



OPERANDUM
OPEN-air laboRatories for Nature based
solutions to Manage hydro-meteor risks

Sperimentazione di una Nature Based Solution sulla spiaggia del Bellocchio (provincia di Ferrara)

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The Challenge: the Bellocchio beach is a 3 km long natural sandy beach located between the sea and a lagoon and affected by strong erosion (8 m/year shoreline retreat). The site is threatened by marine flooding, subsidence rate is 2 mm/year and in decades the input of sand for this stretch by the river Reno has registered a serious deficit sediment supply. Nearby littorals are protected by hard structures that trap sediments and reduce the supply of longshore currents. Relevant **hazard** are **storms** that produce **marine flooding** and **erosion** of the beach. Intense **storm waves** here are associated to BORA weather conditions and **surge events** to SCIROCCO winds. The **vulnerability** of this transitional ecosystem is due to the low beach level. Major **risks** are the loss of dune and lagoon ecosystems, damage to the inland infrastructures, desertification of agricultural soils and loss of tourism potential.

The EU-funded OPERANDUM project (OPEN-air laboRatories for Nature based solutions to Manage Environmental risk) aims to design, implement and assess the effectiveness of Nature-Based Solutions (NBSs) to mitigate hydro-meteorological hazards. The approach of Operandum is based on innovative Open-Air Laboratories where NBSs are co-designed, co-developed and co-deployed.



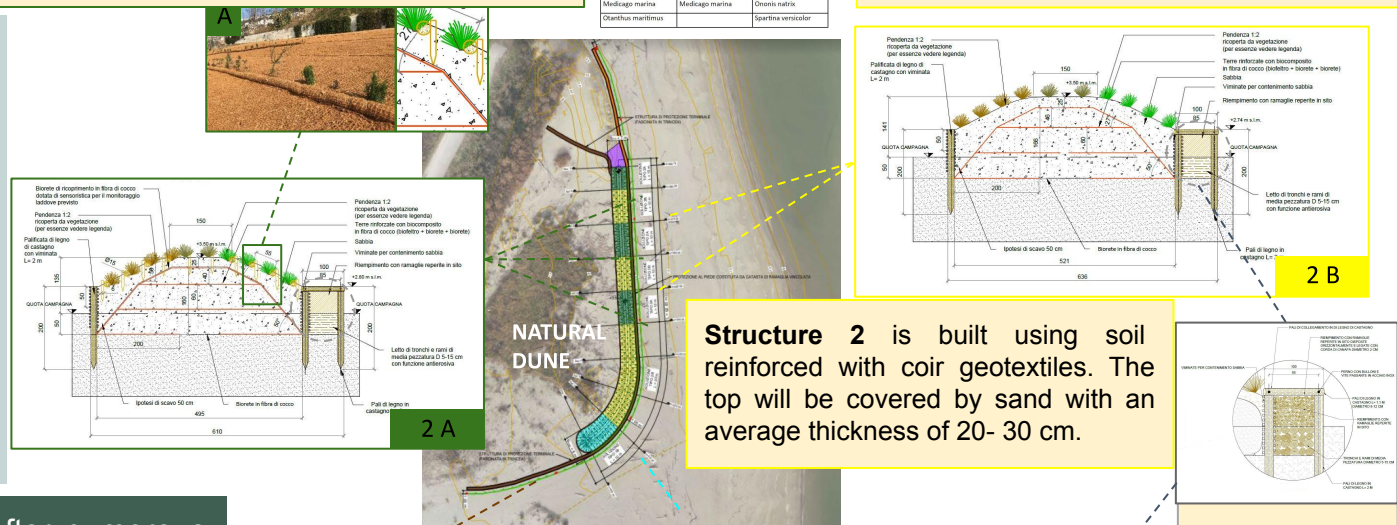
NBS Co-Design (signed by RINA-C): the NBS consists of an experimental **artificial dune** (100 m long, 3,5 m a.s.l high) with the aim to protect one of the residual dunes and obstacle flooding of the inland lagoon. The artificial sand dune will be reinforced with a structure composed of biodegradable material: wood and coir geotextile and inert fillers (sand) in part dredged in site or from adjacent beaches. **2 typologies of structural sections : 1 and 2; 2 typologies of coverages of the top: A and B; 2 typology of further protections** will be installed that will absorb energy and trap sand brought by storm waves (**wooden stacks and fascines of heather**).

Coverage A An additional coir net with an erosion and runoff control system fixed on the sand at the top of the dune, that will control runoff, dissipate energy, retain moisture and encourage vegetation growth and survival of autochthonous plant species that will be planted on the coir net.

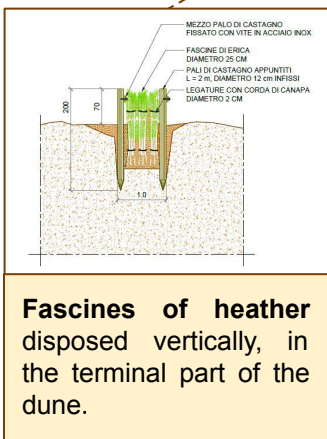
AUTOCHTHONOUS PLANT SPECIES		
front	top	back
Callitriche maritima	Ammophila arenaria	Crucianella maritima
Calyptegia soldanella	Calyptegia soldanella	Cyperus capitatus
Elymus farctus	Cyperus capitatus	Eryngium maritimum
Euphorbia paralias	Euphorbia paralias	Malcolmia littorea
Lotus creticus	Lotus creticus	Sporobolus pungens
Medicago marina	Medicago marina	Chenopodium maritimum
Quercus maritima		Spartina vestitor

Coverage B Autochthonous plant species will be planted directly in the sand at the top of the dune.

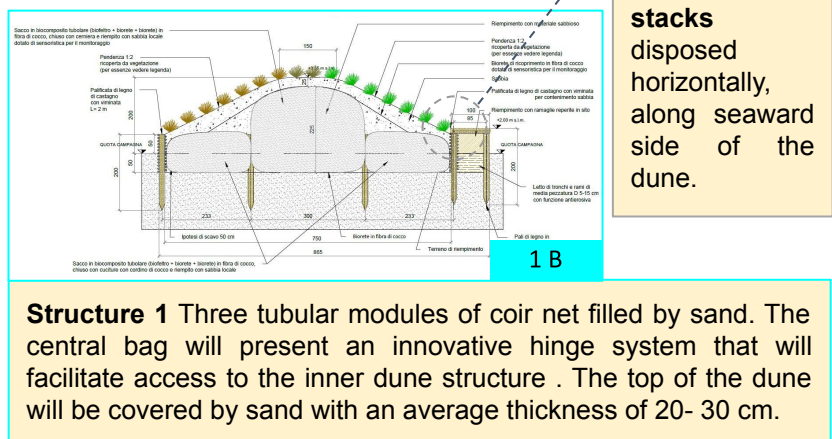
Numerical modeling: 1D numerical simulations with SBeach and XBeach were run to support the NBS design and sizing. Three scenarios with different return period were analyzed. Moreover, a 2D XBeach model was built to analyze the NBS performance. The current and the post-implementation scenario will be compared during current and future sea-state conditions. The forces distribution on the dune surface are obtained by CFD (OpenFOAM) simulations in a down-scaling approach, considering normal and extreme events.



Conclusion and future work: After numerous administrative steps, the Detailed Design has been delivered to the Agency of Land Security and Civil Protection, the authority devoted to implement defence works in Emilia-Romagna. The NBS performance will be monitored through topo-bathymetric surveys and deformations measurements. Unluckily, a strong marine event occurred in December 2020 eroded a large portion of the work site. The team involved in the co-design and co-development is working on looking forward to a solution in order to test the technology.



Structure 1 Three tubular modules of coir net filled by sand. The central bag will present an innovative hinge system that will facilitate access to the inner dune structure. The top of the dune will be covered by sand with an average thickness of 20- 30 cm.



Structure 2 is built using soil reinforced with coir geotextiles. The top will be covered by sand with an average thickness of 20- 30 cm.

