DFSI magazine

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DREDGING FOR SUSTAINABLE INFRASTRUCTURE

Assessing and managing **sustainability**

The role of environmental and social impact assessments.

Senegal's Ndayane deep-water port shows how major infrastructure can boost trade and growth while protecting communities and the environment – offering a real-world example of balancing economic benefits with sustainable development.

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Embracing sustainability enhances social value and **allows contractors to differentiate through innovative approaches.**

EDITORIAL

Creating greater social value

As one of the initiators of the *DFSI Magazine*, I am pleased to present the Winter 2025 edition and deeply honoured to serve as guest editor so soon after my retirement from IADC.

This edition focuses on Chapter Four of the book *Dredging for Sustainable Infrastructure*. With my background in economics, it's a chapter dear to my heart, addressing the societal impacts of maritime infrastructure projects, such as stakeholder engagement and ecosystem services – both essential elements of a sustainable project. Stakeholder engagement is standard practice across the dredging industry. Ensuring the interests of all parties means projects deliver greater societal value and often progress more efficiently, benefiting both clients and contractors. The four case studies in this edition each show how involving local stakeholders contributed to project success.

The local knowledge and experience of fishermen in Jan De Nul's project informed the impact assessment and informed the design of mitigation measures and the monitoring programme. Community support also increases when local people directly benefit from a project; DEME's investment in maritime education for young people is a clear example of such empowerment.

Van Oord's mangrove restoration initiative further demonstrates this principle. More than 100 community members joined an alternative livelihoods programme that reduced reliance on mangrove logging and improved family incomes – an important, lasting benefit beyond the project itself. Managing the environmental and social dimensions of large-scale infrastructure projects is inherently complex, often involving conflicting interests. Boskalis' Gulhifalhu reclamation project shows the evolving role dredging companies play in achieving sustainable results.

Despite declining global support for sustainability, it remains highly relevant to the dredging industry. Embracing sustainability enhances social value and allows contractors to differentiate through innovative approaches. The next step is valuing and monetising externalities – the positive and negative effects traditionally excluded from project evaluations.

IADC's 2015 report *Ecosystem services: Towards integrated marine infrastructure project optimisation* was an important step in this direction. The concept of ecosystem services recognises all positive and negative effects of the services ecosystems provide, the effects of which can be valued and monetised. A common denominator allows for comparing effects and determining where to mitigate or compensate, resulting in a higher social value of the project. The evaluation of the Hondsbossche and Pettemer sea dunes project, available on the IADC website, demonstrates the benefits of incorporating and monetising such externalities.

I hope these articles both inspire and encourage you to take the next step. A more sustainable society benefits us all.

Guest editor
René Kolman
Former IADC Secretary General

ASSESSMENT AND **MANAGEMENT OF SUSTAINABILITY**

In the last edition of *DFSI Magazine*, the concept of how to integrate sustainability in relation to dredging projects was explained. The focus of this article, adapted from the fourth chapter of the *Dredging for Sustainable Infrastructure* book (2018), discusses the assessment and management of sustainability activities that need to be implemented in a project and provides the theme for this issue.

Environmental Impact Assessment (EIA) and added value

Chapter 4 of the *Dredging for Sustainable Infrastructure* (DFSI) book discusses the assessment and management activities that need to be implemented to ensure that:

1. During the planning stages the project has truly considered its overall sustainability profile (both negative and positive effects) and is able to comply with the necessary approval procedures, and
2. During the construction and operation stages the infrastructure design performs as intended (again both with respect to negative and positive effects).

As for any infrastructure project, a design that proactively incorporates added values should also go through a rigorous assessment procedure to see if the project can continue after careful deliberation of positive and negative effects.

Careful appraisal of the potential effect of proposals through EIA should ensure that potential environmental issues and opportunities for added value for the environment are anticipated at an early stage of a water infrastructure project. This allows corrective measures to be incorporated to minimise negative effects or prevent them from occurring, while beneficial effects can be developed within the scope of the project.

In practice, however, most designs are optimised primarily for their economic and technical objectives with the EIA process subsequently applying mitigation measures to reduce any significant negative effects identified. The proactive inclusion of environmental considerations, including added values (natural as well as socio-economic), into the designs from the very start, while in principle facilitated, is not as common as it should be. While the "Environmental Impact Assessment" stage addresses both negative and positive effects, the "Environmental Mitigation and Monitoring" stage tends to focus primarily (if not only) on reducing the negatives. Insufficient mitigation of negatives can jeopardise consent by the regulator. Insufficient stimulation of positives rarely does.

The apparently unavoidable focus on mitigating the negatives ultimately influences the whole EIA process. Consultants performing the impact assessment tend to focus more on identifying and describing the negative impacts as these are the main focus of some of the stakeholders. Stakeholders are conditioned to frame their concerns as negative impact in order to get their interests on the agenda. The resulting implicit focus on mitigating the negatives has a large influence on the design process and the ultimate result, to the extent that it can favour the "least bad yet acceptable" decision over the "more integrated sustainable" one potentially with added value(s).

Basics of the present EIA framework

EIA should strive for a balanced evaluation of effects that are associated with water infrastructure projects; negative as well as positive effects, short-term process effects as well as long-term project effects. A next step is to assess the balance between these effects and decide if it is acceptable "as is", or whether something needs to be done about it. Most jurisdictions around the world require some form of EIA of water infrastructure projects before consent can be granted. Designs that add value to the (natural and socio-economic) system are no exception.

A World Bank study summary of EIA was important because it more or less established the minimum requirements (Bray, 2008):

"[...] EIA is taken to mean the systematic examination of the likely environmental consequences of proposed projects. The results of the assessment – which are assembled in a document known as an Environmental Assessment (EA) – are intended to provide decision-makers with a balanced assessment of the environmental implications of the proposed action and the alternative examined. The EA is then used by decision-makers as a contribution to the information base upon which a decision is made. The overall goal of an EIA is to achieve better developmental interventions through protecting the environment (human, physical and biotic)."

EIA is an important tool for project planning. It assists in the reduction of risk from misunderstandings, provides clarity on potential environmental implications and leads to better co-operation between all stakeholders, including project owners, dredging contractors and the public. A well-executed and thorough EIA can lead to cost-effective mitigation and/or enhancement. When environmental mitigation/enhancement is integrated as a fundamental part of project design, rather than as an add-on exercise, it can reduce project and community costs.

The DFSI book gives an overview and short description of the different stages of an EIA process. Some of these stages will be described below.

Baseline data gathering

The description of the baseline for a study area's environmental and social conditions (i.e. the area that has the potential to be affected directly and indirectly by the proposed project) is crucial for the assessment and management aspects of any scheme. The baseline provides the reference against which potential changes can be put in context with natural conditions and assessed for the predicted level of significance of any impact. It is also the information upon which the sustainability of the project can be measured. A sustainable project as a minimum will need to prevent long-term degradation of resources as a result of the activity. An understanding of the baseline characteristics, and their natural variability, will enable this to be measured and managed throughout the project life cycle. It is important to realise that each location is different and will require unique consideration of the background conditions, threshold values and likely changes.

Baseline data is generally collated for a number of parameters including, but not limited to, the following:

- Designated site information.
- Important physical processes.
- Water and sediment quality.
- Ecology.
- Fish resources.
- Mammals.
- Ornithology.
- Users of the environment (including fisheries, services, navigation).
- Local community.
- Tourism and recreation.
- Archaeology and historic environment.
- Protection and flood defence.

It is important to realise that the work carried out in a baseline survey is supposed to provide the (preferably quantitative) foundation based on which later management measures may be engineered. When designing a baseline monitoring campaign, one should keep this in mind continuously and reflect on whether the campaign is going to deliver the required information. Obviously, the level of survey should be in context with the scale and location of the project and should be designed to meet realistic objectives. Objectives should be specific and have a measurable outcome to determine whether or not they have been achieved. Methods to approach this issue systematically are addressed later in this article.

Mitigation

Management measures to mitigate against project risks and/or stimulate project opportunities can be built into a project at any stage. However, it is often beneficial to consider such measures at an early stage, e.g. during the initial feasibility of the project or early design phase. At this early stage, environmental constraints can be identified and taken into consideration to enable an optimal location for the dredge or method for the dredging, transportation and placement of material.

Appropriate management measures can be selected by following a set process to determine the vulnerability and sensitivity of the receptor and the objective of the project (in terms of project outcome and constraints) followed by consideration of several management measures that may be applied to reduce the significance of an impact. PIANC Report Number 100 (PIANC, 2009b) provides details for a procedure to be followed and provides a selection of management measures for different dredging-related activities.

The selection of the most appropriate management measures should involve expert knowledge from a dredging contractor and should be based on the effectiveness of the measure to achieve the desired goals for environment protection and the amount of effort required to implement the measure. The management measure must be effective in ensuring that the dredging activity does not result in the non-compliance of an environmental objective, but the effort involved in applying the measure should be proportionate to the scale of the project or the impacts. It may be that two smaller management measures in combination would achieve the desired outcome with less effort than one more restrictive measure.

Consider cumulative impact(s)

Once the residual impacts have been assessed for the project it is necessary to determine whether there are any likely cumulative impacts that could occur with other proposed projects planned in the area. In line with Institute of Environmental Management and Assessment (IEMA) guidelines for EIA, cumulative impacts are defined as *"... the impacts on the environment which result from incremental impacts of the action when added to other past, present and reasonably foreseeable future actions ..."* (EU, 1999).

The requirement for Cumulative Impact Analysis (CIA) initiates from the need to consider the impact of a number of individual projects acting on the same resource. Whilst the individual projects in isolation may not have a significant impact on a resource, the combination of changes brought about by all the projects together may have a significant effect.

The identification of relevant projects and their potential cumulative impacts can be initiated during the scoping stage but will be presented within the Environmental Statement (ES).

A sustainable project will need to prevent long-term degradation of resources as a result of the activity.

A tiered approach can be adopted for a projects CIA, based upon the following definitions:

- *Site-specific (or within-project) cumulative impacts* – Different aspects of the project's proposals may have additive or interactive impacts on common receptors. For example, the combined effects of noise, traffic and dust on human receptors and/or ecology; and
- *Wider cumulative impacts* – These are the combined impacts (additive or interactive) that may occur between any component(s) of the project and any other development(s); that is, other "present" and "reasonably foreseeable" plans and projects.

With respect to "past" projects, a useful ground rule in CIA is that the environmental impacts of schemes that have been completed can be a part of the baseline environment; as such, these impacts will be taken into account in the EIA process and, generally, can be

TABLE 1
Indicative EIA planning for a dredging project (*Environmental Impact Statement and **Construction Environmental Management Plan).

Task	Month																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Screening exercise																										
Screening consolutation																										
Reciept of screening opinion																										
Scoping exercise																										
Scoping consultation																										
Reciept of scoping opinion																										
Baseline data gathering																										
Production of EIS*																										
Consent application																										
Consent consultation																										
Consent decision																										
Produce CEMP**, including dredging methodology																										
Approval of CEMP** by regulator																										
Project implementation																										

excluded from the scope of the CIA. However, the environmental impacts of recently completed projects may not be fully manifested and, therefore, the potential impacts of such projects should be considered in the CIA.

Time needed for EIA process

The time to undertake an EIA can vary widely depending on the requirements of the country that the dredging project is being undertaken in and the level of available baseline information. Table 1 presents an indicative programme to carry out an EIA on a dredging project based upon the requirement for 12 months of baseline data gathering, where no or limited baseline information is available. Baseline data gathering often forms a major component of the programme, in particular in areas where there has been a lack of previous development or where seasonal variations need to be understood, such as overwintering and migrating birds, or changes in hydrodynamics (currents). Where an acceptable level of baseline information already exists, the duration of the EIA can be reduced.

Methods for objective-based assessment and management

It has been described how the EIA framework and associated procedures form a benchmark for whether infrastructure designs are acceptable or not. Key in the EIA approach is establishing a baseline against which effects, both positive and negative, can be made explicit.

Since infrastructure development has the potential to influence the interests of many stakeholders it is important to strive for transparency and objectivity so that any potential conflicts of interest may be resolved efficiently. A key step is to be explicit about objectives, the measures that are implemented to achieve them and the methods that are applied to evaluate success.

Formulate a strategic objective

Strategic objectives should align with the overall vision the designer has for the natural system and the socioeconomic context the project is going to be in. When formulated properly strategic objectives tend to vary slowly. Nonetheless they do have a profound impact on the solutions that are considered acceptable. It is well worth spending some time on defining a proper strategic objective that truly reflects the vision of the project and can be embraced by its stakeholders.

Formulate an operational objective

Operational objectives reflect how the designer aims to handle the interaction between the natural and the socioeconomic system. As such operational objectives must be a step more concrete than the strategic objective. This also explains why the one is always an imperfect specification of the other. Specification of the operational objective of choice is typically something that can be done in an interactive setting. Trying out different formulations for operational objectives and thinking through the subsequent consequences of these different formulations, is an excellent way of exchanging ideas and generating a shared view on what is a preferred route to investigate further.

How to benchmark the performance of a design?

A benchmarking procedure is necessary, so that we can systematically and objectively determine when to intervene in the system. Intervention is required when a discrepancy between the current system state and a desired or reference system state surpasses some predefined threshold.

Implicit differences in the desired system state often trigger passionate discussions on what is in the interest of the management objectives and what is not. To facilitate useful discussions, the current state as well as the (implicitly) desired state should be made explicit and preferably expressed in terms of the chosen quantitative state concept. This element of the decision recipe often relies on measured or predicted trends in state descriptions, costs and benefits.

To monitor the performance of a design, it is necessary to establish a reference value against which change can be measured and to determine a suitable methodology to predict and measure the change occurring and how it could affect your objectives.

How to establish a reference?

In an EIA context, baseline measurements are typically intended to establish a useful reference value. Depending on the aspect considered it may take several years of measurements to fully capture the information that is needed to establish a reference value. However, for many projects there will be some level of information available for existing characteristics of the environment which can be used to provide a basis for a reference value. The key to establishing a useful reference is to understand the natural variability in the system, which will enable you to understand the tolerance of any receptors to change. This allows a focused assessment of what level of impact the predicted change associated with the project itself will have on the receptor.

Key enablers for successful assessment and management

The following key enablers play a role in the successful realisation of water infrastructure projects:

- Design-related options for environmental gain or mitigation.
- Valuation methods for environmental gain.
- Key environmental stressors for assessment of the sustainability of a dredging project.
- Dealing with uncertainties.
- Adaptive management to handle uncertainty within projects.

The logic behind the selection of these specific key enablers is, given the main aim of the DFSI book, it is logical that we start with available options to promote environmental gain. Once alternative designs are developed it is necessary to valuate these designs, for comparison amongst each other as well as with other more traditional alternatives. Next to looking for gains, we should not forget to quantify potential negative stresses. Some basic guidelines are provided for turbidity, sound and emissions.

Ultimately, a project design should balance the positive and the negative effects during selection of alternatives. It is good to realise the importance of uncertainties and how to deal with those. This was always true, but the introduction of natural elements into the design and into the valuation of the integral solution makes this issue even more pressing. Finally,

adaptive management is introduced as a means to deal with uncertainties and to prevent an overly expensive overhead. In this article we will elaborate on the first two as the others are more commonly known and already part of the EIA for a long time.

Design-related options for environmental gain or mitigation

Within the design phase of water infrastructure, the project's footprint on and interaction with the broader system are being established. When looking at these aspects, measures that can be taken to introduce environmental gains or reduce the scale of potential impact can be distinguished in:

- selection of location and footprint of the project, including seasonal timing;
- landscaping within the project; and
- nature development within or near the project.

Careful site selection for a project, to make optimal use of natural features or to avoid particularly sensitive areas, is an aspect that positively influences the footprint of a project. Although the general perception of the term project footprint has a negative connotation, footprint merely means "area that the project will directly have an influence on". As an attempt to make that influence more positive, in terms of habitat or ecosystem development, the abiotic features of the designed infrastructure can be optimised to ensure that the newly created landscape provides the potential for natural and ecologicaldevelopment. To actively and quickly make use of this potential, nature development measures, such as seeding, planting or active rehabilitation, can be used additionally.

Legislation associated with dredging projects and waste materials focuses upon the (re-)use of material. As a part of this perspective, reduction of the amount of material dredged and displaced can be seen as the minimum positive contribution to the project's footprint and consideration of re-use of the material within the works before deciding upon the disposal option is an often required second step. Habitat creation or restoration options are

BOX 1

Impact of objectives on the Sand Engine project

The life cycle of the Sand Engine project, constructed in 2010 along the coast of Ter Heijde in the Netherlands, provides a clear example of how objectives influence the steps taken during the project development phases. In April 2008, marked as the end of the initiation phase, an ambition agreement was signed by nine interested stakeholders in which the goals and ambitions of the project were specified. The main and secondary objectives were formulated as:

- combining the long-term safety behind the Delfland coast with more space for nature and recreation in this part of the south wing of the "Randstad" region; and
- innovation and knowledge development.

Planning and design phase

During the design stage of the Sand Engine, a discussion took place on how the intervention should be designed. The most efficient design that met the long-term safety objective would result in an evenly distributed nourishment along the Delfland coast. However, since the project also had an innovation and knowledge development objective, it was decided that a more concentrated nourishment was preferred, as this would have a greater potential for new discoveries. As a result, the strategic project objective thus favoured a more uncertain and more expensive solution.

Construction phase

The inclusion of innovation in the project's strategic objectives in the end was not extended to the construction phase of the project. The design was put on the market in the form of a clearly specified project that focused on lowest cost only (NB: additional points could be scored when for the same budget more hectares would be constructed).

Operation and maintenance phase

It is interesting to see how the original project objectives carry through to the operation and maintenance phase of the project. During the first months of the Sand Engine's lifespan, a gully formed that connected the water body inside the sandy hook with the sea. During ebb and flood, large flow velocities occurred, posing a risk to users of the Sand Engine area. After one particular incident, the responsible management authority took immediate action by closing off the gully with rocks and digging a new channel to guide the flow of water to a less risky location. This solution was met with great scepticism as it sharply contrasted with the Sand Engine's main aim of allowing nature to take its course. The rocks were eventually removed and the original situation was restored. This underscores the importance, even in the operation and maintenance stage, of staying aligned with the overall project objectives and being clear about what constitutes an appropriate intervention when the design behaves differently than expected.

FIGURE 1
The Sand Engine, Delfland Coast, the Netherlands.

another potential use of excess material which not only reduces footprint, but also actively introduces gains to the environment.

A final feature in the design-related options is the factor time. On the one hand, certain receptors have varying levels of sensitivity throughout the year (i.e. coral spawning, berried crabs, burrowing sand eels), making it important to take these into account in designing and planning the construction of the hydraulic infrastructure. This requires sufficient understanding of the potential variability in the timing and extent of such activities to ensure that realistic management measures can be established. On the other hand, other time dependent system features, such as tides, winds, monsoons, etc. could be used to phase dredging and other activities in such way that the risk of significant impact is reduced. This could for instance include dredging at certain periods of the year when dominant currents would move material in a particular direction away from the sensitive receptors.

Examples of design-related options that go beyond careful selection of footprint are listed in Box 2, on the ecological landscaping of sand mining pits and Box 3, on the potential for active rehabilitation of coral reefs in the context of port development projects.

BOX 2

Ecological landscaping sand mining pit

Sand mining removes benthic habitat from the seabed and thus it impacts the local ecosystem. It is known that the removal of the substrate will typically impact the local benthic system (and by extension demersal fish) for a few years, but given time, if the particle size distribution of the bed is similar to that before dredging, the ecosystem will rejuvenate (see Cooper, 2013, for a review of this extensive pool of research). But how can the morphology of the bed of a sand mining pit be designed so that it maximises the recolonisation of benthic and demersal species and perhaps even enables higher productivity than before the dredge?

Research into the recovery of borrow pits excavated for the Maasvlakte2 project, has identified that for that particular situation, landscaping a sand pit to include ridges rather than just a flat bed, promotes the process of recolonisation and can create higher species diversity (De Jong, 2016). Figures 2 and 3 illustrate how the troughs between ridges increase in biomass.

On the one hand, detailed flow and sediment transport modelling is needed to confirm that there is no stratification of temperature or salinity (and hence no adverse effects resulting from deterioration in water quality), and, on the other hand, to ensure that the created landscape will be stable and won't quickly degrade under the action of currents and waves, on the other.

It is likely that the modelling of temperature/salinity will require 3D modelling (since it is the change in water properties throughout the water column that is being investigated). Similarly, it is likely that 3D sediment transport modelling will be required to evaluate the stability of the ridges, unless the ridges are sufficiently shallow sloped.

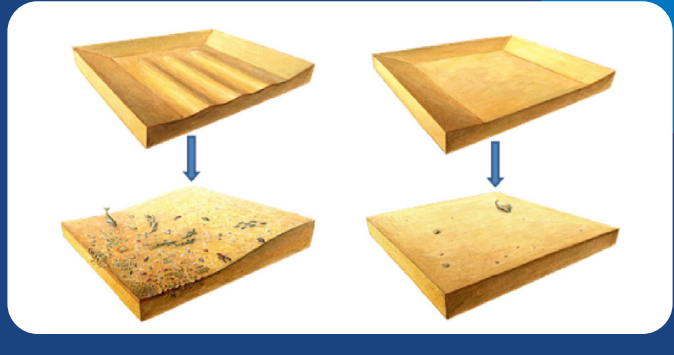


FIGURE 2
A relatively flat seabed (left) remaining after traditional dredging operation versus an artificial seabed landscape consisting of sand ridges that help to accelerate the process of recolonisation and promote higher biodiversity (right) (De Jong, 2016).

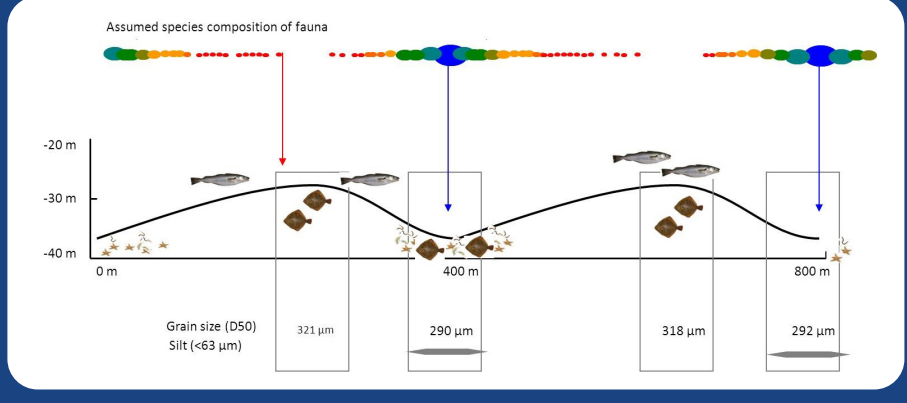


FIGURE 3
Conceptual sand waves with bathymetry, sediment characteristics, macrozoobenthos and demersal fish characteristics (De Jong, 2016).

Valuation methods for environmental gain

Nature-based solutions focus on the use of natural processes in the implementation and operation of hydraulic engineering infrastructure. Ideally, these concepts result in lower life-cycle costs in monetary terms, but this is not always the case. Often, non-financial benefits like ecosystem services and biodiversity are important selling points. In such cases, decision makers should be facilitated to value the project-induced benefits for nature and society to justify the extra investments that may be involved. Contingent Valuation Methods can be used to express non-financial values of water infrastructure developments in monetary terms, in order to include them in a Socio-economic Cost Benefit Analysis (SCBA). The approach is based on the generic concept of ecosystem services.

Ecosystem services

Ecosystem services are defined as the benefits that humans derive from nature (Millennium Ecosystem Assessment, 2005; TEEB, 2010). Ecosystems generate human welfare because they produce goods and services that humans can use directly or indirectly (through the use of other goods or services). Examples of direct forms of use pertain to goods, such as wood, clean water and fish or to services, such as recreational opportunities and protection against flooding or climate change. Examples of indirect forms of use are "nutrient recycling" and "fish nurseries" that result in "clean water" and "fish production", respectively. Generally speaking, ecosystem services are categorised in four different types: provisioning services, regulating services, cultural services and supporting services. Figure 4 provides an overview of several ecosystem services and the constituents of wellbeing they relate to.

IADC recognised the importance of ecosystem services for the dredging industry early on. To help dredging industry professionals – particularly those in positions to promote the ecosystem services concept within their own organisations as well as to project stakeholders – gain a deeper understanding of its value, of the ecosystem services approach, IADC commissioned a study. Titled *Ecosystem services: Towards integrated marine infrastructure project optimisation*, the study was conducted by the Ecosystem Management Research Group (ECOBE) at the University of Antwerp and published in 2016.

The report outlines the concept of ecosystem services and discusses key considerations on its use in the context of dredging projects. It also highlights five case studies from highly distinct environments, showcasing the practical outcomes of ecosystem services in action.

The case studies include:

- Wind farms at sea (C-Power) in Belgium;
- Botany Bay in Sydney, Australia;
- Western Scheldt Container Terminal in the Netherlands;
- Sand Engine in the Netherlands; and
- Polders of Kruibeke in Belgium.

The results presented in the report do not evaluate the projects themselves but instead assess the feasibility of using the ecosystem services approach to gain a more integrated insight. The report also offers general considerations on the governance of ecosystem services assessments and their applicability in dredging practices.

Habitat improvement in the context of water infrastructure projects

In 2014, the government of the Bahamas, Van Oord and Damen Shipyards signed an agreement for a rigorous upgrade of the naval bases on three islands and the delivery of a fleet of new patrol vessels. The scope of the Sandy Bottom project included dredging (deepening of the access channel and port), constructing several breakwaters and quay walls and corresponding civil engineering works.

As is often the case for marine construction works in tropical regions, there were various areas with corals located near the footprint of the construction works. For the corals that were located near the access channel to the Coral Harbour naval base a coral relocation programme was executed. Over 1,500 viable hard coral colonies and a broad range of associated invertebrates were relocated to recipient sites outside of the demarcated impact zone (Ter Hofstede et al., 2016).

BOX 3

Incorporating ecosystem services from the design phase of a project can generate added value that might otherwise be overlooked, prevent irreversible damage that cannot be mitigated and foster support from various stakeholders. This approach plays a crucial role in helping companies in the dredging industry achieve project success. The societal value of ecosystem services is shown in Figure 5.

The ecosystem services framework bridges ecosystems to the socio-cultural context of human wellbeing and addresses the relationships between the two (Figure 5). In addition, this framework helps to analyse the impacts humans have on ecosystems and the feedback effects these changes have for the ecosystem benefits to humans.

The concept of ecosystem services can be used as starting point for the integrated assessment and evaluation of project benefits and impacts. A hands-on method to do so is presented by Boersma et al. (2015). It consists of four basic steps:

Step 1 Identify the different habitat types that are affected by the project.

Step 2 Identify all ecosystem services delivered by those habitat types and select the relevant ecosystem services for the specific project.

Step 3 Describe each ecosystem service as well as the underlying processes driving its delivery.

Step 4 Calculate the impact on all relevant ecosystem services in a quantitative and monetary way as much as possible.

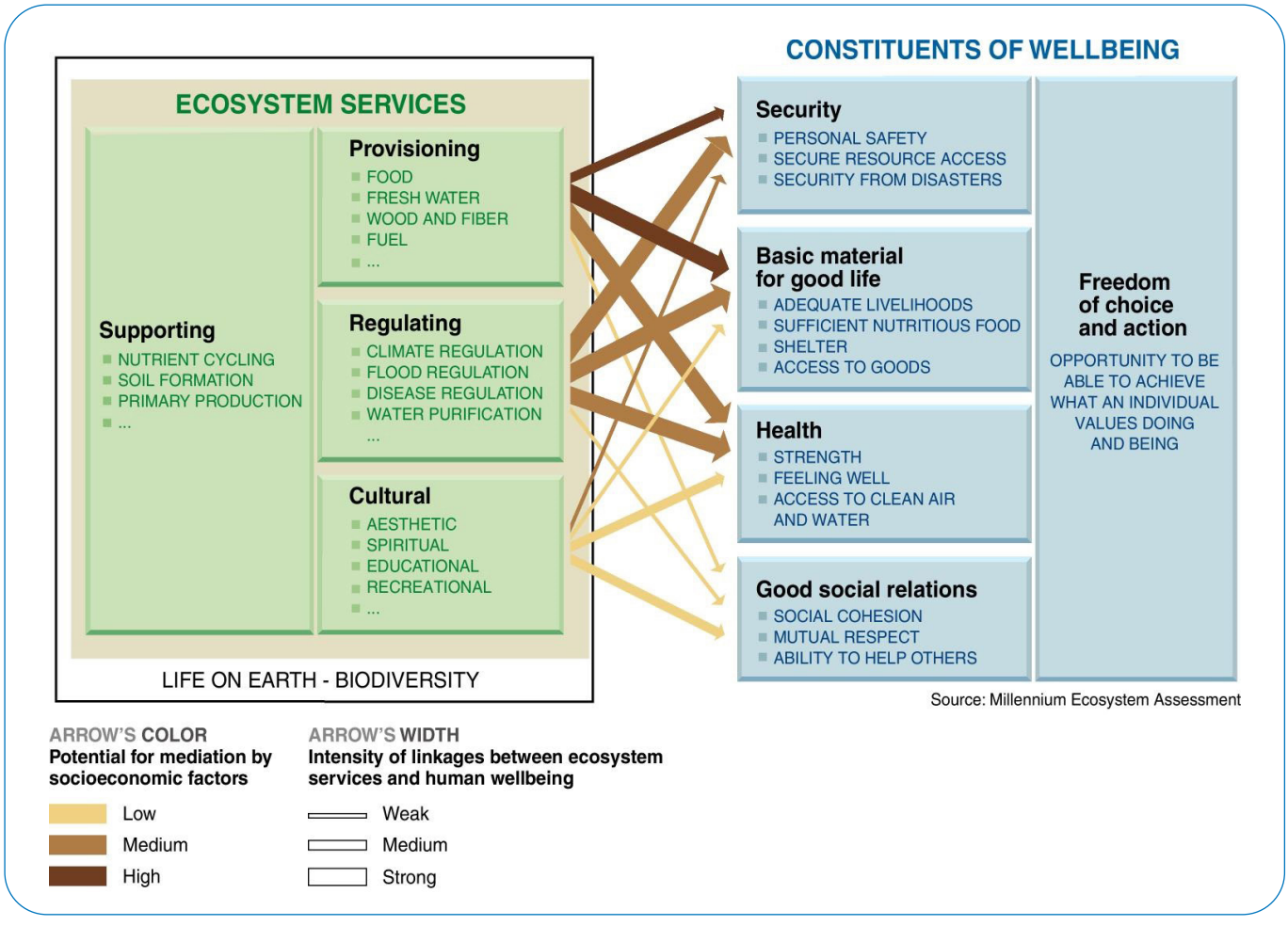


FIGURE 4
Ecosystem services and human wellbeing (Millennium Ecosystem Assessment, 2005).

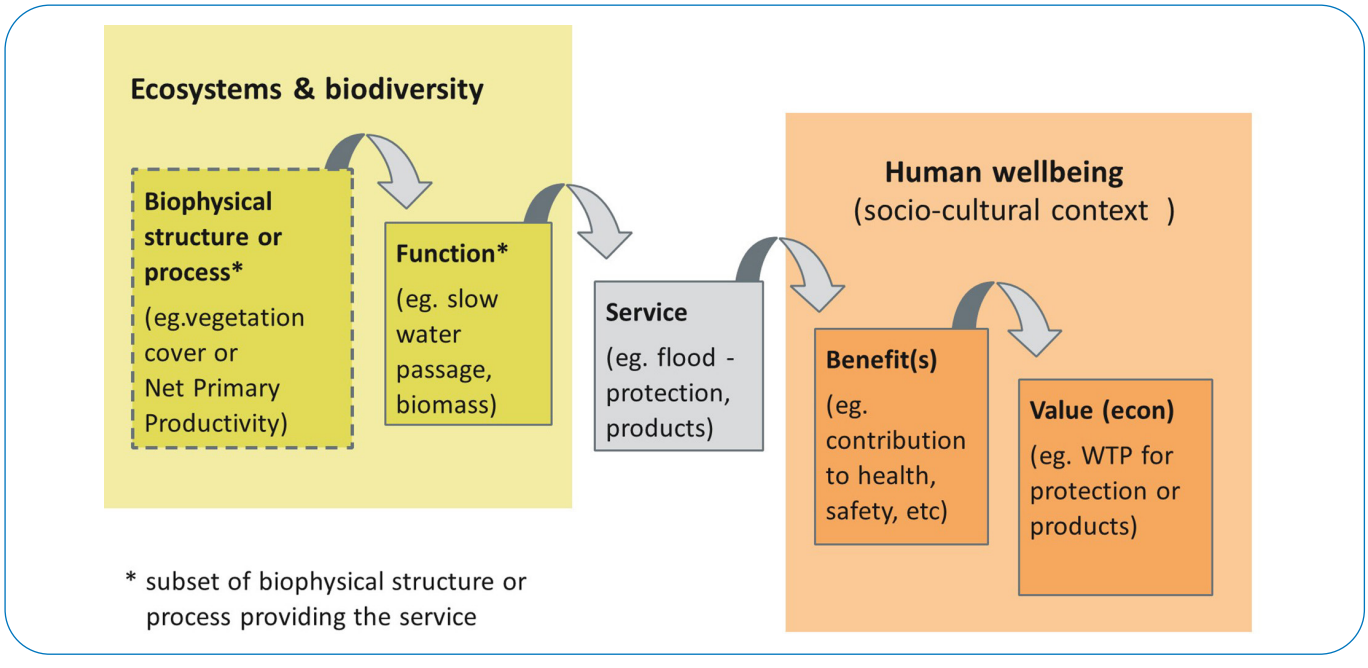


FIGURE 5
Linking the values of ecosystems to human wellbeing. Cascade of ecosystem services (TEEB, 2010).

Given the diverse nature of different ecosystem services, each service generally has its own parameter (hence unit) that is used to enable quantification of effects. For instance, carbon sequestration is expressed in tonnes per hectare per year, while wood production is calculated as a volume (m^3) per hectare per year. For monetary evaluation, these numbers need to be converted into financial figures (e.g. cost per year) to enable an objective comparison of project scenarios or design alternatives.

In the past decades, many experience numbers have been abstracted for the quantitative assessment of ecosystems. These experience numbers cover both physical effects (e.g. the sequestration of carbon) and monetisation values (price tags). Relevant overviews of experience numbers are provided in Ruijgrok et al. (2007) for cases in the Netherlands, and Liekens et al. (2010) for Flemish cases.

Non-use value of nature

Most of the ecosystem services are goods and services that can be used directly by people. The non-use value, however, must be included in the overall balance as well. Not only because we have the responsibility to protect nature values (as an intrinsic value), but also because we generate welfare from the protection of nature values. We feel good by saving or developing nature, for example because these nature values remain available for next generations.

Market prices for non-use value are obviously not available. It is, however, an important element to include in the overall estimation of ecosystem services. The non-use value can be estimated with the help of the Contingent Valuation Method (CVM). In this method, carefully formulated survey queries are used to ask respondents how much they would be willing to pay for conservation of a natural, cultural or environmental good. Formulation of the survey requires careful attention and needs to be in line with the National Oceanic and Atmospheric Administration (NOAA) guidelines for the application of CVM. Arrow et al. (1993) put in requirements on pre-testing of the questionnaire, personal clarification and abstraction of the results and reporting of the characteristics of the population. CVM can be applied to several goods and services, if they meet the following criteria:

- The good or service must be easily recognisable to the respondent.
- The respondent must feel responsible for the good or service that he/she is asked to pay for.
- The good or service must be marked (in terms of time and space) in order to create a proper definition/picture.
- The number of people that are willing to pay must be known in advance or should be abstracted in the questionnaire.

The principal benefit of including non-use values of nature in the evaluation assessment is that they become visible in the monetised overall cost-benefit analysis. In that way, they can play an important role in the acceptability of nature-based solutions for infrastructure projects.

Besides the methods discussed above, other approaches are available to assess benefits for nature and society as part of formal design and evaluation procedures, for example, the Nature Index approach developed by the Netherlands Environmental Assessment Agency (Sijtsma et al., 2009).

In 2021, Ms Viktorija Karaliūtė conducted her master's thesis on the valuation of externalities in maritime infrastructure projects. The thesis explores sustainable asset valuation methods, comparing them based on economic, social and environmental criteria. A secondary research approach was used to identify existing methodologies for sustainable project valuation, with eight methods found to be suitable for maritime infrastructure projects.

Using the Analytic Hierarchy Process (AHP) method, eight of these valuation methodologies were compared. The study's findings suggest that when a project has more than one significant externality, trade-offs occur between the accuracy of their valuation. The Hondsbossche and Pettemer (H&P) sea dunes project was used as a case study to demonstrate the application of this comparison.

The thesis recommends that different maritime infrastructure projects use different valuation methods, depending on the externalities that have the greatest impact and risk on the project. The results of the thesis are published in issue no.165 of the *Terra et Aqua* journal (Winter 2021).

One of the methods investigated is the Sustainable Asset Valuation (SAVi), developed by the International Institute for Sustainable Development (IISD). In 2021, IISD published an economic valuation of the Hondsbosche Dunes sand nourishment project, assessing its contribution to climate adaptation and local development. The study found that the Hondsbossche and Pettemer (H&P) sea dunes outperform conventional flood protection infrastructure. Compared to a "grey" infrastructure alternative of raising the sea dyke, the nature-based infrastructure (NBI) was not only most cost-effective to build, but it also delivered greater benefits for tourism. According to IISD's modelling, the sand dunes are projected to increase tourism revenue by almost EUR 203 million over 50 years, while the grey alternative would generate only EUR 103 million.

"Constructing new marine infrastructure or maintaining ports and waterways often has both positive and negative environmental effects, which can influence surrounding ecosystems in many different ways. That's why sustainability is critical throughout the dredging industry, and finding nature-based solutions is essential for achieving long-term, responsible development", says René Kolman, former Secretary General of IADC and guest editor of this issue of *DFSI Magazine*. "To become truly sustainable, all impacts need to be considered in project evaluations. Factors like the influence on biodiversity or recreation opportunities, for instance, are hardly ever taken into account in project evaluations. IADC believes in promoting the inclusion of all externalities. The result of the SAVi assessment of the Hondsbossche and Pettemer sea dunes has allowed IADC to showcase the benefits of nature-based solutions and the additional value that can be created."

Aerial image immediately after excavation of hydrological interventions (December 2023).

Community-based ecological mangrove restoration

IN QUELIMANE, MOZAMBIQUE

The Quelimane Mangrove Restoration (QMaR) initiative, led by Van Oord, demonstrates a community-based ecological approach to mangrove restoration. Through hydrological interventions and alternative livelihood initiatives, 4 hectares of degraded mangrove habitat are being restored. One year after implementation, seedlings have established and grown well, especially near natural water sources. Over 100 community members have participated in an alternative livelihood programme, reducing dependence on mangrove logging and improving household incomes. Some even made investments such as purchasing property, demonstrating enhanced economic stability. These results highlight the critical role of integrating ecological restoration with community empowerment and livelihood support in achieving sustainable mangrove restoration.

Community Social Officers of Van Oord and ANAICIDUA hosting a community engagement session.

Community-based ecological mangrove restoration

Mangrove ecosystems are among the most productive and biodiverse ecosystems on the planet, offering a wide range of ecosystem services. They play a key role in climate change adaptation and mitigation by providing coastal protection from extreme weather events and carbon sequestration. Mangroves also serve as vital nursery habitats for numerous fish species, thereby enhancing biodiversity, sustaining local fisheries, and contributing to food security. However, mangroves are among the most threatened ecosystems worldwide, leading to increased restoration efforts. Success rates are mixed: in some regions, mangrove cover has expanded through community-led efforts, while elsewhere failure rates of up to 80% persist – often caused when planting occurs in unsuitable sites or without local buy-in. Initiatives increasingly embrace Community-Based Ecological Mangrove Restoration (CBEMR). This approach combines ecological restoration with active community involvement. Ecological restoration focuses on re-establishing the conditions required for mangrove habitat, such as restoring natural hydrology and promoting natural regeneration. This is done with the active participation of local communities to foster empowerment and ensure long-term sustainability. Besides, alternative livelihood programmes (e.g., mangrove-based food production, ecotourism and sustainable aquaculture) have become integral to reducing anthropogenic pressure on mangrove ecosystems, which is one of the root causes of degradation.

Van Oord's Quelimane Mangrove Restoration (QMaR) initiative exemplifies this integrated approach. Located near Icidua, a neighbourhood of Quelimane, Mozambique, the initiative aimed to restore degraded mangroves by addressing both the disrupted ecological conditions and the socioeconomic drivers that led to depletion. A key driver for selecting this site was the urgency expressed by the local community, who were facing severe erosion and recurrent flooding threatening their homes. Together with the local community and implementing partners, we identified, designed, implemented and evaluated ecological and social interventions to restore mangrove habitat at the scale of four hectares. If proven successful, the approach could be applied to large-scale mangrove restoration in similar areas. The initiative comprised four phases: 1) scoping study to assess the existing conditions and stressors; 2) design phase for ecological restoration techniques and social interventions; 3) construction and implementation phase; and 4) monitoring and evaluation.

Scoping study: Addressing the root causes

In May 2022, a scoping study was initiated to identify the root causes of mangrove degradation in Icidua. The study combined community

Van Oord engineers, local leaders, the mayor of Quelimane, community associations and community members performing the traditional opening ceremony of the ecological restoration activities.

consultations, stakeholder meetings and a door-to-door baseline survey, with ecological, topographic and hydrological surveys. It was estimated that the Icidua community consists of approximately 1,900 households, of which 286 participated in the baseline survey. The findings revealed that mangrove degradation is primarily driven by anthropogenic pressures. The local and surrounding communities rely heavily on mangrove wood for charcoal, firewood and construction, while additional loss results from land-use change for agriculture, aquaculture, and urban expansion. These activities not only reduce mangrove cover but also disrupt hydrological connectivity, leading to poor water retention and limited recruitment of seeds. Consequently, natural regeneration of the mangrove area is hindered, as propagules are unable to reach and colonize the site, and soil conditions are too dry to support seedling survival.

Community and stakeholder engagement

From the outset of the QMaR initiative, a wide range of stakeholders were involved in shaping the project, including the local community, local leaders, local authorities, the municipality, the National Oceanographic Institute of Mozambique (InOM), the Eduardo Mondlane University (UEM) and various local associations, such as ANAMA and ANAICIDUA. Guided by a needs-based strategy - set by locals, for locals and with locals - we prioritised community ownership by employing a local team and collaborating closely with community associations. Engagement sessions provided valuable insights into the community's reliance on mangroves, informing an approach that incorporated local knowledge and guided the development of an alternative livelihood programme.

Design

Solutions were co-developed with the local community. These included an alternative livelihood programme, the production of efficient charcoal stoves and awareness-raising campaigns emphasising the role of mangroves in coastal resilience. In parallel, hydrological interventions were designed to re-establish the conditions necessary for natural mangrove regeneration and expansion, a collaboration between

Community members excavating channels for hydrological restoration.

Van Oord and The Weather Makers - a Dutch company dedicated to nature-based design and engineering. These interventions specifically aim to restore hydrological connectivity and improve water retention within the mangrove ecosystem.

Environmental

To re-establish tidal flooding patterns in the area, tidal channels were designed to reconnect the landscape with riparian flows and floodplains, thereby increasing water availability and facilitating natural propagule dispersal. The design included a primary channel to convey water from the river into the restoration site, with two secondary channels branching off to distribute water across the surrounding area, both extending approximately 150 metres into the site. The primary and secondary channels were designed to be fully submerged during high tides and to allow overflow during both rainy and dry seasons, increasing the surface area of the floodplain. Additionally, ten swales (small depressions with soil bunds and basins) were created to enhance water retention and infiltration, improving soil moisture and creating favourable conditions for seedling establishment and survival.

Social

The design of the social programme was based on community needs identified through several stakeholder meetings and community consultations during the scoping survey. This survey revealed that the community depends on mangrove wood for charcoal, firewood and construction materials, and that it is a source of income for many. Therefore, the social programme consisted of three components:

1. An alternative livelihood programme aimed at reducing the community's dependence on mangrove wood.
2. A community awareness-raising campaign to highlight the value of the mangrove ecosystem in protection against erosion and floods, and fisheries support.
3. Introducing sustainable cooking stoves to reduce the need for charcoal or firewood. A community association (Associação Muelabony Nguiro) was established to manufacture these sustainable stoves for the Icidua community.

Construction and implementation

Hydrological restoration

The interventions for hydrological restoration were executed from September to December 2023. Following local customs, the first day of excavation started with a traditional opening ceremony during which the mayor of Quelimane put the first shovel in the ground. To maximise local involvement, the channels and swales were excavated manually by over 200 community members. They were hired by implementing partner ANAMA, an association with experience in hydrological restoration. This approach created short-term labour opportunities and strengthened ownership and understanding of the restoration process among participants. The excavated sediment was reused to reinforce a dyke behind the restoration site, enhancing coastal safety and resilience of the surrounding households.

Alternative livelihood programme

The alternative livelihood programme began in April 2024, with Van Oord's involvement lasting until April 2025. In collaboration with implementing partners, alternative income-generating activities were introduced to 153 households, tailored to local needs and capacities. Together with Nova Madal, an agricultural company focused on inclusive land investment, sustainable agriculture and poultry farming initiatives were launched. Also, eco-friendly charcoal production from eucalyptus trees was introduced, along with training to manufacture energy-efficient cooking stoves. Through a partnership with Mozambikes (a Mozambican social enterprise that manufactures and distributes bicycles), bicycle taxis were donated and bicycle repair workshops and training sessions were facilitated. We also supported the Community Aquaculture Association by facilitating technical exchanges with InOM, improving fish feed quality and productivity. Lastly, the Salt Doctors, a Dutch NGO specialised in saline agriculture, provided training on saline agriculture to help community members adapt to climate change. The livelihood initiatives are ongoing and in the coming period the Sustainable Cooking Stove Association will continue producing stoves for distribution across the community.

Awareness-raising campaign

Community association ANAICIDUA carried out a 6-month awareness campaign focused on the importance of mangroves for flood and erosion protection, as well as supporting fisheries. This initiative engaged community members beyond those directly involved in the restoration efforts, allowing us to listen, respond and build trust through open dialogue. By collaborating with the local school, we introduced mangrove education into classrooms to raise awareness among the next generation. Additionally, a radio advertisement was launched to broadcast key messages about QMaR and mangrove conservation over a period of 6 months.

Monitoring and evaluation

Environmental

Monitoring of the restored area has been conducted since March 2024 to evaluate the effects of the restoration activities. In collaboration with InOM and UEM, monthly field assessments have been carried out to evaluate mangrove development within the channels and swales. Propagule density, seedling establishment and survival were recorded, and several seedlings were monitored individually for their health and growth (Table 1).

Seedlings successfully established around swales (September 2025).

The area behind the hydrological intervention, showing successful seedling establishment (September 2025).

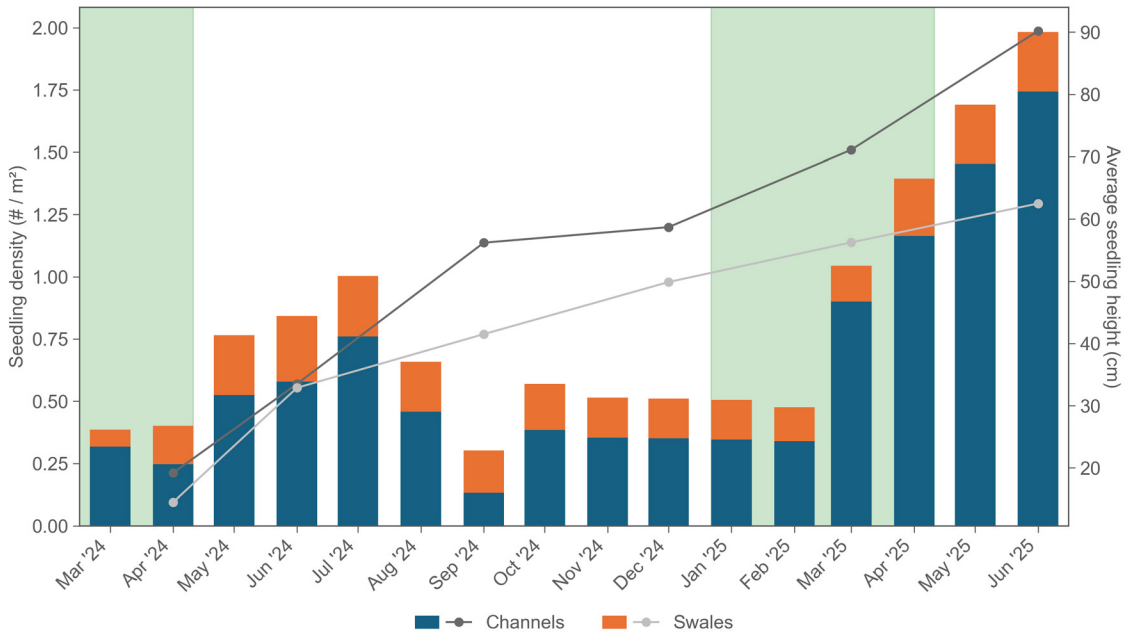


TABLE 1
Dynamics of seedling density in channels (blue bars) and swales (orange bars), and the average height of selected seedlings in channels (n=5, dark grey line) and swales (n=4, light grey line) following restoration. The light green patches indicate the propagule dispersal season of the mangroves in Quelimane, which extends from January to April.

Monthly monitoring has shown that immediately after restoration, natural recruitment and establishment of seedlings occurred in the channels and swales, followed by successful growth. Over the course of a year, seedling density at the site increased significantly compared to the early months following restoration. Moreover, seedlings grew by an average of approximately 40-50 cm during the first year after restoration.

Seedling establishment and growth were most successful in the channels, particularly in the section closest to the river, likely due to persistent inundation even at low tide, in contrast to the swales. A similar pattern was observed in the swales, where seedling establishment was strongest in those located nearest to natural creeks. These findings underline the critical role of hydrological connectivity in promoting mangrove regeneration and, consequently, in achieving successful restoration.

To build local capacity and ensure a responsible exit from Van Oord, we established a community-led Mangrove Management Committee, which received training in ecological monitoring and site maintenance. This committee now works closely with UEM and InOM to monitor the restoration site and carries out maintenance as needed. In addition, the committee serves as a valuable knowledge base within the community, promoting mangrove conservation and potentially supporting future restoration efforts at other sites.

Social

The QMaR initiative demonstrated strong community engagement, with over 200 community members hired for the physical restoration works, including the digging of the channels and swales. Additionally, 134 individuals participated in the alternative livelihood programme from April 2024 onwards, offering activities such as efficient charcoal stove production, poultry farming and sustainable agriculture. Furthermore, 19 individuals completed the Salt Doctors saline agriculture training towards the end of the first year of the programme.

To assess the social impact of the alternative livelihood programme, KPI surveys were conducted before and after implementation with the 134 beneficiaries. Table 2 shows the percentage of households engaging in various coping strategies to meet essential needs in April 2024 and April 2025.

Results after implementation show a 22% reduction in household reliance on mangrove wood for income generation. However, precise quantification is challenging, as mangrove logging is illegal and subject to social control. Individuals may be reluctant to admit engaging in mangrove logging, which could lead to underreporting. This also complicated the identification of community members who rely on mangrove wood for income during the beneficiary selection process, as not everyone was willing to disclose such activities.

WE INTRODUCED MANGROVE EDUCATION INTO CLASSROOMS to raise awareness among the next generation.

Lessons learned

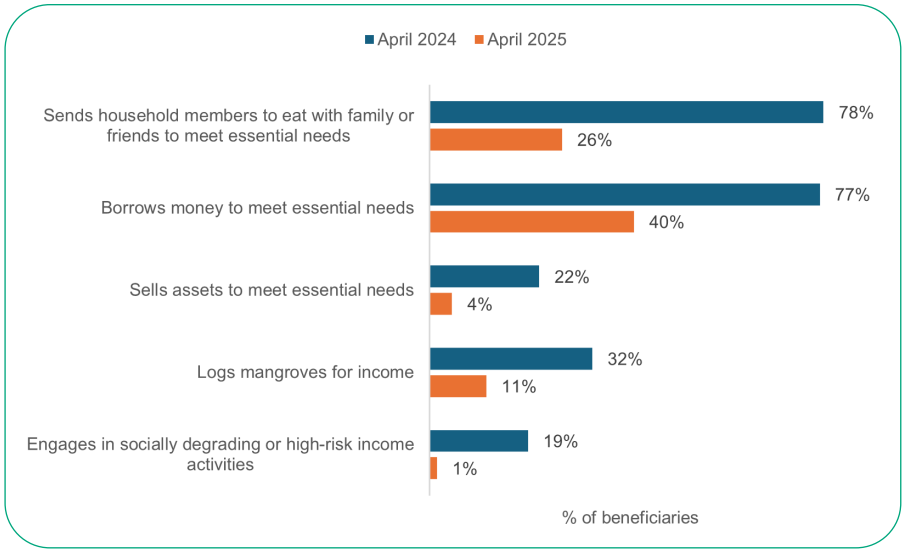
- Having a local team with a good understanding of the socio-economic and cultural context of an area is essential when working with vulnerable communities, both for conflict resolution and relationship building. Their ability to speak the local language, navigate cultural norms and sensitivities, and draw on knowledge of past initiatives in the area plays a critical role in building trust.
- QMaR demonstrated that social-scope interventions span a significantly longer period than ecological restoration activities. While the implementation of hydrological interventions was completed within three months, social interventions required sustained engagement over approximately 2 years.
- Designing hydrological interventions to align with locally available tools and skills, such as matching channel dimensions to wooden frames crafted by a local carpenter, empowers community members to execute the work manually. This approach enhances local ownership, reduces implementation costs and supports long-term sustainability.
- The Mangrove Management Committee remains motivated to monitor the restoration site, but its continued engagement is challenged by limited access to basic provisions. Since the committee members depend on daily labour to meet their essential needs, the time they dedicate to monitoring activities competes with the time required to secure food and income. As a result, the committee still expects some level of continued support from Van Oord, such as meals or snacks, during monitoring activities.

Overall, the KPI survey results suggest a substantial improvement in household stability and resilience, along with a reduced need for high-risk jobs or mangrove logging as a coping mechanism. Some individuals even reported being able to purchase property and assets to improve their livelihoods. As the livelihood initiatives are still active, pressure on the mangrove ecosystem is likely to continue to decline.

Despite the overall success of the alternative livelihood programme, participation in the sustainable agriculture initiative was notably low. This was primarily because the training sessions coincided with the farmers' harvest period, making it difficult for them to attend. Most farmers were occupied with work on their own plots, which were located far from their homes and the training sites. As a result, the timing and location of the programme did not align with the farmers' daily priorities, limiting their engagement. These limitations reflect broader operational challenges faced by implementing partners in aligning programme delivery with community needs.

TABLE 2

Percentage of beneficiaries (n=134) and their coping strategies to meet essential needs, measured through KPI surveys in April 2024 and April 2025.



Towards scalable, sustainable restoration

As Van Oord's involvement came to an end, a closing ceremony was organised to formally hand over responsibilities to the community Mangrove Management Committee, reinforcing community ownership and long-term stewardship, and to encourage all stakeholders to maintain dialogue and momentum.

The results of the Quelimane Mangrove Restoration (QMaR) initiative underscore the importance of integrating ecological and social interventions, providing a valuable model for future mangrove restoration practices. While further monitoring is required to confirm long-term outcomes, the initial successes observed suggest strong potential for applying this approach at larger scales in the region and in other areas facing similar ecological and socio-economic challenges.

As the livelihood initiatives are still active, pressure on the mangrove ecosystem is likely to continue to decline.

Bicycle taxis donated through Mozambikes as part of the alternative livelihood programme.

Beneficiaries of the sustainable charcoal initiative, proudly showing charcoal made from eucalyptus wood.

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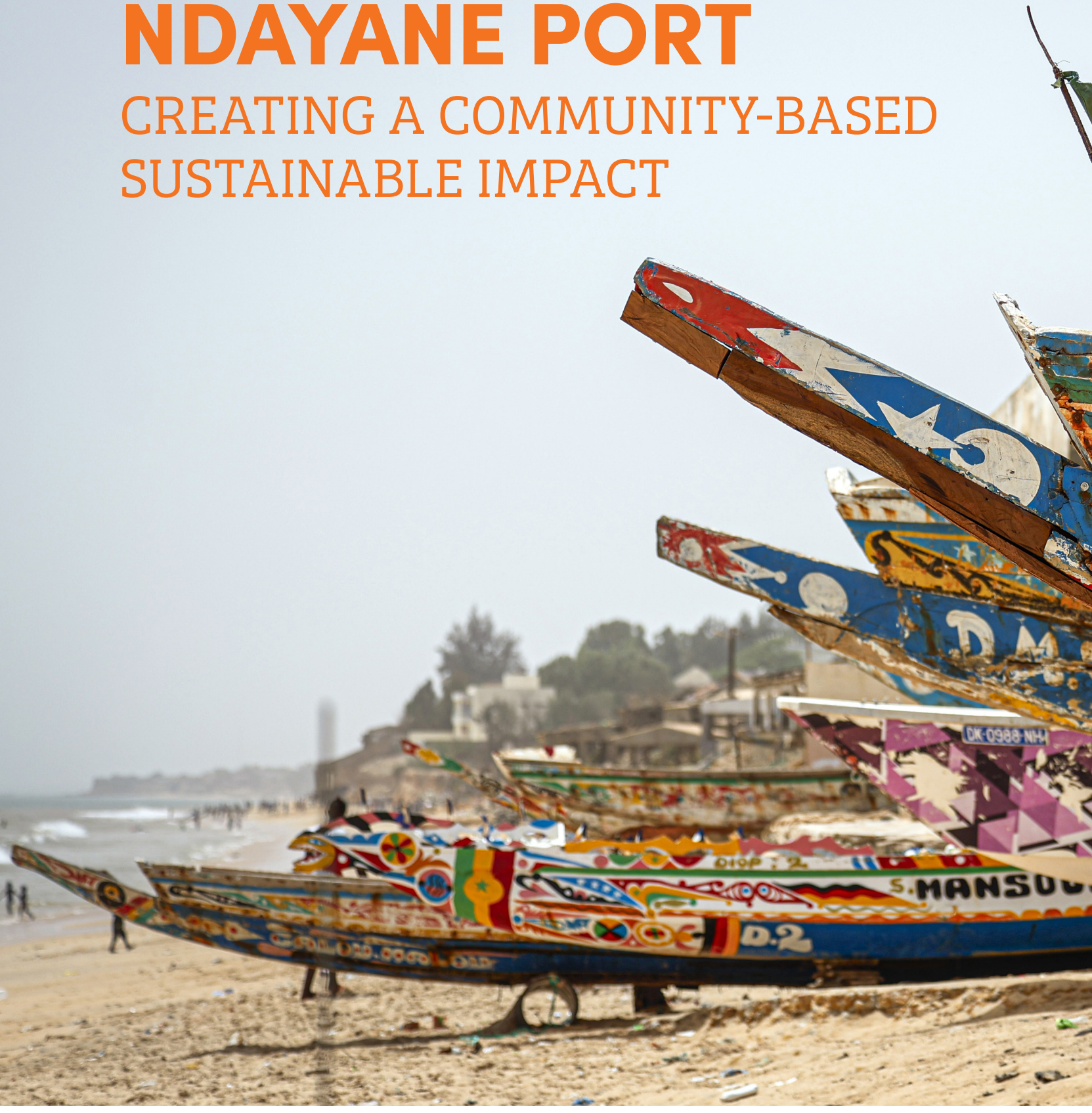
SENEGAL, NDAYANE PORT

CREATING A COMMUNITY-BASED SUSTAINABLE IMPACT



How can we balance the economic benefits of a large port development with measures that protect society and the environment? The deep-water port of Ndayane, 50 kilometres south of Dakar, is a practical example. Developed by DP World, with dredging and reclamation works being done by Jan De Nul, this port facility aims to boost trade and drive economic growth in Senegal, while also showing how major infrastructure projects involving challenging dredging and reclamation activities can create added value for local communities and the surrounding environment.

Geographical location and design of the Senegalese deep-water port of Ndayane.

The project generated skills and opportunities **that extend beyond the construction site itself.**

To balance development with environmental and social responsibility, a comprehensive Environmental and Social Impact Assessment (ESIA) laid the foundation for detailed Environmental and Social Implementation Plans (ESIP), guiding the project from early design to on-site execution. In 2024, Jan De Nul commenced dredging the access channel and reclaiming the 89-hectare platform for maritime services and container storage with the cutter suction dredger Willem Van Rubroeck. Besides the standard environmental management, monitoring and contractual requirements, several initiatives were established together with nearby communities, demonstrating how sustainability assessment and management can move beyond compliance.

Cutter suction dredger Willem Van Rubroeck at the Ndayane Port project.

From assessment to action

ESIA as a guide

Large-scale infrastructure projects inevitably raise questions about their environmental and social impact. The Ndayane Port project is no exception. To address all these potential impacts, the ESIA for the port development was finalised in 2021. The ESIA covers the entire project lifecycle from construction to operation, including both environmental aspects, such as air quality, noise and water parameters, as well as social aspects, including fisheries, employment and cultural heritage. This ESIA is more than a simple compliance document or a checklist of requirements. It functions as a tool for transparency, early dialogue and accountability.

Baseline studies form a central part of the ESIA. These studies capture the "before" situation from environmental conditions to social dynamics. During the construction phase, the ESIA and its baseline study are frequently used as reference points to guide monitoring and decision-making. Community knowledge has played a central role in adding local insights into the ESIA. Residents of the Petite Côte know their environment best, whether it concerns fishery patterns, turtle nesting grounds or cultural heritage. Their input helped the assessment but also shaped the design of mitigation measures and the monitoring programme.

From ESIA to ESIPs

The next step was translating the ESIA into ESIPs. These plans serve as practical implementation plans for the construction phase, ensuring that every aspect is addressed through detailed, specific actions. For example, the waste management plan introduces structured collection and disposal methods, while the local employment plan prioritises

The fishermen community of the Petit Côte.

Local employment workshops at the communities around the Ndayane Port project.

job opportunities for people living in the surrounding communities. Similarly, the cultural heritage management plan outlines best practices for managing cultural heritage within the project area. For the Ndayane Port project, 15 ESIPs have been developed, each addressing a specific environmental or social aspect of the works.

Translating the ESIA into ESIPs was not without its challenges. On the one hand, construction deadlines are strict, with dredgers and earthmoving equipment working around the clock. On the other hand, community involvement takes time: information sessions, feedback rounds and building trust cannot be rushed. The solution lay in early engagement: communities were informed and consulted well before dredging began as part of the ESIA process, ensuring that concerns were addressed and misunderstandings avoided. One clear example is the ESIP on local employment. In the three communities surrounding the project, information sessions were organised not only to explain the works, but also to give local residents priority access to job applications. In this way, the project generated skills and opportunities that extend beyond the construction site itself.

Monitoring compliance

Taking care of environmental quality

To ensure the project meets its environmental commitments, monitoring is carried out systematically and objectively. Calibrated instruments and standardised methods are used to capture accurate and reliable data. For marine water quality, multiparameter probes equipped with sensors are used to measure turbidity, dissolved oxygen, pH, temperature and conductivity. In addition, turbidity buoys provide continuous real-time data. Air quality and noise measurements are conducted at multiple locations around the site, typically over 24-hour cycles to capture daily variations. As part of the marine scope, a Marine Mammal and Reptile Observation programme has been implemented to monitor and protect sensitive species during dredging activities. Light assessments and cultural heritage monitoring are performed on site using dedicated checklists. For certain parameters, such as water samples requiring laboratory analysis, the project collaborates with accredited local laboratories. This combination of international standards and local expertise guarantees reliable results while strengthening local capacity.

In parallel with field monitoring, turbidity plume modelling was conducted for the designated disposal area, which will be used in the final phase of the project when a trailing suction hopper dredger (TSHD) will clean up the spill in the channel. This predictive model simulates how the sediments disperse in the water column during disposal activities.

Water quality monitoring with the local laboratory.

The results are used to examine the impact of the operations and to adapt if deemed necessary.

Environmental monitoring is not a one-off exercise but an ongoing process that runs throughout the project. Monthly follow-ups give a clear view of trends over time, with results compared against the strictest applicable standards, whether set by Senegalese regulations or the World Health Organisation (WHO). This ensures strong compliance while creating a basis for timely adjustments.

Mitigation measures are defined in the ESIPs and further refined through ongoing monitoring. For example, turbidity levels are tracked continuously during dredging operations, with thresholds in place to trigger immediate operational changes. Similarly, dust emissions on project roads are monitored and regular water spraying is applied. This adaptive management approach is increasingly being applied in dredging projects, where monitoring results are compared against the ESIA baselines and trigger values to fine-tune mitigation measures.

Regular trainings and awareness sessions are organised for the entire project team, both onshore and offshore. Toolbox talks, safety drills and dedicated environmental briefings ensure that every team member understands the environmental scope of the project, knows how to identify potential risks and takes responsible actions in daily operations.

Social concerns

Importantly, the Ndayane Port project's monitoring efforts go beyond environmental concerns. A clear example is the safety no-go zone around the dredging area. Local fishermen were initially concerned that it would interfere with their activities. To address this, the project team organised several information sessions, explaining the purpose of the zone and engaging the fishermen themselves in respecting and even safeguarding it. By combining technical monitoring with open dialogue, the project not only achieved smoother operations but also fostered stronger trust within the community.

One of the key pillars of the project is engaging and supporting the local workforce. Rather than outsourcing specialised tasks, opportunities were created for local workers on the job. An important example is our local welders. Experienced welders from the project team mentored young community members, guiding them through the techniques of cutting, joining and shaping steel. This hands-on approach not only enhanced the quality of the work on site but also provided trainees with a marketable skill set that will remain valuable for the rest of their career. For many employees, this training represents the first step towards sustainable employment and financial independence.

Our local workers play a crucial role in turning plans into reality. To strengthen communication and ensure their perspectives are heard, a grievance box was installed on site. Workers are invited to submit their ideas or concerns, which are reviewed weekly by the project team. This simple initiative has proven to be a valuable channel for feedback, helping to identify improvements for the site operations, safety and daily working conditions. It has fostered a culture of openness where the workers know that their voices matter.

Sustainability beyond compliance

Besides complying with the ESIA requirements, several initiatives were carried out in close collaboration with the local communities, pursuing shared sustainability values. One of the most visible activities has been the regular

Environmental training and awareness sessions for the entire project team.

A safety meeting with the fishermen community to explain the dredging and reclamation works.

organisation of beach cleanups, often bringing together up to 100 participants. During the turtle nesting season, those cleanups were even organised on a monthly basis. The Petite Côte is a known nesting area for sea turtles and waste or debris on the beaches can prevent turtles from laying their eggs or threaten hatchlings. By cleaning the beaches and raising awareness, the community contributes directly to turtle conservation.

The importance of this work was particularly highlighted during World Turtle Day, when a special cleanup was organised with local schoolchildren under the slogan "*Zéro Plastique, c'est Fantastique*". The day began with an awareness session, teaching the children about the dangers of plastic pollution, especially to marine wildlife and explaining the importance of maintaining clean coastal environments. Students actively participated in the discussions and learned about the long-term impacts of plastic waste on ecosystems and human communities. After the awareness session, everyone joined forces for a beach cleanup along the Ndayane coast. Armed with gloves and rubbish bags, the participants collected plastic waste along the shore, removing a significant amount of debris and leaving the beach in a much healthier state. To symbolise this effort, welders from the project's workshop created a turtle-shaped waste bin, named Ecotuga. The children helped fill the turtle with the plastic bottles they had collected. Today, the turtle serves both as a functional bin and as a mascot for environmental awareness.

Environmental actions are not limited to the coast. In collaboration with the sisters of a local convent, the project supported the planting of 100 young trees. Community members and project staff were divided into teams, each taking care of a specific task: preparing a fertile plant substrate, digging pits, planting trees, watering and building protection against roaming animals such as goats. Over time, these trees will provide shade during the hot and

Rather than outsourcing specialised tasks opportunities were created for local workers on the job.

Beach cleanup on World Turtle Day:
Zéro Plastique, c'est Fantastique.

dry season for both people and animals, improve air quality and create pleasant community spaces, reinforcing the idea that sustainability is a shared responsibility.

Capacity building was also addressed through education. Evening English language classes were organised for workers, taught by a community teacher. The response has been enthusiastic, with workers recognising the long-term value of language skills. For many, this is the first step towards broader career opportunities, not only within the port project but also in the wider job market.

Although these initiatives were not prescribed by the ESIA, they illustrate how close interaction with the communities can highlight key concerns and leave space for creative, locally adapted responses. The combination of environmental, social, and educational actions demonstrates how a project can move beyond compliance and contribute to meaningful, long-lasting benefits. These positive impacts may continue long after the project construction activities have ended. The project is also continuously exploring initiatives to support local pilot programmes to enhance biodiversity, including the potential establishment of mangrove planting programmes.

Port du Futur

The story of sustainability at Ndayane Port is still unfolding. Several ideas are already on the table for the coming months, with a particular focus on waste management. Community members have highlighted the lack of formal waste disposal points, with litter often left on the streets. Plans are being developed to establish small recycling

Tree planting event with the local community.

Port du Futur.

centres where people can bring their waste. These sites would be managed by trained community members and emptied twice a week in collaboration with local waste companies. In addition, discussions are ongoing with local organisations to recycle the plastic waste from the project into useful products such as furniture.

The long-term ambition is not only to minimise environmental impact during the construction phase of the project, but to also leave behind a culture of sustainability by encouraging people not to throw waste in nature, to see value in recycling and to feel pride in protecting their coast.

The Ndayane Port project illustrates how sustainability assessment and management can go beyond compliance. As the project developer, DP World ensured that sustainability was embedded through a comprehensive ESIA process and executed a suite of implementation plans in collaboration with Jan De Nul. The ESIA provided the framework, the ESIPs translated it into action and the monitoring ensured compliance. Yet, the real added value lies in the extra steps: ensuring fishermen's safety with agreed no-go zones, engaging schoolchildren in cleanups, planting trees with the local community, teaching workers new skills, etc.

This perfectly aligns with the sustainability strategy of both Jan De Nul and DP World. DP World's sustainability strategy "Our World, Our Future" sets out the pathway on how DP World operates as a responsible business, prioritising working sustainability and all that entails in terms of impact on people, the environment and the communities. At Jan De Nul, we are helping to build tomorrow's world whilst taking care of the nature and people around us, in line with our ambition to improve the quality of life of future generations.

The story in Senegal is far from finished. With many ideas still to be realised, Senegal's Port du Futur continues to plant seeds of sustainability that will keep growing in the years to come.

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TALKING HEADS

Liesbeth Casier

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The statement is correct: an environmental impact assessment (EIA) on its own cannot capture whether a port project is truly sustainable. What is critical is to assess environmental, social and economic impacts holistically, in a way that shows decision-makers their material effect on project performance. Climate change illustrates this: sea level rise and extreme weather are causing flooding, raising repair costs and disrupting port-related economic activities. EIAs highlight environmental risks but miss social and economic factors; these should also inform key decisions in the infrastructure cycle. In our work through the Nature-Based Infrastructure Global Resource Centre, we've recently evaluated the environmental, social and economic externalities of a mangrove restoration project for coastal protection for the DEEP C Industrial Zone in Hai Phong, Vietnam. This 3,400-hectare hub for logistics and manufacturing is directly exposed to sea-level rise, storm surges and coastal erosion. A national sea dyke is being built to protect the zone. An EIA would typically conclude that this measure addresses the risk. Yet dykes erode, need costly upkeep and may fail under stronger storm surges and erosion.

Using the Sustainable Asset Valuation (SAVi) methodology, we carried out an integrated cost–benefit analysis of combining the dyke with 70 hectares of mangroves. Unlike a conventional CBA, this integrated approach captures social and environmental externalities alongside financial costs and benefits. Mangroves extend the lifespan of the dyke, reduce erosion and lower maintenance needs. Across scenarios, they avoid between USD 0.5 million and USD 5 million in flood damages, while property values increase by up to USD 7.3 million over 26 years. They also create jobs, provide public space and sequester carbon. In the most favourable scenario analysed, each dollar invested generates USD 3.40 in benefits, with an internal rate of return of 32%.

For the Hai Phong People's Committee, the evidence supports co-financing mangrove restoration. For businesses, it demonstrates that nature-based infrastructure is not an environmental add-on but a safeguard for assets and supply chains. For the engineering community, it shows that hybrid solutions, grey reinforced by green, deliver greater resilience than hard infrastructure alone.

The Vietnam case confirms that EIAs alone provide an incomplete picture. To assess the sustainability of port and coastal protection projects, evaluations must integrate social outcomes and monetised externalities. An integrated cost–benefit analysis should be seen as a necessary complement to EIAs, ensuring infrastructure fulfils its primary function while delivering long-term value to society.

Nature-based infrastructure is not an environmental add-on but a safeguard for assets and supply chains.

Successful sustainable port and coastal protection projects require more than environmental impact assessments; an integrated economic analysis that monetises social and environmental impacts is essential to reveal societal value and assess sustainability. We asked two industry professionals to share their expertise on the topic.

Jan Hoffmann

Global Lead,
Maritime Transport and Ports,
The World Bank

Environmental Impact Assessments (EIAs) are a cornerstone of responsible port development. They identify potential harm to air, water, biodiversity and climate, and propose mitigation measures. Yet, as the third edition of the Port Reform Toolkit stresses, an EIA alone does not guarantee a sustainable project. Ports are complex nodes where trade, logistics, urban development and ecosystems converge. To secure legitimacy and long-term sustainability, environmental considerations must be integrated with social and economic dimensions, and externalities must be recognised and – ideally – internalised.

Sustainable port projects depend on governance models that extend beyond narrow technical assessments. Port authorities increasingly act as community builders, balancing trade facilitation with societal expectations. This requires structured dialogue with local communities, labour representatives and municipal governments. By incorporating the social component early, projects can build trust, reduce conflict and ensure that benefits are widely shared.

From a financing perspective, risk allocation must reflect not only commercial and operational issues but also environmental, social and governance (ESG) factors. Monetising externalities, both positive and negative, is a powerful tool. It allows the economic evaluation of ports to move beyond financial returns to capture societal value: cleaner air, reduced congestion, resilience to climate risks and opportunities for green industries. Only when such impacts are quantified can investors, regulators, and citizens understand and ensure sustainability.

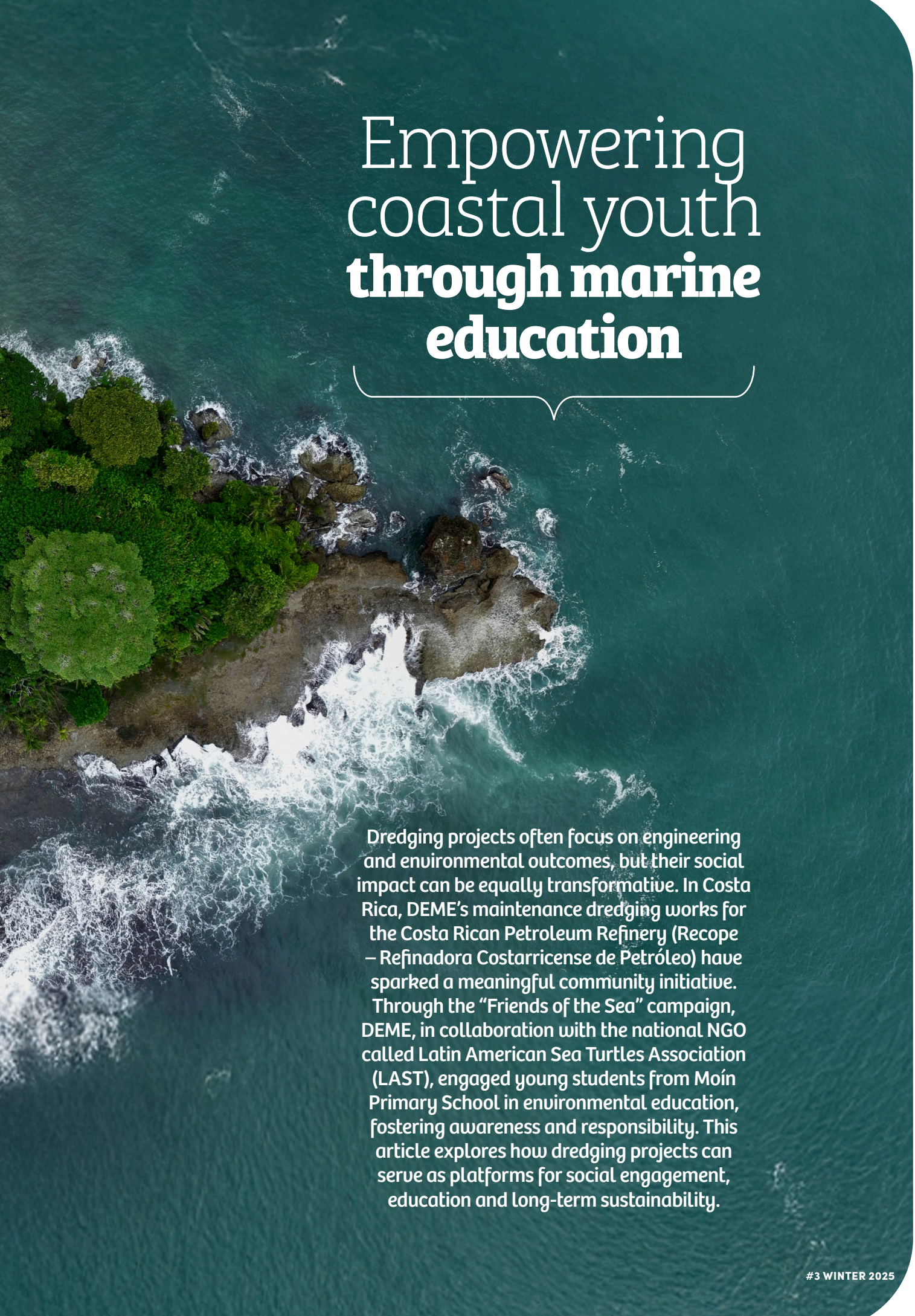
Private sector involvement is most effective when aligned with public objectives. Well-designed public–private partnerships can mobilise capital and know-how, but they must also include incentives for environmental performance and community value creation. Contracts that price externalities or reward low-carbon technologies turn sustainability from a compliance burden into a competitive advantage.

An essential element in this context is the tender process. The World Bank and IFC require environmental and social assessments throughout the project cycle, with clear safeguards on resettlement, Indigenous Peoples and climate impacts. Yet in many client countries, tender documents still omit sustainability requirements. As highlighted in the Port Reform Toolkit, embedding such criteria in procurement is decisive: it ensures that bidders internalise sustainability from the outset, aligns contracts with international good practice, and avoids costly retrofits or conflicts later.

Ports must co-evolve with their cities, addressing congestion, air quality and land use conflicts. Embedding social and environmental goals within port–city planning ensures that infrastructure becomes a driver of inclusive growth rather than a source of tension.

Only when externalities are quantified can investors, regulators and citizens ensure sustainability.

Empowering coastal youth **through marine education**



Dredging projects often focus on engineering and environmental outcomes, but their social impact can be equally transformative. In Costa Rica, DEME's maintenance dredging works for the Costa Rican Petroleum Refinery (Recope – Refinadora Costarricense de Petróleo) have sparked a meaningful community initiative. Through the "Friends of the Sea" campaign, DEME, in collaboration with the national NGO called Latin American Sea Turtles Association (LAST), engaged young students from Moín Primary School in environmental education, fostering awareness and responsibility. This article explores how dredging projects can serve as platforms for social engagement, education and long-term sustainability.

Project context and environmental sensitivity

This project was carried out in Costa Rica, a country renowned for its commitment to conservation, biodiversity and leadership in global environmental issues such as climate change and reforestation. As a result of stringent national environmental policies and specific regulatory requirements, the project posed a significant challenge.

The Port of Moín, situated within the Port Complex of Limón province, occupies a strategically vital location just 12 hours from major global trade routes connecting North America, South America, the Caribbean, Europe and the Panama Canal. The maintenance dredging project at Moín encompassed seven distinct zones, including the access channel, manoeuvring basin and areas facing the main pier. Dredged material was disposed of at a designated disposal site 5.5 kilometres northeast of the port entrance, at depths between 50 and 70 metres.

This region is characterised by dynamic sedimentary processes, influenced by local rivers and marine currents, resulting in variable water turbidity and moderate concentrations of metals. The marine ecosystem has experienced significant degradation with reduced coral cover and loss of seagrass meadows, impacting biodiversity and keystone species as the manatee, sea turtles and marine mammals.

Given these sensitivities, the project's Environmental Management Plan (EMP) incorporated rigorous measures for monitoring water quality, ecosystem conservation status, controlling sediment dispersion, minimising emissions and protecting marine life. The overarching aim is to balance port development with environmental stewardship, ensuring that all activities are conducted in accordance with national and international regulations and contribute to the long-term sustainability of Costa Rica's coastal resources.

In light of Costa Rica's unique environmental landscape and its strong culture of conservation, we recognised the importance of going beyond the technical and regulatory scope of the EMP. To complement these measures, we launched a dedicated social initiative aimed at promoting ecosystem preservation through youth empowerment. The marine education programme was specifically designed to involve the local community – particularly young students – in learning about and protecting their marine surroundings. This initiative not only

Environmental education in community spaces becomes a vital tool for change.

Species like the manatee and sea turtle inspire ongoing conservation work to restore and strengthen the marine ecosystem.

Moín Primary School students. Credit: All school photos courtesy of DEME Costa Rica project team.

deepened environmental awareness but also reinforced the project's broader commitment to social responsibility and long-term sustainability.

A holistic approach to environmental education

DEME's "Friends of the Sea: Discovering, Caring and Enjoying" campaign was more than a one-off event – it was a carefully designed environmental education workshop aimed at primary school children in Moín, Costa Rica. Led by environmental educators and specialists, the initiative took place at the Moin Primary School.

The workshops were grounded in the principles of environmental education, which seek to develop critical awareness of the human-nature relationship. It promotes values and attitudes that support the conservation of natural resources and ecological balance. In this context, the campaign aimed to provide children with tools to understand the importance of marine ecosystems and adopt sustainable practices in their daily lives.

Pedagogical foundations and justification

The campaign's pedagogical strategy was based on mediation – an approach that encourages dynamic learning through dialogue, reflection and action. This method is particularly effective in community settings, where conservation efforts depend on citizen engagement. The workshops used playful activities to facilitate interaction and knowledge construction, helping children become active agents of environmental protection.

The justification for the workshop was clear: the global environmental crisis, marked by biodiversity loss, ecosystem degradation and climate change, demands urgent educational responses. Environmental education in community spaces becomes a vital tool for change, linking scientific knowledge with everyday actions. By fostering a responsible and critical citizenry, such education contributes to building equitable societies in harmony with nature. The activities also involved teachers creating a training-of-trainers base to provide school staff with the skills to continue the work.

Discovering, caring and enjoying the ocean

The workshop was structured around three core themes: discovering, caring and enjoying the ocean. These themes guided the activities and learning outcomes.

- Discovering: Children explored the marine world through sensory experiences and games. They learned about species, ecosystems, and ecological interactions. The goal was to foster admiration and respect for nature, encouraging children to see the ocean not just as a recreational space but as a vital habitat.
- Caring: Once children understood the ocean's value, they were introduced to its threats – plastic pollution, habitat loss and human impact. The workshop promoted concrete actions, such as reducing plastic use and respecting marine life. These lessons were aimed at strengthening environmental responsibility.
- Enjoying: Responsible enjoyment of nature reinforces emotional connections with biodiversity. Children were encouraged to appreciate the ocean's beauty while understanding the need for its preservation. The workshop promoted sustainable tourism and recreation practices.

Interactive activities and learning dynamics

The workshop featured a series of participatory activities designed to engage children physically, intellectually, and emotionally.

- "Who Am I?" Marine species game: Children identified local marine animals using visual clues and learned about their ecological roles and threats. This activity strengthened species recognition and ecological understanding.
- "What belongs and what doesn't?" Ocean sorting game: Participants distinguished between natural marine elements

and pollutants. They discussed the impact of waste on marine life and shared ideas on how to prevent pollution.
- Marine species relay race: Children mimicked the movements of marine animals and navigated their correct habitats. This activity combined physical movement with ecological learning, highlighting the challenges marine species face.

After these activities, children returned to their classrooms for artistic sessions. Younger students coloured a storybook titled "The incredible journey of a little turtle", while older students constructed paper models of leatherback turtles. These creative tasks reinforced the day's lessons and allowed children to continue learning at home.

Workshop schedule and participation

The workshop was divided into two sessions to accommodate all 103 children aged 4 to 12. Each group engaged in the same core activities, adapted to their age level.

Teachers played a crucial role in supporting the activities, ensuring that each child could participate meaningfully. The schedule also included breaks for snacks and lunch, creating a relaxed and inclusive learning environment.

Expected outcomes and educational impact

The workshop aimed to achieve several outcomes:
- Strengthen environmental awareness among children.
- Promote sustainable habits at home and school.
- Encourage participation in experiential learning.
- Inspire ecological projects and follow-up activities.

These outcomes reflect the campaign's commitment to long-term impact. By integrating environmental education into community education, DEME contributed to building a culture of conservation and active citizenship.

Linking to the UN Sustainable Development Goals

The campaign aligned with the UN's Agenda 2030 and its Sustainable Development Goals (SDGs):
- SDG 4: Quality education – The workshop provided inclusive and meaningful learning experiences, promoting environmental literacy from an early age.
- SDG 13: Climate action – Children learned how their actions can mitigate climate change effects on marine ecosystems.
- SDG 14: Life below water – The programme motivated greater understanding of ocean conservation and encouraged responsible use of marine resources.

The marine species identification activity allowed children to learn about local marine biodiversity.

Students received eco-friendly gifts, including scholar materials, to reinforce sustainable practices.

Celebrating a successful day of learning and connection with participating students and educators.

By creating educational spaces that involve the community and motivate environmental action, the campaign also supported broader goals of equity and sustainability.

Reflections on social engagement in dredging projects

The "Friends of the Sea" campaign in Moín is a testament to the positive social impact dredging projects can have when they prioritise community engagement and integrate social dimensions into their operations. By engaging with local communities, educating young minds and fostering environmental stewardship DEME has shown that sustainable infrastructure development is going hand in hand with education and empowerment.

This approach not only enhances the social licence to operate but also contributes to the resilience of coastal communities and future generations. As the industry evolves, integrating social programmes into project frameworks will be key to building inclusive and lasting legacies. It shows that dredging is not just about reshaping coastlines – it's about shaping futures.

By integrating environmental education into community education, DEME contributed to building a culture of conservation and active citizenship.

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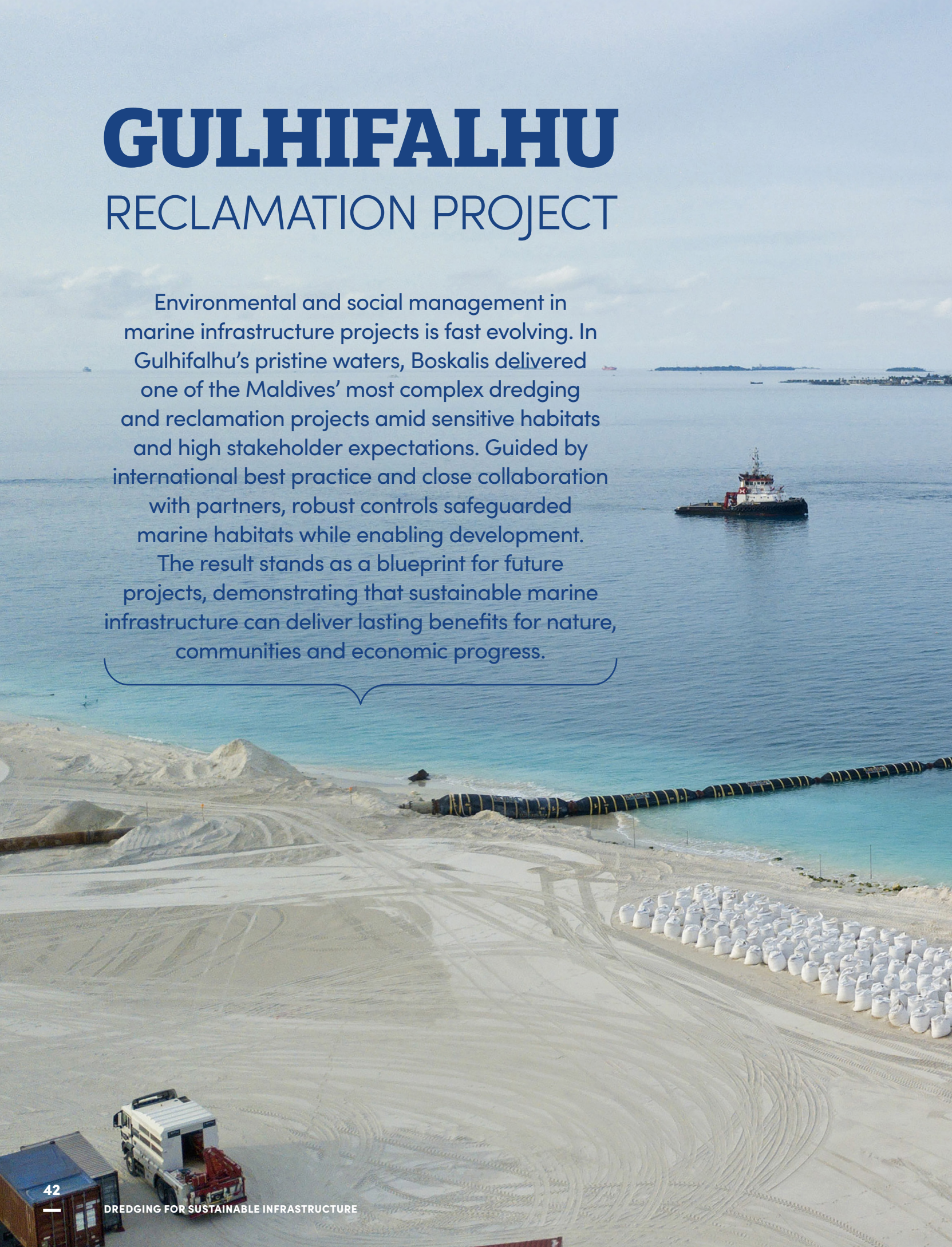
GULHIFALHU
RECLAMATION PROJECT

Environmental and social management in marine infrastructure projects is fast evolving. In Gulhifalhu's pristine waters, Boskalis delivered one of the Maldives' most complex dredging and reclamation projects amid sensitive habitats and high stakeholder expectations. Guided by international best practice and close collaboration with partners, robust controls safeguarded marine habitats while enabling development. The result stands as a blueprint for future projects, demonstrating that sustainable marine infrastructure can deliver lasting benefits for nature, communities and economic progress.




FAIRWAY
Boskalis

Environmental and social (E&S) management on dredging projects has become increasingly complex in recent years. Rising expectations – from regulators and the communities we work alongside – translate into more stringent requirements, with greater emphasis on measurable environmental and social performance. Delivering against international requirements in jurisdictions with different domestic regulations can create challenges, but it is attainable through close collaboration with project owners, consultants and stakeholders to achieve the best outcomes for people and nature.

Boskalis' work on the Gulhifalhu reclamation project offers a strong example of how this complexity was navigated. It is one of the first projects undertaken by the Government of the Maldives in compliance with international E&S standards, reflecting both the challenges and opportunities of aligning such requirements with large-scale marine infrastructure – and highlights the evolving role of a dredging contractor in shaping sustainable results. From the outset, the Ministry and Boskalis shared a clear objective: harmonise national processes with international E&S requirements, ensuring that financing, delivery and environmental stewardship worked in concert. Our experience illustrates how robust E&S frameworks can be seamlessly integrated into dredging operations – reinforcing responsible project delivery while safeguarding sensitive environments.

Maldives context and land reclamation

The Maldives is renowned for its breathtaking natural beauty and exceptional marine biodiversity. The archipelago, consisting of 26 atolls and over 1,000 coral islands, is home to some of the most diverse and vibrant marine ecosystems on the planet. Coral reefs attract tourists from around the globe, provide vital support for local communities and fisheries, and act as natural barriers, protecting the islands from storm surges and coastal erosion.

At the same time, Malé, the capital, is one of the most densely populated cities in the world, with limited residential space. Rising sea levels and frequent flooding intensify this situation. Creating new land through reclamation activities is therefore essential.

Land reclamation in the Maldives can compete for space with critical marine ecosystems. Carrying out construction activities in such an environmentally sensitive area presents significant challenges and necessitates careful planning and execution to minimise environmental and social impacts.

Gulhifalhu project

Located 2.5 kilometres west of the capital Malé, the Gulhifalhu expansion is a critical project aiming to create housing to ease overcrowding. The Gulhifalhu project owner is the Ministry of Construction, Housing and Infrastructure – the government authority responsible for planning and development of public infrastructure and housing.

Boskalis has delivered the project in two stages. In stage I (2020), roughly 30 hectares were reclaimed along the outer

The trailing suction hopper dredger Oranje pumps sand to the reclamation area.

The trailing suction hopper dredger Queen of the Netherlands.

lagoon, which was funded by the Government of Maldives. In stage II, the island was expanded by about 150 hectares within the inner lagoon. For this stage, the Ministry pursued external financing through an Export Credit Agency (ECA)-backed loan provided by international lending institutions and Atradius Dutch State Business. As a condition of the financing arrangement, the project was required to comply with the International Finance Corporation's (IFC) Environmental and Social Performance Standards. This financing structure helped focus all parties on clear roles, traceable commitments and proportionate controls across the project lifecycle.

International financing and the IFC Performance Standards

Securing funding through international financial institutions (IFIs) can play a pivotal role in enabling large-scale infrastructure projects to be realised, particularly in developing countries where access to capital may be limited. Advantages of IFI funding include access to substantial funding not typically available through local banks, more favourable borrowing terms and lower capital costs. Equally important, financing can serve as a catalyst for enhancements, such as extended baselines, cumulative-effects analysis and more frequent verification that strengthen confidence in project decisions.

More than 130 leading global banks and financiers adhere to the Equator Principles - rules to ensure that the projects they finance are both socially responsible and environmentally sound. These projects are required to meet IFC's Environmental and Social Performance Standards, a global benchmark for managing risks throughout the project lifecycle. Addressing issues, such as fair labour practices, resource efficiency, community well-being and biodiversity protection, these standards help ensure every stage of development delivers benefits for people, nature and the economy.

At Boskalis, we have seen firsthand how these standards shape the approach to environmental and social management and are key to the success of projects like Gulhifalhu.

Role of the dredging contractor in E&S management

Boskalis often operates in jurisdictions where E&S regulations and practices differ from internationally recognised standards. To deliver consistently, Boskalis applies its company-wide E&S management system, based on the OECD Guidelines for Multinational Enterprises, ensuring coherence across planning, execution and monitoring. We identify and evaluate E&S risks and impacts, apply the mitigation hierarchy (avoid, minimise, restore, offset), and embed controls into plans, training for personnel and monitoring.

There are practical limitations: we manage the impacts we cause or control during execution, while the project owner retains overall E&S accountability. On large projects with multiple contractors, it is not possible to direct others, but we always strive to gain insight into how E&S is being managed

Boskalis assisted the Ministry of Construction, Housing and Infrastructure with the relocation of coral colonies to nearby resorts.

across different interfaces. As a responsible contractor, we actively draw on our experience to guide, constructively engage and support involved parties where appropriate. This approach helps us meet our commitments and drive continuous improvement across the project, respecting local context while aligning with international best practice.

Preparations for Gulhifalhu stage II

Robust E&S management was established from the project's inception. A national Environmental Impact Assessment (EIA) was already in place based on Maldivian regulations, but meeting international best practice required additional work. Together with the Ministry, we conducted complementary studies and independent reviews alongside the national process and consolidated findings into a comprehensive Environmental and Social Impact Assessment (ESIA) covering the period from construction through to operation. To align with international best practice, the Government showed its commitment by engaging with local and international experts.

Together with CDE Consulting, a Maldivian E&S specialist, we assessed critical habitats and biodiversity, local livelihoods, cumulative impacts, labour risks and climate risk/resilience. Focused consultations were held with affected groups, including fisherfolk and Vilingili dive operators, ensuring that their voices were heard and included in the ESIA.

Treating the ESIA as a platform for delivery, we translated its findings into tailored management plans, procedures and monitoring frameworks. The Ministry appointed an independent E&S consultant and together we established a project-wide E&S management system with clear roles, controls and reporting.

Key protections were captured in the Project Environmental and Social Management Plan and supporting documents such as the Biodiversity Offset Management Plan. These were reviewed and approved by the lenders before construction began, ensuring safeguards were in place from day one.

From preparation to execution

Environmental management and monitoring

The reclamation and borrow areas are located within a highly sensitive marine environment, surrounded by key marine protected areas (MPAs), thriving coral reefs, fishing areas and resort islands. These sites, known as sensitive receivers, faced potential risks from sediment dispersion and changes in water quality during the dredging and reclamation process.

Based on detailed habitat assessments, stakeholder input and collaboration with local and international experts, all sensitive receivers were incorporated into the environmental management plans. Tailored work methods and targeted mitigation measures were implemented to keep impacts to a minimum.

Boskalis executed the environmental monitoring scope, delivering accurate, real-time data to guide operations in accordance with environmental safeguards. The Ministry's independent E&S consultant oversaw compliance and monitored all work.

Turbidity management

Plume modelling by a third party identified locations most likely to experience higher turbidity, informing "no-dredge" zones and operational adjustments such as reducing overflow via a green valve. At the reclamation site, a sediment bund and silt curtains were used to limit dispersion.

Daily in-situ turbidity measurements at various locations were complemented by weekly laboratory total suspended solids (TSS) analysis. Sedimentation traps measured deposition rates. Coastal profiles helped identify shoreline changes. The extensive monitoring programme enabled early warnings and adaptive management when thresholds were approached.

The reclamation and borrow areas are located within a highly sensitive marine environment.

Sensitive coral environment

The sensitive coral habitat required special attention. Together with CDE Consulting, we conducted coral health surveys across all reefs surrounding the reclamation and borrow areas. Except for coral close to the reclamation site, coral health appeared to be unaffected by the dredging activities.

We paid particular attention to coral health during two critical but distinct events. During mass coral spawning, when corals reproduce and are highly sensitive to disturbance, we coordinated with nearby resorts and the Maldives Marine Research Institute (MMRI) to adjust or temporarily pause works to avoid disruption. During the coral bleaching season, when elevated temperatures

We successfully relocated thousands of coral colonies.

cause stress and mortality, we intensified monitoring to assess impacts and recovery. This revealed significant bleaching across the entire atoll. Together, these experiences highlight the need for long-term planning and continuous monitoring of construction projects in sensitive reef environments.

Supporting the client

Biodiversity offsets

The ESIA identified unavoidable coral loss within the Gulhifalhu lagoon. To offset this impact, the Ministry (working closely with CDE Consulting) established two new MPAs and developed conservation action plans for both sites. This marked a major milestone in the protection of coral reefs in the Maldives. In addition, a long-term restoration plan was established to rehabilitate corals at the MPA adjacent to Gulhifalhu island, ensuring that ecological recovery continues well beyond the project's construction phase.

Before the project commenced, Boskalis assisted the Ministry with the relocation of coral from the Gulhifalhu lagoon to nearby resorts. This process involved careful planning and execution to move coral colonies to designated safe areas without causing damage, ensuring their survival and continued growth. The coral relocation was carried out in collaboration with local marine biologists to determine the optimal methods and setup at selected resort sites. Through our own initiative, we successfully relocated even more coral totalling thousands of colonies. The initial survival rate was high, which is promising for coral conservation throughout the Maldives. The lessons learned and partnerships forged with resorts and local experts now form a practical playbook for future projects.

Stakeholder engagement

Boskalis supported the Ministry with stakeholder engagement and grievance management throughout the project. A dedicated project website was developed and actively updated during the project, including all monitoring reports. This acted as a one-stop information site to keep communities and stakeholders informed of studies, progress, key milestones and planned activities.

In close collaboration with the Ministry, we launched a practical, accessible grievance management system designed to make every voice heard. Submissions can be made online or in person, with each complaint logged, tracked against agreed timelines and addressed promptly and consistently. To strengthen community engagement, the Ministry appointed a dedicated Community Liaison Officer as the first point of contact for stakeholders and grievance handling. On site, teams were fully briefed on how to refer inquiries, capture and track concerns, and escalate issues swiftly, ensuring feedback was handled transparently and with accountability.

Cumulative impacts

Managing cumulative impacts is inherently challenging where multiple projects operate on overlapping timelines and in connected marine and community environments. Visibility into adjacent projects' schedules, mitigation measures and monitoring data is often limited, making it difficult to attribute effects and coordinate responses.

Boskalis worked with the Ministry to identify plausible cumulative impacts (e.g., turbidity, vessel traffic, noise, access to fishing grounds), request and share relevant information and, where feasible, align thresholds, monitoring locations and early-warning triggers with neighbouring activities. When potential cumulative issues emerged, we raised them promptly through the Ministry's coordination forums so measures could be adjusted at a programme level.

Capacity building to contractors and suppliers

To help embed good practice locally, Boskalis provided targeted capacity building to contractors and suppliers we engaged with who had limited prior exposure to IFC-level documentation and monitoring. Activities included pre-mobilisation workshops on E&S requirements, method statements and risk controls, along with practical coaching and joint inspections. They also featured toolbox talks on topics, such as waste management, spill prevention, marine fauna protection and community safety. This practical, hands-on approach improved consistency on site and strengthened local ownership of E&S performance all the way up to IFC standards.

Oversight by project lenders

The project was subject to project lenders' oversight, with independent advisors reviewing plans and performance against agreed standards and actions. Prior to construction, key E&S plans underwent external review and approval. During execution, the lenders conducted periodic site audits and document reviews, focusing on implementation and monitoring results. Boskalis and the Ministry responded promptly to findings with corrective and preventive actions agreed with the lenders. This oversight promoted continuous improvement, ensured traceability of commitments and provided assurance that E&S measures were effectively implemented in practice.

Creating new horizons through collaboration and E&S excellence

Dredging projects are increasingly complex, driven by rising expectations for transparency, accountability and long-term sustainability. In this context, Boskalis and its clients choose to act responsibly, planning for long-term outcomes rather than short-term delivery. The Gulhifalhu project exemplifies this commitment.

Elevating a project of this scale to meet international E&S standards required substantial capacity, specialised expertise,

In his inauguration speech, Maldives President Ibrahim Mohamed Solih called the Gulhifalhu project "an important development initiative with significant, positive impacts for the entire country".

strong managerial support, sufficient time and seamless communication among all stakeholders. These requirements posed considerable challenges compared to projects that solely rely on national benchmarks, particularly in areas, such as biodiversity management, stakeholder engagement and grievance mechanisms, where national legislation and global standards can differ significantly.

Together with the Ministry, we carried out works in line with environmental and social best practices. Our approach combined targeted E&S studies, extensive stakeholder consultations and careful alignment with both the local regulatory framework and site-specific impacts.

The Gulhifalhu project demonstrates that proactive E&S management and collaborative delivery can achieve rigorous performance while harmonising national and international E&S processes. Through early alignment, close collaboration, clear interfaces and adaptive management, we delivered positive outcomes in a sensitive environment. Most importantly, this project gave the Government of the Maldives an opportunity to strengthen institutional capacity and take meaningful steps toward raising future projects to international E&S standards.

This partnership model fits the growing complexity of large-scale projects in support of durable and sustainable outcomes, setting a precedent for responsible, world-class marine infrastructure delivery.

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Breaking new ground:
The first DFSI course in Asia

18 November 2025 – Singapore. As the morning sun rose over the city, 24 professionals from around the world stepped into a meeting room at the Holiday Inn Atrium. They had gathered for the latest edition of the IADC–CEDA course Dredging for Sustainable Infrastructure, ready to spend three days immersed in the evolving world of sustainable water infrastructure.

Guiding them were three seasoned lecturers: Erik van Eekelen (Van Oord), Thomas Vijverberg (Boskalis) and Sina Saremi (DHI). Through a mix of presentations, discussions and hands-on workshops, the trio led participants through the eight chapters of the guidebook *Dredging for Sustainable Infrastructure*.

What sets this course apart is its forward-looking approach. Developed to reflect the rapidly changing demands of today's water infrastructure sector, the programme blends the latest methodologies with innovative techniques and a range of real-world case studies. Interactive sessions challenge participants not only to absorb the concepts but to apply them directly to their own work.

The first day closed on a warm note with an authentic Penang–Peranakan buffet, giving attendees a chance to unwind and exchange early impressions. Day two began bright and early at 8:00 AM, when a bus took the group to Marina South Pier. During a boat trip, four impressive vessels from IADC member companies were spotted hard at work – Prins der Nederlanden (Boskalis), Vasco da Gama and James Cook (Jan De Nul) and Cassiopeia V (Penta-Ocean).

> The course challenges you to look not only for ways to mitigate negative impacts, but also for opportunities to enhance nature and human wellbeing using dredging and nature-based solutions as a tool.

The afternoon returned to theory, interwoven with practical workshops. The final day followed the same dynamic rhythm, balancing knowledge-building with application. By late afternoon, certificates were presented, photos were taken and new professional connections were sealed with smiles and handshakes.

Why this course matters

At its core, the programme shows how dredging can meet functional needs while supporting and enhancing natural and socio-economic systems. Rather than treating sustainability as an add-on, it emphasises integrating environmental awareness and stakeholder engagement from the start, empowering professionals to identify opportunities, reduce risks and design resilient, future-ready infrastructure.

The course attracts a diverse group of government officials, port authorities, consultants, engineers, dredging contractors, NGO representatives, suppliers and shipbuilders, all united by a commitment to advancing sustainable water infrastructure.

Together, they explore practical answers to key questions: the role of dredging in global sustainability goals, how to design water infrastructure that works with natural and socio-economic systems, and how to maximise positive impacts while identifying and mitigating negative ones. They also examine which equipment and sediment management options are most effective and which tools and frameworks can best support sound project planning and decision-making.

Interested to know more about IADC events: https://www.iadc-dredging.com/seminars-courses/

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