A Quantitative Assessment of Human Interventions and Climate Change on the West African Sand River

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Introduction: The West African coast consists of a narrow low-lying coastal strip, maintained by sediments from rivers and transported along the coast by waves and currents, comparable to a "sand river". Today, however, much of the fluvial sand is retained behind river dams and/or interrupted at several locations by harbour jetties. For these reasons, the sandy coastal barrier is eroding almost everywhere; the already critical situation is likely to be worsened in the future due to climate change.
In this study, a quantitative and consistent large-scale sediment budget study based on a unique numerical modeling framework has been set-up for the following countries: Ivory Coast, Ghana, Togo and Benin. The study provides quantitative information of the sand moving along the coastline within the "sand river". Moreover, the possible effects of the major man-made interventions and climate change on the alongshore sediment transport and shoreline changes have been investigated.

Methods: A unique input dataset for the entire region was created, largely based on open-source and global data in order to overcome the existing fragmentation of information between the different countries. The dataset was used to force one set of numerical models, including: (a) a large-scale wave model and 15 nested wave models, based on the Delft3D-WAVE code and (b) one sediment transport and shoreline evolution model for the entire coastline, based on the UNIBEST-CL+ code. The sediment input towards the coast, from each of the major river rivers, was estimated based on the hydrological model WFLOW and combined with empirical formulas to estimate the sediment yield.
A hindcast simulation was carried out for the period 1985-2015 in order to compare model results with literature values. The validated model was then used to simulate different scenarios for the period 2015-2100 in order to assess: (a) the possible effect of major anthropogenic interventions in the region (i.e. major ports and river dams); (b) the possible effect of climate change.
In order to be able to share information and create awareness among local stakeholders and organizations, a number of workshops and an open-source viewer were also set-up as part of the study.

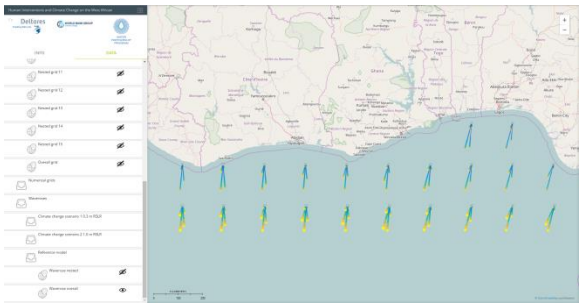

Fig. 1: On-line viewer for the visualization of the model results.

Results: The model validation has shown that the modeling framework is able to describe the large-scale sediment budget of the region (i.e. longshore transport rates and shoreline changes).
Although some of the anthropogenic interventions have only a local effect, others may have a much larger spatial effect (e.g. the effect of the port of Lomé after 30 years extends up to nearly 50 kilometres). The study has also shown that the effect of the major ports on coastal erosion will be on the same order of magnitude than the effect of sea level rise when considering the lower sea level rise scenario's (RCP 4.5). However, sea level rise may overrule the effect of the other anthropogenic interventions by the end of the century if considering the largest predicted sea level rise scenario's (RCP 8.5).

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References: [1] Giardino Alessio, Schrijvershof Reinier, Brière Christophe, Nederhoff Kees, Tonnon Pieter Koen, Caires Sofia, 2017. Human Interventions and Climate Change Impacts on the West African Coastal Sand River. World Bank, Washington, DC.