STRENGTHENING COASTAL DEFENCE WITH ARTIFICIAL DUNES

Pieter Rauwoens, KU Leuven, pieter.rauwoens@kuleuven.be
Glenn Strypsteen, KU Leuven, glenn.strypsteen@kuleuven.be
Jennifer Derijckere, KU Leuven, jennifer.derijckere@kuleuven.be
Dries Bonte, UGent, dries.bonte@ugent.be
Sam Provoost, Research Institute For Nature and Forest, sam.provoost@inbo.be
Toon Verwaest, Flanders Hydraulic Research, toon.verwaest@mow.vlaanderen.be
Steven Muylaert, Department Mobility and Civil Works, steven.muylaert@mow.vlaanderen.be
Peter Van Besien, Coastal Division, peter.vanbesien@mow.vlaanderen.be

INTRODUCTION

The Belgian coast is primarily sandy and is locally subject to erosion (Deronde, 2004). Traditionally, erosion was counteracted using hard engineering structures like groynes, seawalls and sea dikes. Nowadays, the Belgian government uses a different strategy by adopting a more soft and dynamic approach where possible. Many 'soft' managing activities at the Belgian coast are carried out in the form of regular and routine sand nourishments to cope for future flooding risks and coastal erosion (Houthuys, 2012). This method gives room to a new approach for coastal management where the natural elements and processes facilitate the development of new engineered dune areas at locations where traditional dike structures currently protect the hinterland. In the context of climate change and strict requirements for water safety, these hard to adapt engineering structures will not resist future flood events and more innovative solutions like dune in front of a dike principles to deal with rising sea level are receiving considerable attention. As a result, concepts are worked out in which traditional sea dikes are reinforced with newly created dune systems, offering a high level of protection of coastal infrastructure and at the same time offering a more natural appearance and higher ecological and socio economical values.

In the framework of the SARCC project, one pilot site is realized in Raversijde (Figure 1). Besides the coastal defense function of the artificial dune, a second benefit is achieved: mitigating the nuisance, created by aeolian sand transport and preventing roads and tram tracks at the dike crest to be buried in sand.

STUDY AREA

Commissioned by the coastal division of the Flemish Government, a new dune area of 750 x 20 m² is created 10 m in front of the traditional sea dike in Raversijde in the spring of 2021 (Figure 1). Marram grass (Ammophila arenaria) is planted in a split plot design of 10 x 10 m² blocks. In order to anticipate valuable research results, a large parameter variation is applied in the design. Vegetation is planted in different spatial distributions (regular, random and clustered) with low and high densities. Vegetation is sometimes surrounded by brushwood fences of 1.5 m in height. Other zones are designed without brushwood. Also, the effect of human disturbance is taken as a parameter by creating openings through the brushwood fences. Besides the large study area in Raversijde, a smaller pilot is constructed earlier (January 2021) in Ostend Oosteroever to study the effect of marram grass density and pattern on dune development.

METHODS

The monitoring of the study sites consists of a combination of surveys featuring large spatial cover at limited temporal scale and dedicated field campaigns featuring high temporal resolution on a limited spatial domain. The area is surveyed monthly by using drones for topographic and vegetation mapping. In addition the morphological response to storms is measured. As we expect the coupled topographic and biological changes to be attributed to gradients in aeolian sediment flux, dedicated campaigns measuring aeolian sediment flux upwind and downwind of the vegetated dune area are performed. Correlations are made with parameters such as wind speed and direction, moisture content, coarse surface layer fraction, water level and wave heights. Specific field campaigns in this early stage of dune development focus on the different effect of sediment trapping by the various planting strategies provided in the study area. The monitored data sets will serve as validation for dune models, that can be used by coastal managers and constructors in their quest for the answer to the question what is the optimal design and maintenance strategy for a coastal dune.

Figure 1 – Location of the artificial dune in front of an existing dike in Raversijde, Belgium (52°00'00"N, 04°00'00"E). Within the engineered dune design vegetation has been planted in different spatial distributions (regular, random and clustered) with low and/or high densities. Vegetation is occasionally surrounded by brushwood fences.

RESULTS

In this paper, we focus on the morphological changes in the dune field in the first year of monitoring. Hence, we restrict the analysis to the data provided by the topographic measurements by drones.

The artificially planted dune area is spatially divided into 8 zones (Fig. 2), from which volume changes are deducted. For a detailed analysis of the erosion and accretion, several transects are defined.
The difference map between the installation of the dune (March 2021) and the most recent survey (June 2022), reveals the efficiency of the brushwood fences. Indeed, in the zones where fences were installed, the capture of sand yields much higher altitudes (+2m) compared to the zones without brushwood fences, only featuring marram grass vegetation (+1m). Next to the accretion in the dunes, also the erosion at the foot of the dry beach plateau is obvious. The erosion must be attributed both to Aeolian action, transporting the sand into the dune field, and hydraulic action by waves and storm surges.

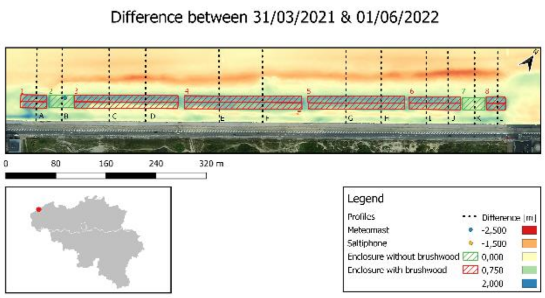

Figure 2 - Difference map of altitude between the installation of the dune and a recent survey. The zones used for data analyses are demarked with numbers, the transects used for deducting profiles are demarked with Arabic letters.

Figures 3 and 4 provide a more detailed insight in the morphodynamics of the dune. Fig. 3 shows a transect at a location with brushwood fences. Note the 10m by 10m boxes of brushwood fence, clearly visible at 20, 30 and 40 meters from the dyke. In the topographic survey, the presence of the fence is visible. We did not filter the fence out of the survey data. Clearly, sand accumulated firstly at the location of the most seaward fence due to onshore winds, from which, lateron, progresses inland. The most seaward box (20-40m) was saturated from March, after which the second box started filling with sand. Also notice that in the zone between the dyke and the dune (0-20m), there are hardly any changes in the profile.

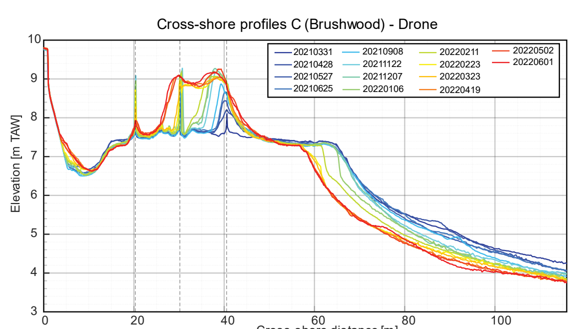

Figure 3 - Cross-shore profiles in transect C, which is a typical representation for the morphodynamic changes at a location featuring brushwood fences.

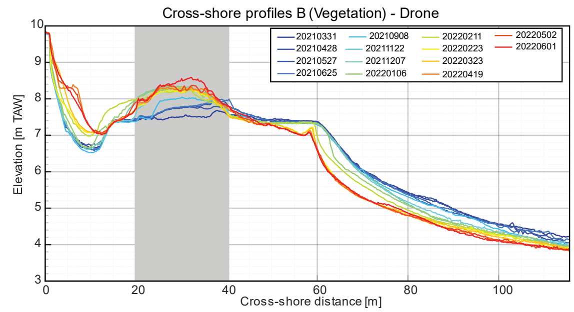

Figure 4 - Cross-shore profiles in transect B, which is a typical representation for the morphodynamic changes at a location featuring only vegetation without brushwood fences.

In figure 4, a more distributed deposition of sand in the dune area is found. In this cross-section, no brushwood fences are present. As all zones and sections are subjected to the same amount of Aeolian sand input, it is clear that not all sand influx could accrete in this area. This can be attributed to the saturation of the vegetation. Indeed, when all vegetation is covered in sand, there is no longer a reduction of the wind shear stress to induce sand deposition. The observation that sand blows through the dune is also obvious in the region close to the dyke (0-10m), where the filling of the ditch and the piling up of sand against the dyke can be clearly noticed.

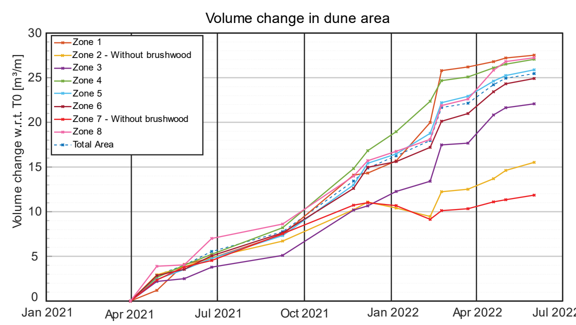

Figure 5 - Volume changes in the respective zones, expressed per meter in longshore direction.

Figure 5 confirms the huge accumulation of sand in the dune field (ca. 20m^3/y), which is approximately 4 times higher than observed in the natural dunes over a decadal time span. The difference between the zones with and without brushwood fences only becomes significant after 6 months, due to the saturation of the vegetation.

REFERENCES

SARCC project: Improving the understanding of Nature Based Solutions in coastal cities, https://www.sarcc.eu/
Deronde, B. et al. (2004) Proceedings of the European Association of Remote Sensing Laboratories 3, 26 33
Houthuys, R. (2012) Morphological trend of the Flemish Coast in 2011. Coastal Division, 150 pp. (in Dutch)
Strypsteen G. et al. (2019). Dune Volume Changes at Decadal Timescales and Its Relation with Potential Aeolian Transport., J. Mar. Sci. Eng. 7, 357.