implement climate-adaptive solutions and protect vulnerable coastal areas from the impact of the rising waters. The coastal protection project in Togo and Benin provides a forceful demonstration.

WACA

The coastal protection project in Togo and Benin is part of the West African Coastal Areas Management (WACA) programme. This programme was developed in collaboration with local communities on the coast, who depend on the region for their livelihood, food security and well-being. Thanks to the World Bank, WACA can support the efforts of several countries to improve coastal management and mitigate natural and human-made risks to coastal areas.

Because coastal erosion leads not only to the loss of homes and beaches – as well as the region’s most lucrative working area – but also to damage to existing infrastructure such as roads. Nevertheless, Togo and Benin are not the only countries in West Africa suffering from coastal erosion. The World Bank has designated seven countries around the Gulf of Guinea where this is a problem. In addition to Togo and Benin, they are Senegal, Ghana, Nigeria and the islands of São Tomé and Príncipe.



Local children with their bikes on the new cycling path.

Indeed, now the work has been completed in this part of West Africa, that base is now even stronger. And that is precisely one of the goals of the West African Coastal Areas Management (WACA) programme, which includes the coastal protection project. “The inhabitants of this region depend primarily on fishing and tourism for their incomes and livelihoods. Thanks to this coastal protection project, they can benefit from the opportunities the beach and coastal environment offer them, now and in the future,” says Boskalis regional manager Pieter Boer.

Soccer pitch, drones and jet skis

Indeed, the coastal protection project has given the region a huge boost. And not just socially and economically. The number of tourists visiting the region has also increased significantly, in part due to the planting of an urban forest and trees, and the construction of cycle paths. In addition, an existing soccer pitch was re-laid. The pitch was in danger of being lost to coastal erosion but dredging work was done to stop that happening. In a joint effort with local residents, the pitch was actually overhauled

to create a fully-fledged sand pitch where, for example, schools can organise sports lessons. A not unimportant detail here is that the young people no longer have to cross a busy road to get to the sports field, making things safer for the inhabitants, young and old.

But let’s return to the dredging work itself. Here too, the local community was emphatically involved and local materials were used whenever possible. For example, much of the rock in the existing groynes was reused and other rock was mined

from an inland Togolese quarry. Moreover, from the outset of the project, local residents were involved in the onshore project organisation. They were trained as surveyors, for example, which allowed them to use theodolites, specially equipped drones and even a jet ski to see firsthand how their “defence sand” was applied and how it held up in the occasionally turbulent conditions of the South Atlantic.

Idea embraced by government

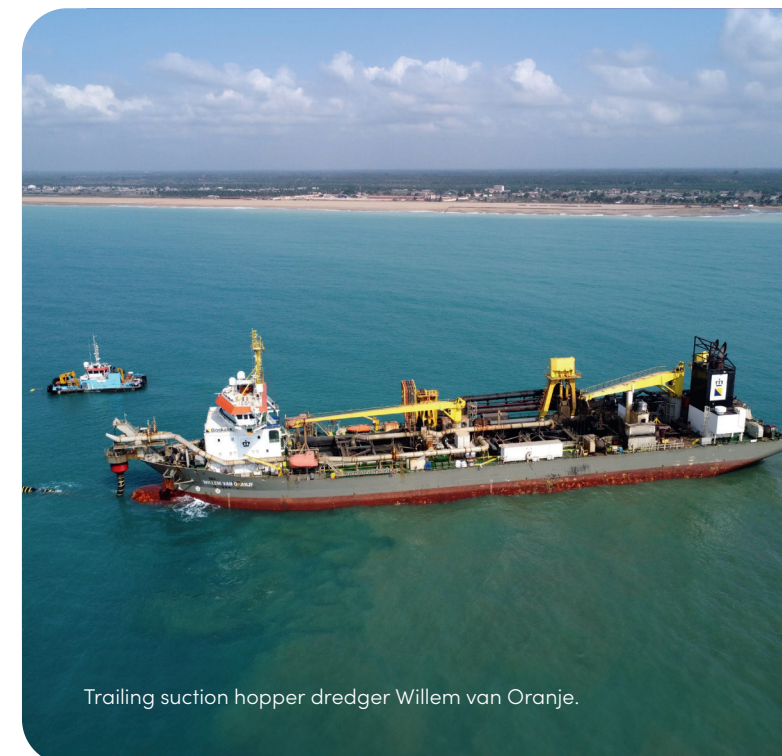
The final cubic metre of sand was applied to the beach in the summer

of 2023. A few months later, the entire project was completed, including some additional community initiatives in both countries. On the beach in Benin, for example, there are now several concrete toilet blocks equipped with septic tanks. In addition, rainwater is collected that visitors can use to wash their hands. This prevents the beach being polluted by people using it as a toilet. The government has now embraced this initiative, with plans to extend it along the entire coast of Benin.



Bas Boerma
Communications
Advisor,
Royal Boskalis,
the Netherlands.

Community engagement.



Trailing suction hopper dredger Willem van Oranje.

Key figures for the Togo and Benin coastal defence project

- Project duration: 19 months
- Deployed trailing suction hopper dredger: Willem van Oranje (Boskalis)
- Number of hopper trips: 790
- Dredged volume: 7.0 million m³
- Volume sand motor: 6.4 million m³
- Coastline covered by sand motor: approx. 30 kilometres
- Number of new groynes: 15
- Number of rehabilitated groynes: 6
- Amount of rock: 250,000 tonnes
- Project staff: 250 people

Boskalis also constructed a 5-kilometer-long cycle path along the beaches and four public toilet facilities.



DEPLOYING PRIVATE CAPITAL to accelerate the green transition

Green solutions in ports, waterways and coastal projects have increasingly become available thanks to many years of research and pioneering efforts in practice. These sustainable solutions have shown to be good alternatives for classic solutions, but application is far from mainstream yet. One of the major hurdles is the lack of access of private capital to finance these kinds of solutions despite the strong interest of capital markets in green infrastructure opportunities. Identifying the hurdles and paving a way forward to overcome these hurdles could therefore help to increase the uptake of those green solutions.

A promising perspective

Although state-of-the-art sustainable solutions have proven to be effective in practice, application at scale is certainly not the case. A major hurdle is that these types of solutions almost entirely rely on direct public investment and the willingness of governmental bodies around the world to take such a step. This limits the uptake and scaling of such solutions.

From the investment side, limitations in public budgets mean there is a bigger role for private capital to play to finance such projects. Moreover, increasingly this private capital is seeking such green opportunities. This increase is driven by fiscal regimes, regulations and reputational drivers. This capital is deployed, for instance, in wind parks, solar fields, electrification of railways, but seeks further diversification in the infrastructure sector. Deploying private capital to accelerate the uptake of green solutions for ports, waterways and coastal projects is therefore a promising perspective.

This particular issue came to table in discussions with the Swiss based MAVA foundation in 2019. This foundation aims to push sustainable development in a wide sense. Leveraging the force of capital markets to make real-world impact is a key pillar of their approach. The discussion led to the idea to build an initiative around the topic of financing green infrastructure in and around ports, waterways and coastal areas. This idea quickly took shape in a cooperation between Vital Ports (a Dutch NGO dedicated to this topic), B Capital Partners AG (Swiss-based Infrastructure Investment House), Swiss Re (Re-insurance Company), IADC (International Association of Dredging Companies) and CEDA (Central Dredging Association).

Financial partners

The Swiss Re Group is one of the world's leading providers of reinsurance, insurance and other forms of insurance-based risk transfer, working to make the world more resilient. B Capital Partners is an independent investment house established in 2003 in Zurich. They work with, and for, international institutional investors and large family offices, often

in close co-operation with developers. Linking these Swiss networks to the networks of the dredging community at large therefore seemed a promising way forward.

A promising perspective, however, is not something that will unfold itself to deliver its fruits, as soon became quite clear. To find the synergy, a roundtable was organised in Zurich at the Swiss Re Centre for Global Dialogue. This roundtable, with representatives of all involved organisations and their constituents, took place in February 2020.

The roundtable clarified a few points. The first being that the financial world and the world of dredging and engineering companies speak different languages. The financial specialists were very unfamiliar with vocabulary, project types and activities of the dredging community. And vice versa. The landscape of financial concepts, specialisations, interests and way of working was a lot to digest for the dredging community. Secondly, it was clear both communities aim for similar goals; increasing the uptake of green infrastructure projects, which is in line with the ambitions of all individual companies at the table. Thirdly, it was clear that progress can only be made when mutual understanding is further increased.

A joint study

The dialogue in Zurich asked for a practical step to gather all current understanding and knowledge about green projects and finance in a dedicated report. Such a report could be used to support further conversation with a wider variety of actors in the field. This led to the publication of the report "Financing of Sustainable Marine and Freshwater Infrastructure: A joint study to explore financing of green coastal, river and port projects". The report is based on the findings of a broad international team of experts.

The study provides six key lessons to enhance the uptake of green investment in this sector. In a later stage, these lessons have been summarised in an infographic. This article discusses the key lessons, introduces the infographic and discusses the further reflections on

the key lessons from a wider audience. Conclusions and recommendations are also provided.

Green port and waterway infrastructure

Before diving deeper into the role of private capital, it is useful to describe what is meant by green port, waterway and coastal infrastructure and how this differs from classic solutions. (Note: terms, such as green and sustainable are used interchangeably in this article. The collection of works at coastlines, rivers, canals and port areas are generally required to enable or provide flood protection, urban development, port development, navigable waterways and upgrade of recreational areas. Perhaps most telling is a summary of project types that describe the field. Classic examples, not necessarily green, are:

- land reclamation;
- flood barriers like dams, dykes, dunes;
- beach nourishment;
- integrated coastal zone management;
- riverbank protection;
- dredging of navigable waterways;
- port development; and
- breakwater construction.

Green variants of these assets can be seen as ranging from "more sustainable than a classic solution" up to nature-based solutions where benefits of natural processes from ecosystems help to deliver upon project needs. In general, the sustainable concepts are not only technically different, but also rely on early and extensive stakeholder involvement and execution methodologies with minimised ecological impact. Such green examples are:

- wetland restoration;
- mangrove forestry;
- coral reef restoration;
- hybrid land reclamation, including habitat improvement and expansion;
- circular use of materials, use of local materials;
- eco-friendly river protection;
- eco-friendly breakwaters;
- bird islands from dredged materials; and
- integrated river system development.

These green solutions are readily available to be applied on the precondition of a suitable financial

structure. Important to mention is that all these described concepts are mature solutions and have been applied in real-world situations. For many cases, monitoring and evaluations took place and showed the effectiveness both in terms of services provided as well as ecological quality.

Financing projects

In short, financing means that capital is provided to develop a project where the capital provider expects, in time, to receive or earn back this capital including some interest or profit. However, the majority of marine and freshwater infrastructure projects are traditionally funded by the public sector (i.e. with taxpayers' money), without involving financing. The responsible public agency will pay for project development expenses directly in accordance with the contractual arrangement with the

developer/contractor. In contrast, financed projects have a capital provider covering the costs of development with a payback mechanism kicking in after completion of the project. Two different types of financed projects can be distinguished on the basis of the cashflow for interest payments and loan repayments.

These broadly fall into two categories based on the origin of those cashflows:

- Public service projects (e.g. coastal protection): The government, as project client, pays periodically after completion, where the payments may be based on performance or availability criteria (Figure 1).
- Commercial projects (e.g. private port development): The users or beneficiaries pay for the project's results or services. Cashflow is generated based on the project's business model (Figure 2).

Figure 1 and 2 show graphically how these two types of financing differ. In practice, a wide spectrum of variants and combinations can be used, sometimes referred to under the title of "blended finance".

Key lessons identified in the report

Experts from Vital Ports, B Capital Partners, Swiss Re, CEDA and IADC constituents explored what is needed to improve the connection between private capital and sustainable waterborne infrastructure projects. One main conclusion is the need to clarify sustainable concepts and associated financial structures in order to introduce the topic to both the financial sector and the dredging community. In addition, to develop ideas on how to bring this to mainstream infrastructure investment asset classes.

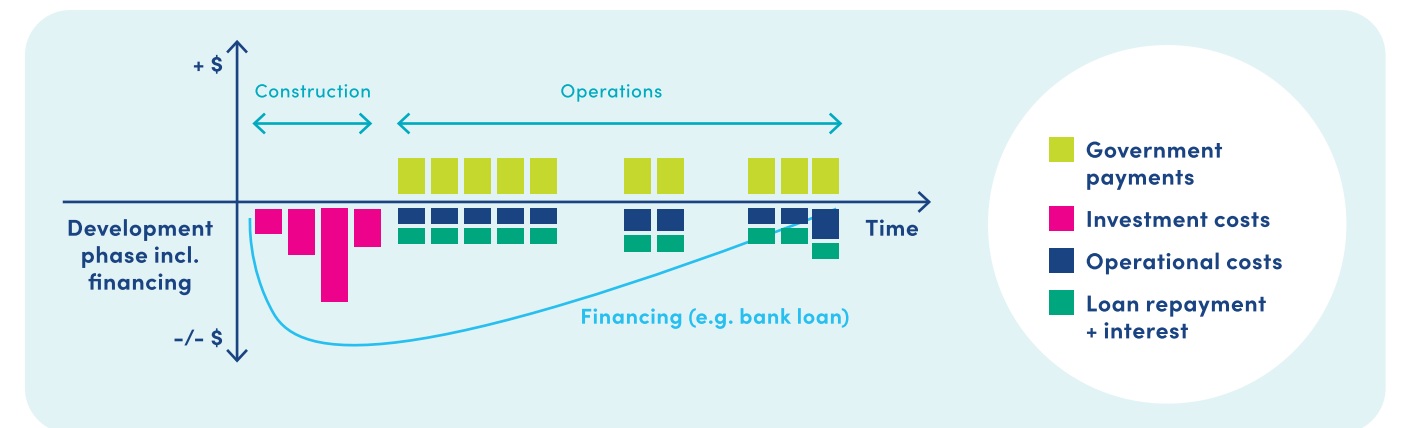


FIGURE 1
Public service projects.

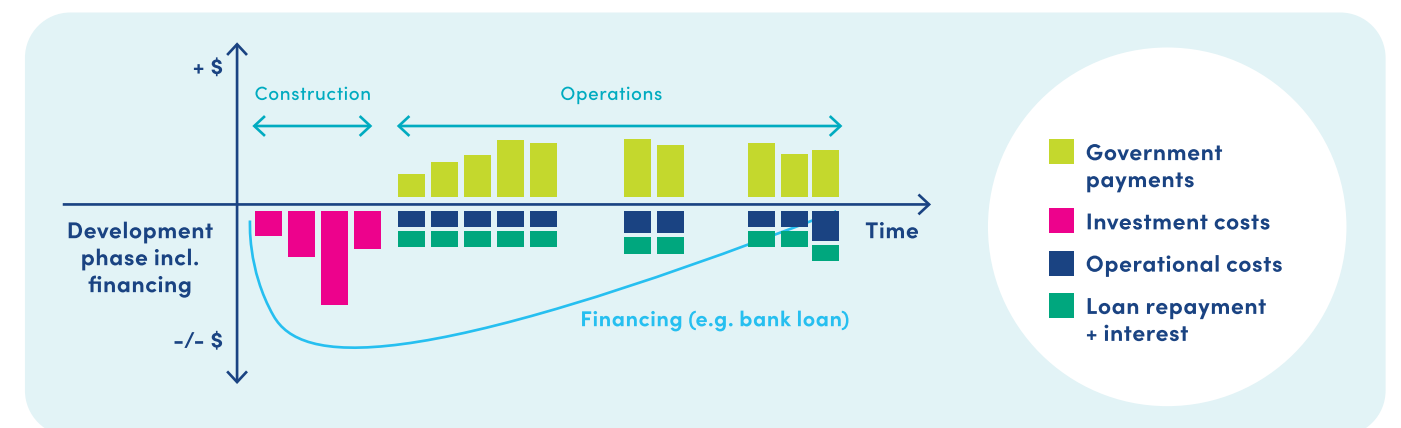


FIGURE 2
Commercial projects.

The report provides content for further dialogue to foster the uptake of green marine and freshwater concepts by private investors. This dialogue concentrates around the key lessons as identified in the report. These key lessons are:

1. To improve the availability of private capital in this segment, a joint screening by sponsors and private capital suppliers is strongly encouraged. Working jointly early on may avoid following leads, which may be attractive from a mere construction CapEx (capital expenditure) side but are unviable for investors economically and/or sustainability wise. A joint selection effort based on sustainability and contractual solutions can focus scarce resources on the most promising

opportunities, with a snowball effect of projects' private funding;

2. Since 2021, the European Commission requires institutional investors, financial intermediaries, lenders and asset managers to comply with a stringent investment process as well as transparent reporting (Sustainable Finance Disclosure Regulation (SFDR)) with respect to the sustainability and Sustainable Development Goals (SDGs) impact of their investments. These mandatory requirements urge financial investors of all kinds to adopt a pre- and post-investment ESG (environmental, social and governance) risk management and controlling system. Certification of green projects might be instrumental in moving forward;

3. Develop standard frameworks that allow private capital to enter

sustainable marine and freshwater infrastructure market – including, for example, updating concession-type legal frameworks that allow public-private partnerships;

4. Reporting tools and harmonised methodologies still need to be built to capture some of the associated benefits that are often overlooked as they are difficult to quantify, particularly in relation to future savings;

5. The insurance industry as a “de-risker” can be transformational in establishing a longer-term investment framework. It can create new types of insurance offerings that make infrastructure projects more standardised, cashflows more predictable and infrastructure as an asset class more attractive to investors – thus unlocking financing; and

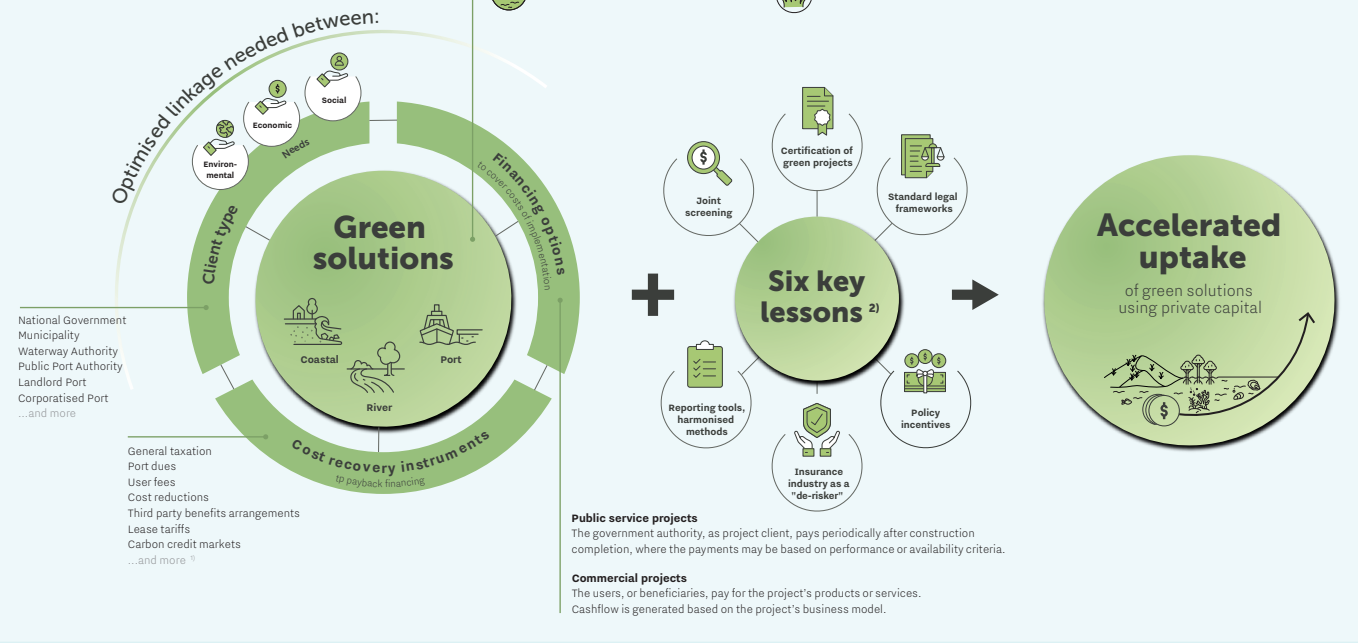
7. Green solutions require a more holistic approach and greater coordination,

Mangrove restoration in the village of Timbul Sloko, Java, Indonesia.



Financing of Green Coastal, River and Port Projects

Private capital can help to accelerate the uptake of green solutions; the sustainable alternatives for hard structures. This capital would finance the costs of implementation but needs to be paid back in time. Therefore, clients need to carefully link green solution, financing structure and cost recovery instruments. For green projects this is far from a beaten path. Key lessons show how to improve this process and pave the way forward.



With: IADC, CED4, VITAL PORTS, Swiss Re, B CAPITAL PARTNERS

References: Quick Scan Green value, www.vitalports.org/tools-services; Financing Sustainable Marine and Fresh Water Infrastructure; IADC, CED4, Vital Ports, Swiss Re, BCapital Partners, 2021; Examples at platforms like www.ecoshape.org, www.planc.org, www.sustainableworldofports.org

FIGURE 3 Financing of green coastal, river and port projects infographic.

and cooperation. They will also need to be incentivised through policy frameworks that increase their uptake and allow rerouting or unlocking new funds to support them.

Given the size and attractiveness of the sustainable marine and freshwater works segment, and the growing appetite for sustainable infrastructure projects, it is expected that in due time more avenues will open up to pursue the kind of projects featured in the report and more private capital can be put to work.

Infographic

The report captures the content and provides examples of the way financing of green infrastructure in port, waterways and coastal areas can be structured. In that sense, it serves its purpose well to

support further conversations between the dredging and financial communities. It was decided the development of an infographic could help in spreading the message to a wider audience.

As an infographic should be self-explanatory, it proved quite a task to bring in all the elements. Projects involving dredging are a world in itself. The meaning of nature-based solutions can fill bookshelves. The same is true of finance and cost recovery models. Bringing this all together for an audience specialised in one sector, but unfamiliar with others, was a challenging task. The resulting infographic (Figure 3), just like the report, is free to use and distribute.

The infographic conveys the message of three steps: basic options and structures

for green solutions; the key lessons learned; and the goal of accelerated uptake to be reached through these steps. The element at the left-hand side shows the key parts of a tailor-made puzzle. A desired solution needs to be embedded in a structure where the institutional setting, a cost recovery model and financing fit together.

Cost recovery models require particular attention. Green solutions might open up new ways of cost recovery as these solutions typically offer wider societal benefits. This requires special effort to capture and monetise these societal benefits to ensure these can be of support for the project. Some examples of such models are selling carbon credits (either in voluntary or compulsory markets), habitat banking, inclusion of

sources supporting natural development or involve outside beneficiaries (tourism sector, fisheries) with an interest to make the project happen. Figure 4 shows an example of this.

Conclusions

The main conclusion of the report is that sustainable waterborne infrastructure solutions are available, have been tested and are economically viable. The potential of these kind of solutions was widely recognised and seen as the way forward.

As clear as this conclusion may stand, the picture becomes far more nuanced when deployment of private capital is brought into the conversation. One of the key issues that comes with this is the necessity of generating cashflows to ensure paying off those loans and investments. Rich discussions took

place around appropriate business models, identifying beneficiaries of the wider benefits of sustainable solutions, converting benefits into revenue streams and the roles of the public and private sectors in this. A first general conclusion is that work needs to be done to establish widely acknowledged business models for green port, waterway and coastal projects. Such business models should include clear ways to determine the additional, holistic, benefits of sustainable solutions and ways to monetise these.

Directly following this conclusion is the debate around the definition of "green". Although a diffuse concept in the wider infrastructure sector itself, it is a sensitive and important topic for investors and bankers as well. Defining what is green and sustainable is key considering a large influx of green-labelled capital

and potential reputational and financial damage when mislabelling investments. At the same time regulations for utilising these labels and associated benefits, like the green taxonomy in the EU, is growing. However, this is still work in progress in the sector itself and needs further maturing. The conclusion from the report that certification could be helpful was supported by the wider audience and seems like a no-regret step to take.



Download the report
**Financing Sustainable
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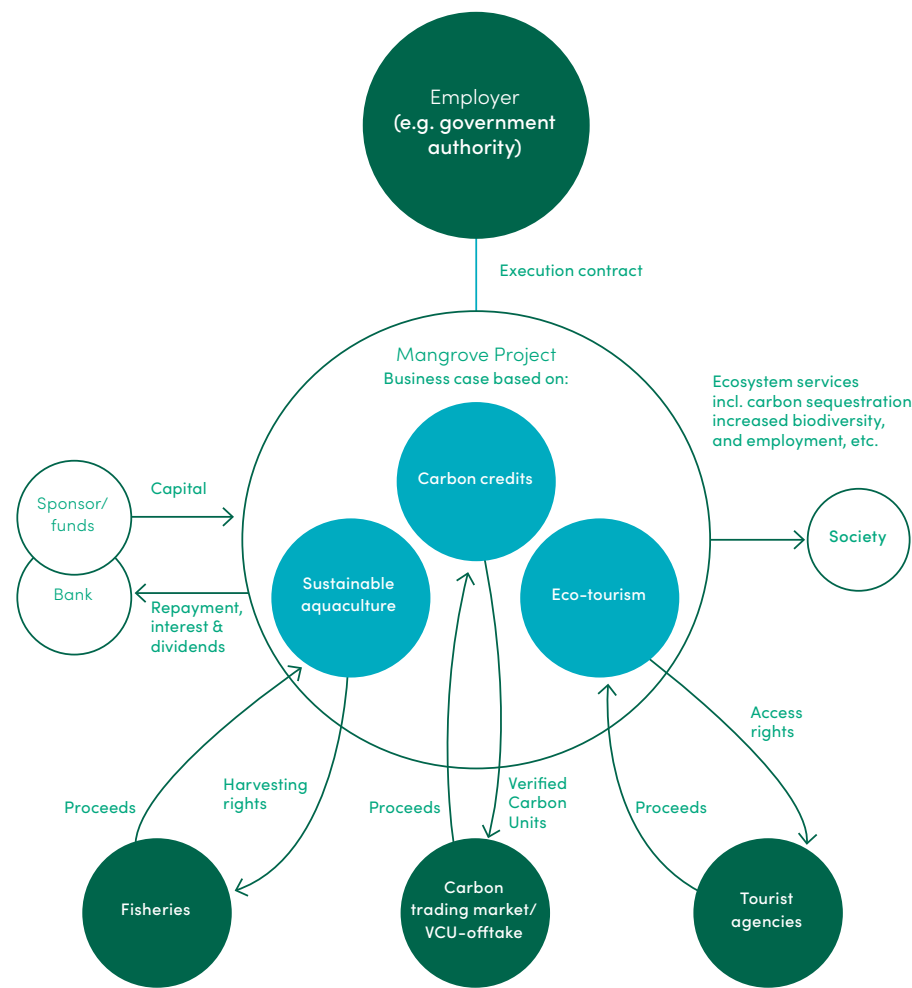


FIGURE 4
Example of utilising the wider socio-economic benefits created by a mangrove restoration project.



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