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URBAN DUNES: PROMOTING BwN DUNE FORMATION AT NOURISHED BEACHES THROUGH SPATIAL DESIGN (Abstract)

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INTRODUCTION

Sandy shores offer a multitude of ecosystem services; regulating- (e.g. protection against flooding), production- (e.g. drinking water) and cultural services (e.g. recreation), all depending on the quality of supporting services (e.g. natural balances of water, nutrients and sediment). For *sandy* shores especially, the long-term physical existence is depending on the sediment balance. Therefore, based on Building with Nature (BwN) principles, sediment balances and -dynamics represent essential components of any spatial design of sustainable urbanized sandy shores. Examples of such design are nourishments where the sand balance of the system is amplified and natural dynamics distribute sediment ashore. This approach is used in the Netherlands to compensate for coastal erosion with a total yearly nourishment volume of 12 million m³ of sand. Typical magnitudes of individual nourishments are 1 to 2 million m³, whereas the Sand motor is an experimental mega nourishment of 20 million m³. After nourishment, the sediment is transported by natural processes (waves, tide, wind etc) contributing to the growth of dunes. The question is how to support this dune development, not just to improve the coastal safety, but also the combined use with other urban & ecological programs in the coastal zone. In this contribution we discuss spatial design principles and their influence on the transport of sediment for the formation of dunes; supporting flood safety, urban and landscape qualities. This requires an interplay of nourishment, *directed* sediment transport in the beach-dune interface and the desired buffer capacity established by the dunes. Depending on the preferred defence strategy (seaward, landward or consolidating) different spatial interventions can be made to enhance dune formation after nourishment.

SPATIAL PRINCIPLES FOR BwN DUNE FORMATION

Several investigations (GIS and field work) have been made to track down interacting spatial mechanisms between coastal occupation and dune formation following nourishments. Six spatial principles, such as shadow dune formation, have been derived and investigated further during a field experiment in spring 2019 (figure 1). These principles can be applied to compose dynamic arrangements supporting the build-up of new dunes as a sustainable coastal buffer.

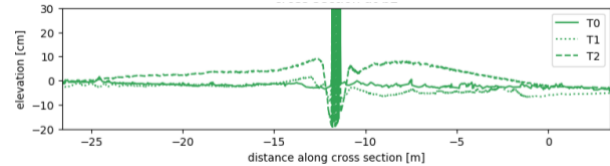


Figure 1a, b - Aeolian sand deposition around built objects as one of the spatial principles to support BwN dune formation

BwN DUNE FORMATION FOLLOWING NOURISHMENT IN URBAN COASTAL ZONES

Depending on the objectives of the nourishments, urban and ecological interventions can be made to direct the location of dune formation following nourishment. Examples of optimized spatial arrangements for BwN in time, employing the developed principles, are given by two Dutch case-studies: A) mega-nourishment Sand Motor at the Delfland coast with a vast, rural, high dynamic profile; and B) the coastal resort of Noordwijk with a compact, high urban, low dynamic profile and a seaside boulevard typology. In the Noordwijk case an increased sea level scenario of + 85cm in NL 2100 has been applied to see how much sandy reinforcement of the current profile is needed. This relates to different nourishment volumes (Stronkhorst et al., 2017) and can result in alternative coastal profiles. Urban implications of both coastal profiles are discussed, to show if and how multiple use of the coastal buffer can be made compatible with wind-driven dune formation processes. Conclusions reflect on the effectivity of BwN approaches regarding different coastal settings (urban, high dynamic) and the scaling up of urban interventions in combination with nourishment strategies.

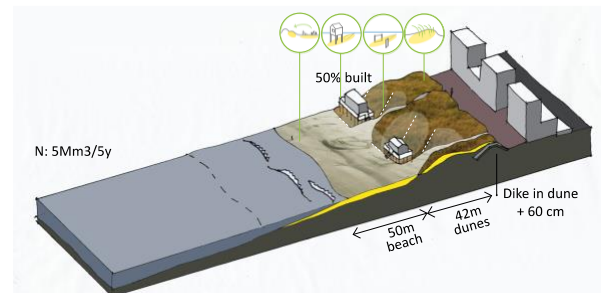


Figure 2 - Seaward sandy strategy for Noordwijk following regular nourishment, applying aeolian principles to stimulate dune formation, including urban (re)configuration.

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Stronkhorst, Huisman et al. (2017): Sand nourishment strategies to mitigate coastal erosion and sea level rise at the coasts of Holland (The Netherlands) and Aveiro (Portugal) in the 21st century, *Ocean & Coastal Management*, ELSEVIER, vol 156, pp 266-276.