A Global View on Beach Erosion

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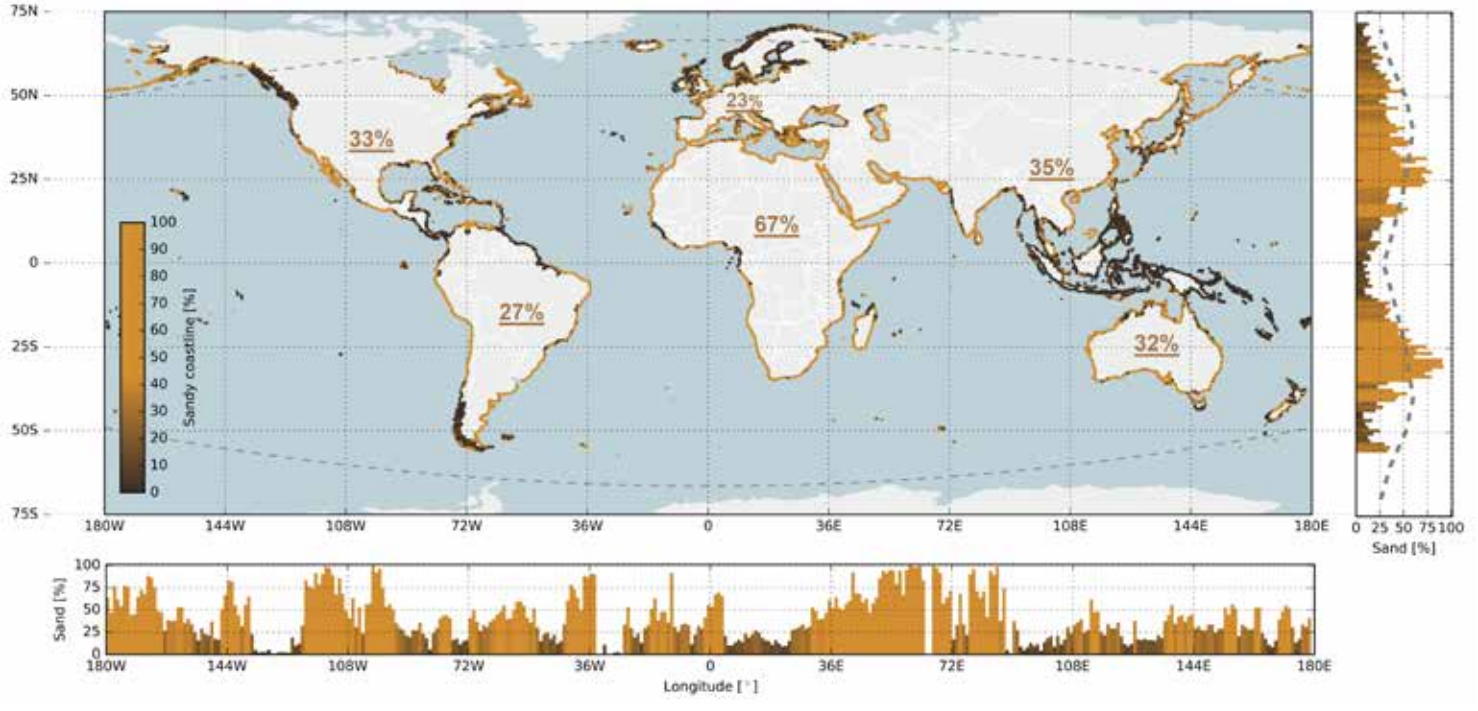
Publication date
2019

Document Version
Final published version

Published in
The Sand Motor: A Nature-Based Response to Climate Change

Citation (APA)
Luijendijk, A. (2019). A Global View on Beach Erosion. In *The Sand Motor: A Nature-Based Response to Climate Change: Findings and Reflections of the Interdisciplinary Research Program NatureCoast* (pp. 174-175). Delft University Publishers.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33%
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Sandy coastline [%]
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80
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Sand [%]
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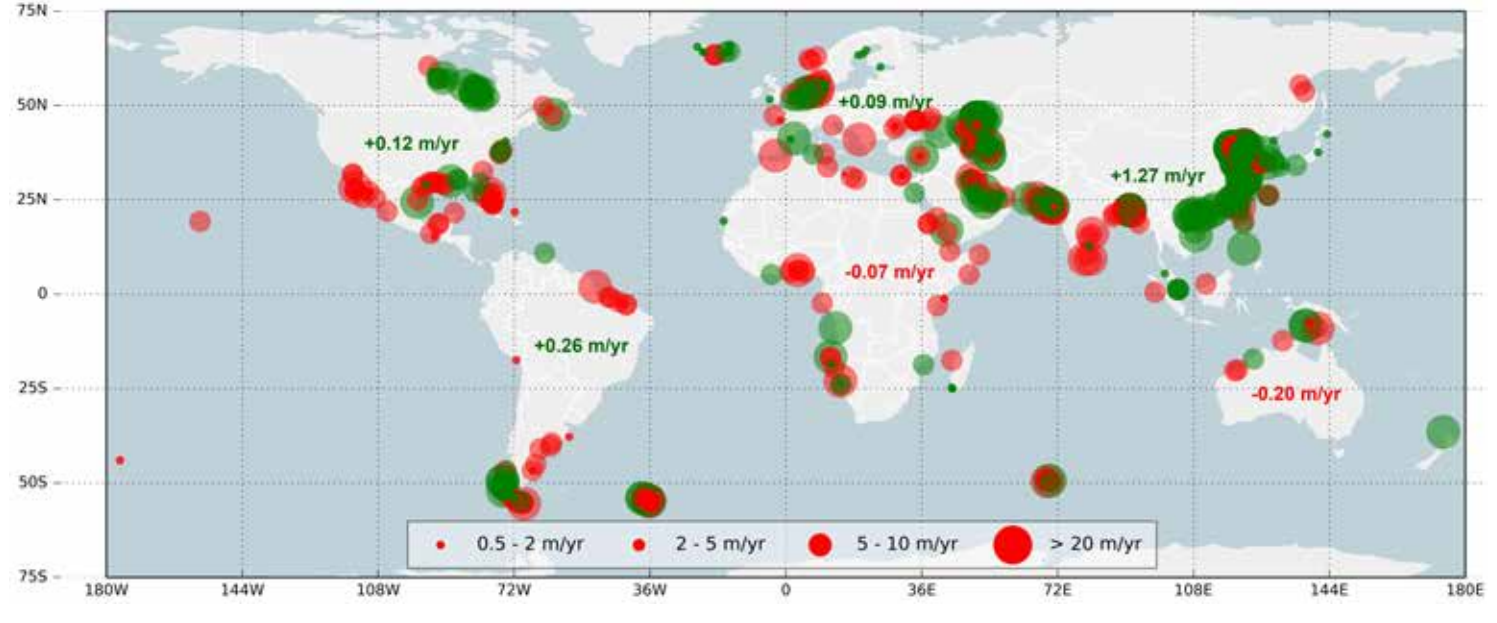
Longitude [°]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108E
144E
180E
+0.12 m/yr
+0.09 m/yr
+1.27 m/yr
-0.07 m/yr
+0.26 m/yr
-0.20 m/yr
0.5 - 2 m/yr
2 - 5 m/yr
5 - 10 m/yr
> 20 m/yr

Arjen Luijendijk

A GLOBAL VIEW ON BEACH EROSION

Coastal zones have long attracted humans and human activities, due to the economic opportunities they offer, their aesthetic value, and the diverse ecosystem services they provide. As a result, coastal zones throughout the world have become heavily populated and developed, with 15 of the world's 20 megacities (population >10 million) being in the coastal zone. The global coastline is spatially varied and comprises different coastal landforms, such as barrier islands, sea cliffs, sandy coasts, tidal flats, and river deltas. Of these different coastline types, the sandy coasts are highly dynamic in time and space and constitute a substantial part of the world's coastline. Sandy coasts are highly developed and densely populated due to the amenities and aesthetics they offer, but erosion of these coasts over the last few decades is already causing coastal "squeeze." The impact of climate change on these coasts will only exacerbate this situation.

Despite the utility and economic benefits that coasts provide, no reliable global-scale assessment of historical shoreline trends is available. Using freely available optical satellite images captured since 1984, in conjunction with sophisticated image interrogation and analysis methods, we conducted a global-scale assessment of the presence of sandy beaches and the rates of shoreline change at those locations. Applying pixel-based supervised classification, we found that 31% of the world's ice-free shoreline is sandy. Africa has the highest percentage of sandy beaches (66%), while in Europe only 23% of the shoreline is sandy (Figure 1).

Applying an automated shoreline detection method to the sandy shorelines that were identified resulted in a global dataset of shoreline change rates for the period 1984 - 2016. Analysis of the satellite-derived shoreline data indicates that 24% of the world's sandy beaches are eroding at rates exceeding 0.5 m/yr, while 28% are growing, and 48% are stable. About 18% of the sandy beaches are experiencing erosion rates exceeding 1 m/yr.

More severe erosion rates are found at various locations across the globe. About 7% of the world's sandy beaches experience erosion rates classified as severe (i.e., more than 3 m/yr). Erosion rates exceed 5 m/yr along 4% of the sandy shoreline and are greater than 10 m/yr for 2% of the global sandy shoreline. From a continental perspective, Australia and Africa are the only continents with net erosion (−0.20 m/yr and −0.07 m/yr, respectively), with all other continents showing net accretion. The main causes of this accretion are land reclamations, natural sediment supply by rivers, and nourishment strategies. For example, the country-mean change rate for the Netherlands is 2.8 m/yr since 1984.

The database is publicly available at *shorelinemonitor.deltares.nl*. The Shorelinemonitor tool can assist in understanding the coastal dynamics over the last 33 years for every beach in the world. This database allowed us to identify the coastal stretches that are eroding around the world (i.e., erosion hot spots). A hotspot is defined as a coastal section of at least 5 km of sandy shoreline where all considered transects showed erosion larger than 0.5 m/yr over the 33-year data set. The numerous hotspots shown in Figure 2 illustrate that erosion affects large sandy beach sections around the globe. Combining this data with the information on urban development, derived from nightly satellite images, we can identify the hotspots for coastal "squeeze." These are areas that may need coastal protection measures to mitigate coastal erosion in urban areas, either now or in the future. Investigating the feasibility of sandy strategies in these areas would be very valuable.

In addition to encouraging nourishment to mitigate coastal erosion, we should investigate ways to optimize existing nourishment strategies, or even consider constructing artificial beaches on non-sandy coasts. Any such assessment or proposal will need to start with a comprehensive understanding of the physical conditions and the ecosystem, as well as the governance setting.

Figure 1. (top left)
Global distribution of sandy shorelines; the coloured dots along the world's shoreline represent the local percentage of sandy shorelines (yellow is sand, dark brown is non-sand). The subplots present the relative occurrence of sandy shorelines per degree latitude and longitude. The underlined percentages indicate the percentages of sandy shorelines averaged per continent.

Figure 2. (bottom left)
Global hotspots of beach erosion and accretion; the red (green) circles indicate erosion (accretion) for the four relevant shoreline dynamic classifications (see legend). The numbers presented in the main plot represent the average change rate for all sandy shorelines per continent.