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Management strategies for coastal erosion problems in west Africa: Analysis, issues, and constraints drawn from the examples of Senegal and Benin

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ABSTRACT

In West Africa, coastal erosion remains a problem for the socio-economic development of the coastal zone. Case studies in Senegal and Benin indicate a strong intensification of coastal erosion, in relation to human influence, as shown by the analysis of shoreline change rates from satellite data. The "Langue de Barbarie," a sand spit bounding the mouth of the Senegal River delta in the Saint-Louis Region, Senegal, is relatively densely inhabited and developed. The spit was artificially breached in 2003 to alleviate potential river flooding that threatened the historical city of Saint-Louis. The analysis covers two periods: the pre-breach period (1984–2003) characterized by sectors alternating between erosion and accretion, and the post-breach period (2003–2016) indicating a generalization of the erosion process, with a noteworthy average rate of −3.72 m/yr affecting the entire spit, strongly destabilized by the artificial breach. In Benin, shoreline evolution is equally affected by human interventions. Following the construction of the Nangbéto Dam on the Mono River, the "Bouche du Roi," outlet of this river, has been characterized by marked instability, with an eastward migration exceeding 700 m/yr. Other human alterations of the coastal system include the installment of major seaports and groins that have resulted in some erosion downdrift near Cotonou. These examples highlight the limits of governance regarding the coast in West Africa, including adaptation strategies developed at regional, national and local levels, which often produce more setbacks than solutions.

1. Introduction

The coasts of Senegal and Benin, on the Atlantic coast of West Africa (Fig. 1) respectively stretch over 706 km between Mauritania and Guinea-Bissau, and over 125 km between Togo and Nigeria (Diaw, 1984; Laïbi, 2011). West African coasts are composed of loose sediments which account for 97%, while only 3% are rocky (PRLEC-UEMOA, 2010). These proportions are similar to the coast of Senegal, with estimates, respectively, of 92% and 8% (Diaw, 1997), whereas the coast of Benin is 100% alluvial. Given this dominant alluvial context, morphological units of these coasts, composed of sandy beaches and beach ridge barriers, aeolian dunes, sandy spits, estuarine bars, deltaic deposits, lagoons, and back-barrier or shore-front mangrove swamps, evolve rapidly.

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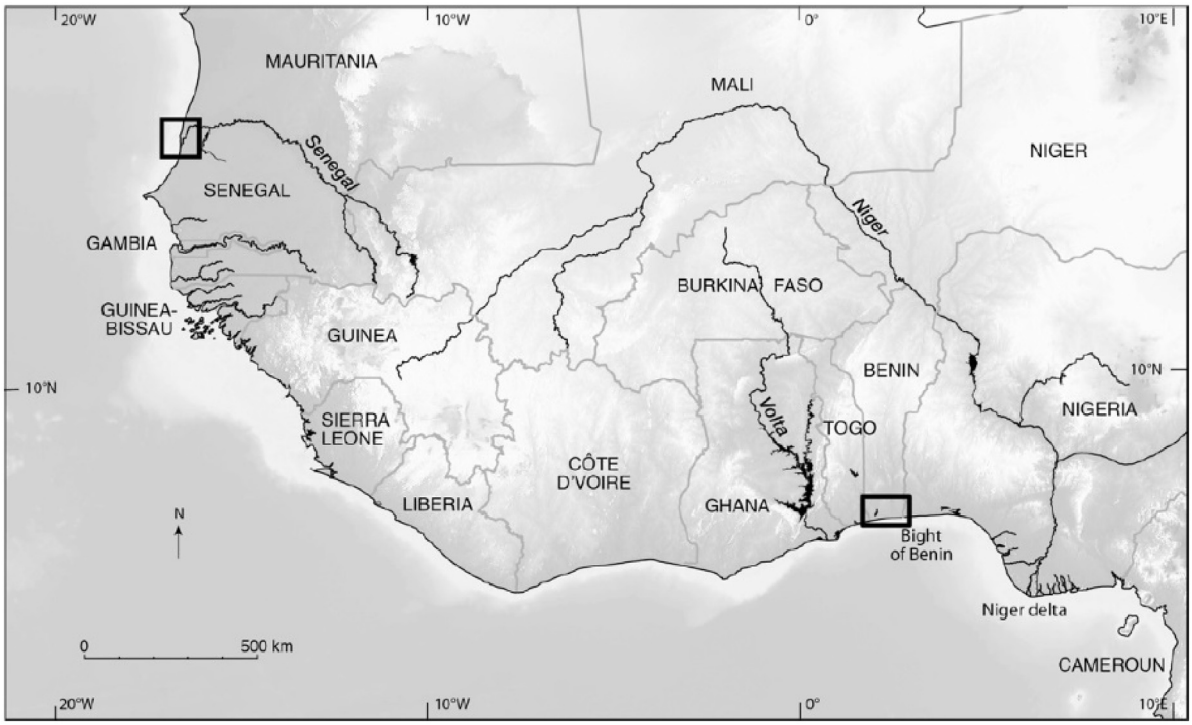

Fig. 1. The coast of West Africa and the two study sites in Senegal and Benin (boxes). The coast is characterized by of long stretches of wave-dominated coast and a limited, predominantly tidal, estuarine sector between Sierra Leone and Guinea-Bissau (broad, low-gradient continental shelf), subject to significant wave energy dissipation. The two sandy sectors on either side of this muddy estuarine coast are under the influence of dominantly long and regular swell and shorter-fetch trade-wind waves. Abundant sand supplies and strong wave-induced longshore drift have favored the construction of numerous sand spits in Senegal, and massive beach-ridge barriers bounding lagoons in Benin.

Various man-made installations (seaports, tourist and urban facilities, roads, etc.) also characterize these coasts. The coastal plain of Benin shelters more than 80% of all the country's industrial units implanted in the cities of Cotonou and Porto-Novo (MEHU, 2007).

In fact, in both countries, the administrative and economic capital cities are located on the coast, characterized by anarchic and often illicit and fast-spreading settlements. Given these important economic, industrial and administrative functions, the coastal population of Senegal is quite high, estimated at 8,500,000 inhabitants within a radius of 60 km, and represents more than 65% of the country's total population (CSE, 2015). Similarly, the coast of Benin shelters 50% of the country's population estimated at 10,725,000 inhabitants in 2015 (MEHU, 2007). The various installations and infrastructure have often been constructed on the coast without any appropriate planning and knowledge on the physical dynamics driving the coastal system (Delgadillo-Calzadilla et al., 2014; Jonah et al., 2016). Consequently, in numerous coastal areas in Senegal and Benin, this intensive occupation, which also commonly involves the uncontrolled exploitation of coastal resources and the implementation of ill-adapted strategies, contributes to the erosion phenomena.

The purpose of this article is to analyze the evolution of this coast, in the light of all the anthropogenic pressures underscored above. The work is based on an example from Senegal devoted to the analysis of the behavior of the Langue de Barbarie spit, a major coastal feature bounding the Senegal River delta (Fig. 2A). A brief review of the evolution of another spit, the Sangomar spit, from the published literature, complements the analysis. Both spits have undergone breaching, with consequences on spit stability and human settlements. In Benin, the study sector concerns the coast from Hillacondji to Grand-Popo including the “Bouche du Roi” outlet of the Mono River mouth bound by a sandy spit (Fig. 2B), and the dynamics of which has been affected by river dam modulation of discharge. In these examples, the factors at stake, the strategies deployed at various levels (local, national and regional), the governance of the coast and its limits, along with related recommendations, have been the object of reflection that is summarized in this paper. The recommendations deal with the state of coastal erosion and strategies in Senegal and Benin. These case studies highlight situations that are similar to many further observations made on other coasts where human activities generate numerous issues, and strategies fail to give effective solutions (Rangel-Buitrago et al., 2015).

2. Characteristics of the coasts of Senegal and Benin and factors at stake

The coasts of Senegal and Benin are part of West Africa's passive Atlantic margin, characterized by relative tectonic stability. However, numerous micro-fractures affect the Secondary and, less frequently, Tertiary series of the sedimentary basins that rim parts of this West African margin, which also constitutes the continental terminus of major Atlantic fracture zones associated with mild earthquake activity (Bellion and Guiraud, 1979; Sall, 1982; Jones, 1987).

Like much of the West African coast north and south of the muddy tidal estuarine sector of Guinea, Guinea-Bissau and northern Sierra Leone (Fig. 1), the coasts of Senegal and Benin are characterized essentially by sand barriers. According to Anthony (2015), these two coasts are under the influence of dominantly long and regular swell and shorter-fetch trade-wind waves. In conjunction with abundant fluvial sand supplies during the Late Pleistocene sea-level low stand on the presently drowned inner shelf, the dominant swell wave regime associated with long waves generated in the Atlantic Ocean (see below) favored the construction of

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