

# THE CONTRIBUTION OF NATURE-BASED CONCEPTS TO SUSTAINABLE PORT DEVELOPMENT

by

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## ABSTRACT

The potential added value of ecosystem-based concepts in port design are explored using a series of examples from the Netherlands and Ghana. The first example relates to the sandy dunes comprising part of the protection of the Maasvlakte II extension to the Port of Rotterdam. The second example focusses on enhancing the habitat suitability of bed protection, while the third example addresses improved connectivity and potential restoration of a brackish wetland adjacent to a recent harbor extension in Africa. The paper illustrates that the design of nature-based infrastructure requires a focus on opportunity creation and restoration of healthy ecosystems. Healthy ecosystems, in turn, help to ensure that benefits accrue to local as well as regional and global stakeholders in a port development process.

## 1. INTRODUCTION

Building with Nature is an ecosystem-based concept that specifically seeks to use natural materials, interactions and dynamic processes effectively in the design, realisation, operation and maintenance of hydraulic infrastructures (Waterman, 2010; Ecoshape, 2018). As such, it aims to identify and utilize opportunities to benefit nature while undertaking the infrastructural development of ports required to meet the trade, energy and development challenges of the future. This and similar concepts such as Working with Nature (PIANC, 2011) and Engineering with Nature (Bridges et al., 2016) are being applied in infrastructure design and construction around the world. Indeed, the concept is being implemented in practice in the Netherlands through an adaptive “learning by doing” approach. This paper provides examples of the use of nature-based concepts in port design, and highlights the potential of the approach by illustrating the connection of infrastructure design alternatives and the restoration of ecosystem services.

Since Costanza’s seminal work (Costanza et al., 1997), we have come to understand that healthy natural ecosystems provide services to individuals and to society (MEA, 2005; Bateman et al., 2013). These ecosystem services are considered to comprise production services (such as food harvesting), regulation services (such as flood control) and cultural services (such as recreation, spiritual significance). The ecosystem services concept is now widely used in identifying, quantifying and evaluating the effects of infrastructure design alternatives on the delivery of services to humans by the affected ecosystem. The use of ecosystem services to assess nature’s value constitutes a growing field of research over the past decade, and has been associated with the Building with Nature concept (Smith & Deerenberg, 2012).

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## 2. EXAMPLES OF NATURE-BASED ALTERNATIVES IN PORT DEVELOPMENT

A first example of a port-related and nature-based infrastructural project is the extension to the Port of Rotterdam, the Maasvlakte II, which is protected from coastal storm surge mostly by sandy dunes. The dune field enhances nature development, recreation and is simultaneously extremely effective and less costly than full protection by breakwaters. However, designing this option instead of a standard breakwater is not available to ports that are located on rocky coasts, or where sand is not readily available or could be damaging to ambient ecosystems such as coral reefs. An example of nature-based methods which could be relevant in such areas, draws on a study of the distribution of cavities (size and connectedness) in the bed-protection at the base of wind turbines. This study by Buijs (2015) investigated which size ratios of the rocks comprising the bed protection were best suited to the creation of appropriate cavities to shelter rock lobster in the North Sea. The outcomes yielded insight in the selection of rock size ratios, and indicated that the habitat suitability for rock lobster could be improved without significant additional cost. In addition to these two more general instances of ecosystem-based infrastructure design, the project “Integrated and Sustainable Port Development in Ghana in an African Context” (NWO 2018), has sought to extend the practice-based learning to a case study in Africa, namely the Port of Tema.

Preliminary investigative work on potential nature-based alternatives in the extension of the Port of Tema was undertaken by Vrolijk (2015). She identified the Sakumono Lagoon to the west of the harbour as a potential site for ecosystem restoration or opportunity creation, and this was confirmed through the stakeholder engagement process undertaken for the Tema case study (Slinger et al., 2018). At present, a multidisciplinary group of students from the Delft University of Technology is currently working with students and professors from the University of Ghana to design a number of interventions aimed at restoring this lagoon, or at the least effectively managing the water quality and habitat loss issues of this wetland area. partners and supporting parties (see Vellinga (2017) for information about the project organization) was held in Delft, the Netherlands, in September 2016 with similar objectives (Vreugdenhil, 2016). The Ghanaian researchers participated in the workshop through an active skype link. The workshop agenda incorporated an introductory presentation on the project, which included the input from the first workshop, a question and answer session, a personal mini-survey over what is (or is not) a sustainable port in Tema or an ideal world. This was then followed by group sessions on sustainable ports and general discussion. Then, the serious game Port of the Future was played as part of the workshop. This was done for parity with the stakeholder workshop in Ghana. Finally participants were asked to reflect on workshop. The outcomes were similar to the first workshop in Tema, namely increased awareness of sustainability and consensus on the most important issues to address via the project. In addition, the connectedness of the network around the project was strengthened, and the inputs and insights from the Ghanaian partners added depth to the discussion on sustainability within an African context.

The Sakumono II Lagoon is located very near to the furthest extension of the new breakwater of the expanded port of Tema. Currently the exchange of water with the sea is strongly curtailed as the connection only occurs through two large culverts extending under the coastal road. Given the anticipated increase in traffic to and from the expanded port it is understood that the road network around Tema will need to be developed. This is already happening with the connection between the Port and the main highway immediately to the north of the city of Tema currently being improved. However, the coastal road cannot lag far behind. Accordingly, preliminary designs for a bridge to replace the culverts and allow the free exchange of marine and freshwater through the mouth of the Sakumono II Lagoon are being investigated in collaboration with scientists from the project Integrated and Sustainable Port Development in Ghana in an African Context. Restoring the connection would restore continuity of water flow and sediment exchange and re-establish a brackish environment. Following Slinger (2000), it is anticipated that after some adjustment time, involving dieback of the freshwater vegetation that has colonized the lower reaches of the lagoon, the flora and fauna characteristic of a brackish wetland would re-establish. However, it is not sufficient to simply restore water exchange. The wetland is subject to high nutrient loading from waste effluent and has experienced decades of sediment infilling owing to reduced flushing and landfill for settlement. Additional interventions such as dredging and nutrient management (cf. Taljaard et al., 2017) would

also be required if opportunities for nature, and concomitant ecosystem services benefits, are to be realised. These benefits include increased livelihood fishing opportunities for the fisherman of Sakumono village (to the west of Tema) whose marine fishing grounds have decreased with the expansion of the harbour. Additionally, the residents on the upstream eastern bank of the lagoon may be flooded less frequently. At present they are suffering flooding on an annual basis in the wet season as the constricted mouth causes back-flooding. A nature-based approach focussed on the restoration of ecosystem processes, so as to once again permit the delivery of production and regulatory ecosystem services, would simultaneously restore the aspects of the cultural services. The Sakumono II Lagoon holds spiritual significance for the indigenous peoples of the area.

### 3. IN CONCLUSION

In this paper, we have illustrated that the design of nature-based infrastructure requires a focus on opportunity creation and restoration of healthy ecosystems. This helps to ensure that benefits accrue to local as well as regional and global stakeholders in a port development process.

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