Reducing the ecosystem-based carbon footprint of coastal engineering

Executive Summary

Wetlands INTERNATIONAL

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The Problem

The ecosystem-based carbon footprint of coastal engineering projects, such as land reclamation, port development and coastal protection, is more significant and complex than previously thought. This is because such projects impact the carbon balance of ecosystems and sediments both on or off-site. Under some circumstances, the disturbance causes previously sequestered carbon to be emitted as greenhouse gases (GHG), while under different circumstances the exact opposite may occur. Although the emissions arising from the burning of fossil fuels can be very thoroughly quantified, emissions from ecosystem and sediment disturbance have not, until now, been sufficiently accounted for.

Coastal ecosystems such as mangroves, sea grass meadows, salt marshes and unvegetated intertidal wetlands contain sediments that are often rich in organic carbon. This is why they are referred to as 'blue carbon' ecosystems. Mangroves typically hold five times as much carbon as a similar area of rainforest. Due to their high carbon storage capacity, activities that interfere with the carbon cycle in these coastal ecosystems may result in significant GHG emissions. However, with the right adjustments, those emissions can be mitigated and even reduced. Moreover, there are also opportunities to enhance blue carbon sequestration by applying the so-called Building with Nature approach that integrates Nature Based Solutions into water and marine engineering practice.

Most coastal engineering affects coastal ecosystems and their carbon sequestration capacity directly, by dredging and displacement of sediment, but it can also do so indirectly, by changing the hydrological or sedimentation dynamics. For instance, ports and harbours are situated at the mouth of rivers, on sandy shorelines or adjacent to intertidal areas. Both carbon and nutrient cycling of coastal sediments are significantly impacted for example by the excavation of a harbour basin and access channel, and construction of dams and quay walls. But also ports and land reclamations result in lower to no carbon sequestration, when coastal wetlands are transformed into urban areas and industrial zones. Smart, carbon-benign design of coastal engineering projects may provide a solution to mitigate those impacts.

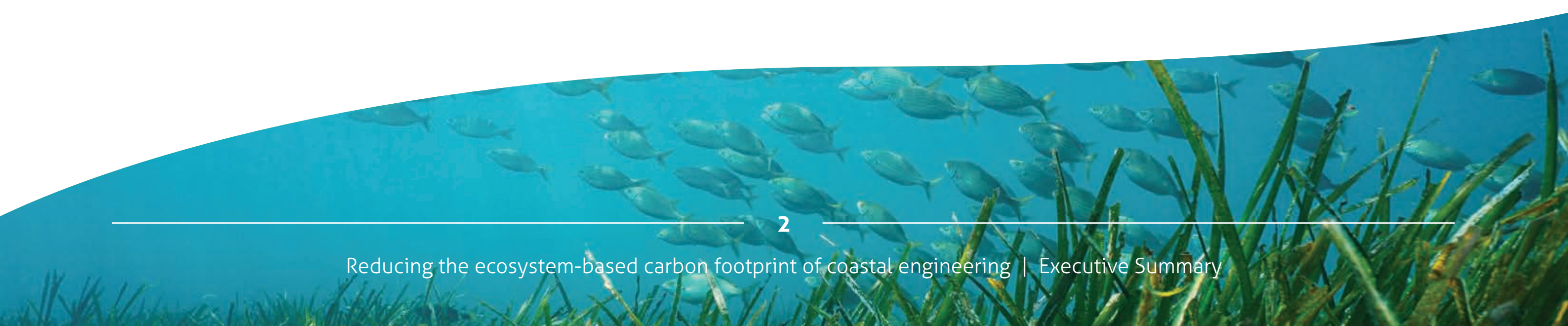
The urgency

To limit the temperature increase to 1.5°C above pre-industrial levels, as set out in the Paris Agreement, many governments have adopted targets to reduce their emissions by 50% by 2030 and by 95% by 2050. All stakeholders, including the hydraulic engineering sector, need to act urgently to bring down GHG emissions and enhance sequestration of GHG from the atmosphere. In the Netherlands, companies in the maritime and dredging sector that operate worldwide, have already adopted net zero targets by 2030 for fuel-based emissions.

Current efforts to reduce GHG emissions from coastal engineering focus mostly on the emissions related to the deployment of construction vessels and the supply of materials such as concrete and steel. However, the impact of these projects on the carbon balance of nearby coastal wetlands may be far greater. The effects on these coastal ecosystems are long-lived, and so may be ecosystem-related GHG emission or sequestration. To properly account for this, we need a pragmatic approach that also helps to determine management options.

Aim of this report

This report presents a methodology for quantifying the ecosystem-based carbon footprint of hydraulic engineering projects along with potential options for reducing their carbon footprint, with a focus on coastal blue carbon ecosystems and coastal engineering. We hope to raise awareness, encourage discussion and action among the stakeholders who commission, finance, design, implement or maintain these projects.



Ecosystem-based carbon footprint methodology

Over the last century, understanding of the carbon cycle has vastly grown, and analysis of carbon cycling in ecosystems has become increasingly complex. Previously, the quantification of biomass and soil organic matter degradation had been sufficient, but now an entire network of processes has to be analysed. Complex interactions and lateral flows between ecosystems are often involved, which is particularly relevant for coastal ecosystems.

In order to help coastal engineers and designers with practical guidance how to optimise the ecosystem-based carbon footprint of their projects, this complexity has to be reduced to its essence. Therefore, we highlight four types of perspectives:

Simplifying carbon cycling in the carbon seascape (chapter 2):

1. **Ecosystem-based:** the processes that determine production, burial, decay and sequestration of organic matter in open coastal systems;
2. **Long-term sequestration:** the emphasis on long-term storage of carbon in stable positions, most relevant at the time scales important for climate action;
3. **Sediment-centred:** the characteristics of sediments and processes that determine sedimentation rates and release of carbon and nutrients from sediments.

Using these three perspectives we were able to simplify the complexity of organic carbon cycling in coastal systems and distilled the most relevant information that needs to be assessed in the form of a 'sediment passport'. The required information can be retrieved as part of standard field campaigns that are needed to underpin the design and execution of any engineering project.

And based on that, zooming in on the impacts of coastal engineering on the carbon seascape (chapter3):

4. **Project-oriented:** the activities within coastal engineering projects that influence organic carbon cycling, as well as potential adjustments in e.g. sediment handling that reduce emissions and increase sequestration.

The ecosystem-based carbon footprint of a project is then the difference between emissions from an undisturbed coastal zone (business-as-usual scenario) and the emissions arising from the coastal engineering project. Evaluation comprises four steps (chapter 4), which may run parallel to an ongoing Environmental Impact Assessment study:

1. A description of the carbon seascape where the project takes place;
2. A description of the coastal engineering project (the project alternative) and the business-as-usual scenario in terms that are relevant for the ecosystem-based carbon footprint;
3. Assessment of potential and relevant effects;
4. Calculating the ecosystem-based carbon footprint.

Figure 0.1: Our approach using four points of focus

1

Ecosystem based:

Organic carbon in open coastal systems and related lateral fluxes in carbon, nutrients and (fine) sediments.

Focus on:
- Soil organic matter
- Labile organic matter and biologically available C/P and C/N ratios
- Lateral fluxes between coastal wetlands, sediments and the sea

2

Long-term sequestration:

In soils, sediments, long term present dynamic biomass and dissolved CO_2 in deep sea reservoirs.

Focus on:
- Stable soils and sediments and carbon stocks
- Sequestration rates
- Recalcitrant forms of organic carbon
- Long-term trends and incidents

3

Sediment-centred:

Effects related to the handling of sediments and changes in the conditions for soils and sedimentation caused by coastal engineering projects.

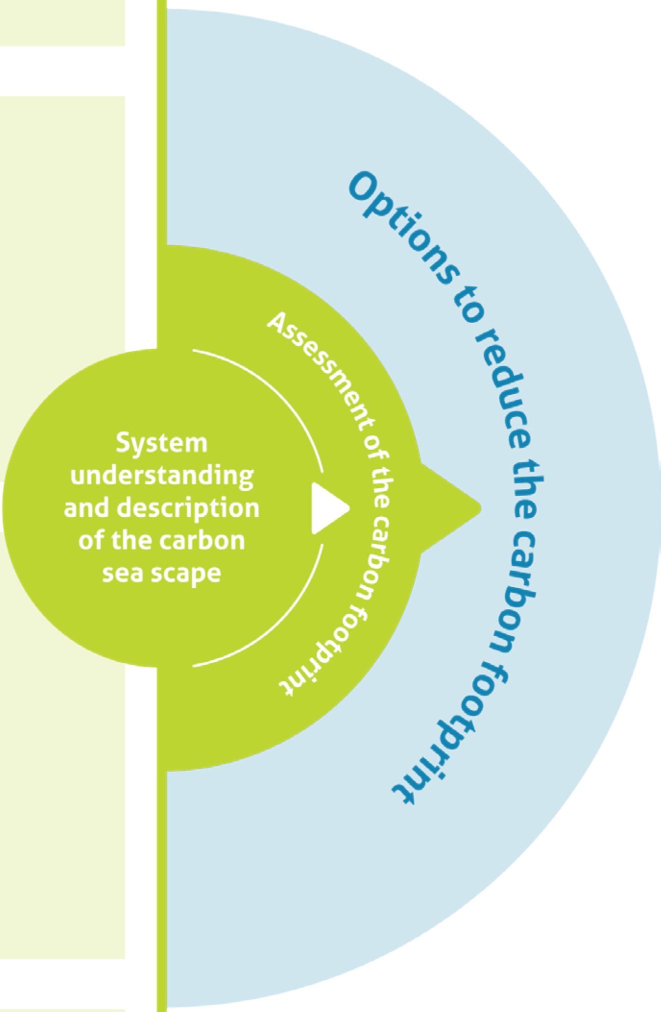
Focus on:
- Carbon sea scape
- Changing conditions for sedimentation and soils
- Fine sediments and labile and stable organic carbon
- High carbon seascapes

4

Project-oriented:

Coastal engineering projects and how related activities influence the carbon seascape.

Focus on:
- Sediment handling
- Hydraulic impact on sedimentation
- Hydrological impact on crabon stocks
- Direct loss of wetlands and soils



Adjustments that reduce GHG emissions from, and enhance carbon sequestration by, coastal engineering projects

Once the ecosystem-based carbon footprint of a project is calculated, it becomes possible to identify options to reduce it, by optimizing the design, use of sediments, modes of construction and maintenance. These include, among others:

- More carbon-benign handling of sediments during dredging, for example by optimizing dredging plumes, using the sequestration potential of sand pits, by adopting different approaches to the dredging of waterways and harbours, and for land reclamation.
- Beneficial use of dredging sludge; for instance for wetland creation and restoration, or land reclamation.
- Creating beneficial hydrological conditions, such as environments sheltered from waves, where higher sedimentation rates lead to coastal wetland development and its associated carbon sequestration.
- Careful release of dredged materials into the seascape, according to sediment characteristics (rich or poor in organic matter, fine sediments, or rich in carbonate), for example when used for beach nourishment, land reclamation, or coastal wetland development.
- Steering currents and reducing undesired sedimentation in navigation channels, and the compensation and mitigation of environmental effects.
- Adopting the Building with Nature approach and integrate nature in the design, implementation and maintenance of the coastal engineering project.
- Protection, restoration and creation of coastal wetlands, such as mangroves and salt marshes, because of their potential to store carbon. These can sequester 'blue carbon' in vast quantities, exceeding emissions from coastal infrastructure development.

Policy, legislation and funding mechanisms

Nature conservation legislation and policies mandating the restoration of carbon-rich coastal and wetland ecosystems provide opportunities for capturing blue carbon. The EU Habitats directive limits conventional hydraulic engineering projects on sites included in the Natura 2000 network. Biodiversity frameworks provide targets for nature restoration and a focus on ecosystems that store carbon. Environmental impact assessments facilitate the inclusion of effects on biodiversity, ecosystem services and climate change into decision making.

Globally, the Paris Agreement requires action to minimize GHG emissions and enhance carbon sinks, but most countries have not yet adopted blue carbon strategies. Moreover, GHG emissions from hydraulic engineering projects are rarely included in carbon accounting and carbon pricing.

Incorporating the full scope of GHG emissions into national carbon accounting - including those associated with coastal ecosystems and dredging activities - is essential for optimising carbon mitigation strategies, reducing cost, and implementing incentives such as carbon pricing, targets and standards and allocating subsidies for mitigation. The ecosystem-based carbon footprinting methodology outlined in this report enables accounting for the full scope of emissions and suggests approaches to dealing with uncertainties.

Nations and other actors in the water sector can support climate- and ecosystem-friendly hydraulic engineering by adopting GHG reduction targets for the sector and by setting standards as requirement for permits or licenses. To successfully minimise carbon emissions, national policies and legislation need to be translated into project goals and tasks at the appropriate stages for design and engineering firms, contractors and maintainers overseen by the project commissioner.

Since the business case for climate- and ecosystem-friendly hydraulic engineering, in the context of a free market, is not yet sufficiently strong, additional funding mechanisms and the pricing of externalities are crucial. The most cost-effective solution is carbon pricing, through either a carbon market or carbon tax. Further financial incentives can be provided by subsidising projects that purposefully sequester blue carbon, through voluntary carbon markets, by direct payments for wetland restoration, or by creating funding streams for the co-benefits of wetland restoration.

Conclusions and recommendations

- We demonstrate that the ecosystem-based carbon footprint of coastal engineering projects can be significant and needs to be accounted for.
- We present a pragmatic ecosystem-based carbon footprinting methodology to support actors that commission, design or implement these projects to identify options that reduce their ecosystem-based carbon footprint.
- We encourage stakeholders to use this methodology, share data and findings, in order to enable its continued improvement and global uptake.
- Furthermore, we identify existing legislation and policies that enable climate- and ecosystem-friendly hydraulic engineering, along with recommendations to further strengthen the policy environment and associated financial incentive mechanisms.

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Read the full report:

www.wetlands.org/publications/reducing-the-ecosystem-based-carbon-footprint-of-coastal-engineering/

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