Nature-based solutions: evaluating dune development with brushwood fences and marram grass along the Belgian coast

Derijckere Jennifer[1], Strypsteen Glenn[2] and Rauwoens Pieter[2]

[1] Civil Engineering, KU Leuven, Kasteelpark Arenberg 40, 3001 Leuven, Belgium
E-mail: jennifer.derijckere@kuleuven.be
[2] KU Leuven Campus Brugge, Spoorwegstraat 12, 8200 Brugge, Belgium

Introduction
The Belgium coast consist of a sandy beach, providing a natural flood protection. However, during strong wind conditions, wind-blown sand accumulates on coastal infrastructures. Every year, a lot of effort goes into cleaning the road and tramway tracks, especially in Raversijde, Belgium. Jerseys blocks already present on the dike are able to stop a part of this wind-blown sand but are insufficient during high windspeeds. To mitigate this sand nuisance, a dune-in-front-of-a-dike solution was implemented, marram grass and brushwood fences were planted on the upper beach in front of the seawall, strengthened the traditional sea dike. This nature-based solution created a more natural vision, higher ecological values and at the same time a higher level of coastal safety. The overall aim of this study is to relate dune volume changes and changes in dune parameters to forcing factors (e.g., windspeed and -direction), parameters of vegetation and brushwood fences (e.g., cover and density) and sand supply.

Methods
In Raversijde, Belgium a new artificial dune area of 1.5 ha is constructed 20 m in front of the traditional sea dike in Raversijde in the spring of 2021. The new dunes are designed in an area of 750 x 20 m² where vegetation (*Ammophila arenaria*) is planted in a split-plot design of 10 x 10 m² blocks. This vegetation is planted in different spatial distributions (regular, random and clustered) with low and high densities.

Occasionally, vegetation is surrounded by brushwood fences with low and high densities at an original height of 1.5m. Images of these brushwood fences are captured to assess their porosity. These images undergo a binarization process to determine the ratio of black pixels, corresponding to the openings in the brushwood fences, to the overall pixels within the image. Topographical changes are monitored by means of monthly drone surveys, simultaneously with local and regional wind conditions. Analyses are done along 12 cross-shore profiles and 8 divided zones.

Results
Preliminary results show a clear difference in cross-shore development for the different zones during the initial months of development, the influence of vegetation combined with brushwood fences is much more prominent than vegetation on itself. At the end of the first year the dune captured a volume of 18-26 m³/m in the zones characterized by the combination while the vegetation zones captured 12-14 m³/m. These brushwood fences are able to capture a larger amount of sand, but their trapping efficiency decreases over time as several combined zones become completely saturated by the end of the first year. When considering vegetation alone, the landward dune toe moves landward at a faster rate compared to combined zones. Yet, within the combined zones, the dune toe shifts more rapidly toward the land as porosity increases. Furthermore, in vegetation-only areas the dune crest is lower than those in combined zones, as the dune crest's elevation is influenced by vegetation and brushwood fence heights. The interaction between transport-limiting factor heights and the maximum sand accumulation level is always occurring. However, compared to vegetation, these fences are unable to grow and consequently capture sand in the future, so new planting in these combined zones will be necessary.

Keywords
Early-stage Dune Development; Dune Morphodynamics; Nature-based Solution; Field Measurement