Assessment of soft coastal protection alternatives for Saint-Louis (Senegal)

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ABSTRACT

The Barbarie spit (*Langue de Barbarie*) is a 100–400 m-wide West-Africa coastal barrier that has fluctuated in length between 10 and 30 km over the last century (Anthony, 2015). The changes in length reflect the variable position of the Senegal river mouth, where rates of spit growth vary greatly (100 to 700 m/year), depending on variations in wave characteristics, river discharge and river mouth dynamics, combined with barrier-breaching events (Bergsma et al., 2020).

The Barbarie sandy barrier protects the island of Saint-Louis, within the Senegal river delta. Of particular significance is the historic city of Saint-Louis, a UNESCO world heritage city (Anthony, 2015). Coastal erosion can be severe along the 2 km stretch in front of Saint-Louis, with retreat rates of up to 20 m/year (Tavenau et al., 2021). Moreover, the coast in front of the city is home to small-craft fishing activity of high socio-economic implications.

Given the Saint-Louis settings and the Barbarie spit dynamics, the city is at high coastal erosion and flooding risk. So, informed coastal management is necessary, based on the assessment of alternative coastal protection solutions. Given the world-wide success of several soft-management (beach nourishment) interventions, this paper addresses and compares four alternative solutions, consisting of artificial protective offshore islands and shore-attached peninsulas.

1. Methodology

ShorelineS (Roelvink et al., 2020) is an open-source, free-form coastline model that can describe most kind of planar coastal transformations based on the relatively simple principles of 1) longshore transport gradient driven changes as a result of coastline curvature and 2) spit formation at high-angle wave incidence (Elghandour and Roelvink, 2020). It relies on a vector-based coastline concept, describing the coastline like a freely moving string of points. An arbitrary number of coastal sections is supported, which can be open or closed, and can interact with each other through relatively straightforward merging and splitting mechanisms. Also, rocky parts or structures may block wave energy and/or interrupt longshore sediment transport. These features allow for developing shoreline undulations and formation of spits, migrating islands, merging of coastal shapes, salients and tombolos.

In this paper, the model is first applied and calibrated with satellite derived shorelines of Barbarie spit (Fig. 1), from 2015 to 2019. Model parameters were set to reproduce the estimated net average littoral drift in this area, as well as the Barbarie spit growth rate. Subsequently, the model is used to assess the medium to long term coastal evolution, forced by the hindcast wave time series. Several options in terms of intervention at the nearshore region seaward of Saint-Louis are assessed, with nourished sand mounds varying in initial number and shape.

2. Results and preliminary conclusions

The tested soft-solutions caused the breaching of Langue de Barbarie within less than 3 years of simulation, except for one out of four solutions. These breaches occurred mostly south of Saint-Louis (within 1-3 km away), as can be seen in Fig. 2 for one of the solutions. The breaches are likely caused by shoreline instabilities triggered by the partial and transitional sheltering effect of the interventions. These instabilities and the erosion/accretion patterns at Langue de Barbarie, however, are not restricted southwards of Saint-

Louis. Compared to other locations with less intense longshore sediment transport, the lifetime of the soft solutions sandy mounds appeared to be quite brief (of the order of 3 years).

To conclude, it would be desirable to confirm the present findings by confronting them with those from alternative shoreline evolution models.

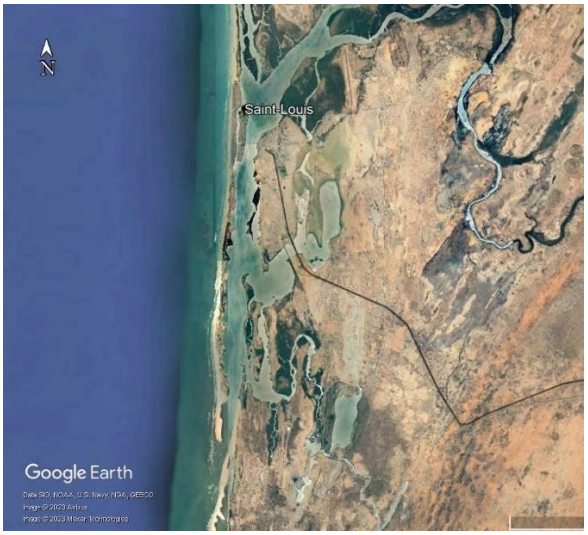

Fig. 1. General view of the coast in front of Saint-Louis (Senegal).

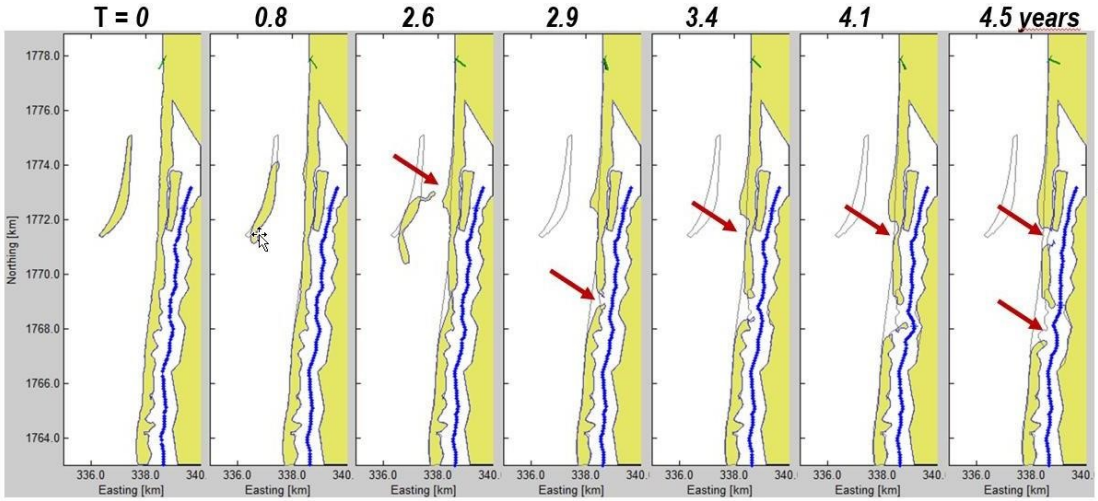

Fig. 2. Shoreline evolution after the implementation of an offshore island. (Arrows point to disturbances triggered by the protective solution).

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