The Senegal river mouth migration

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ABSTRACT

The Senegal River presents one of the most dynamic river mouths in the world. It has shown a very fast migration in the last 12 years, as a result of an artificial channel. This new inlet was made in October 2003 over the Langue de Barbarie. In that year, the heavy rains originated a flood all along the river, so that the authorities had no other choice to open a new inlet through the sand spit to facilitate the river discharge. The original channel dimensions were 4 m wide, 200 m long and 1.5 m deep, and it was located approximately 7 km south of Saint Louis. The pressure of the river water flowing at very high speed originated the quick channel widening. Since then the morphodynamic change in this area has been very fast. Few months after the opening, the artificial channel evolved to form the new river mouth, and the ancient mouth was naturally closed due to the weakness of the river flow and the strong longshore drift. Nowadays the mouth dimensions are very large, reaching nearly 6 km in width. The coast facing this new mouth is completely exposed to wave action and therefore it suffers very strong coastal retreat.

INTRODUCTION

The study area is located at Langue de Barbarie, a sandy spit with N-S orientation, situated on the northern coast of Senegal, near the border of Mauritania. Its origin is dated about 4000 years ago. At that time ocean waves, currents and wind favored the formation and accumulation of offshore bars that migrated onshore and formed a barrier facing the Senegal River mouth [1]. Nowadays the mouth of the Senegal River is a very dynamic environment which changes its position over time due to the strong longshore drift. This natural forcing has led to the formation of one of the largest spits in the world associated to a river mouth.

Nowadays the beach runs along the coast around 45 km, forcing the river to lead Senegal some 30 km south of Saint Louis (Fig. 1). The estuary of the Senegal River and the Langue de Barbarie is a quite complex environment, since the sand barrier is influenced in its outer side by the marine influence, in the central part by wind action which transports and distributes sediment, and on the inside of the lagoon by the river flow.

The river flow is directly determined by rainfall, which greatly varies between the wet season (from July to October but sometimes could be to December), and the dry season (the rest of year).

During September and October 2003 extremely heavy rains originated a highly severe flood all along the river. On the night of 3 to 4 October 2003, the authorities facing an imminent risk of flooding, decided to make a channel in the Langue de Barbarie to increase the drainage capacity of the river and therefore designed to reduce the water level quickly. The channel dimensions were 4 m wide, 200 m long and 1.5 m deep, and it was located approximately 7 km south of Saint Louis.

The pressure of the river water flowing at very high speed originated the quick channel widening, so that two days after opening it was 80 m wide and three weeks later it was about 330 m. Since then the morphodynamic changes in this area has been very fast.

This paper aims to assess the morphodynamic evolution of this dynamic system since the situation previous to the new opening to nowadays, and estimate its future evolution.

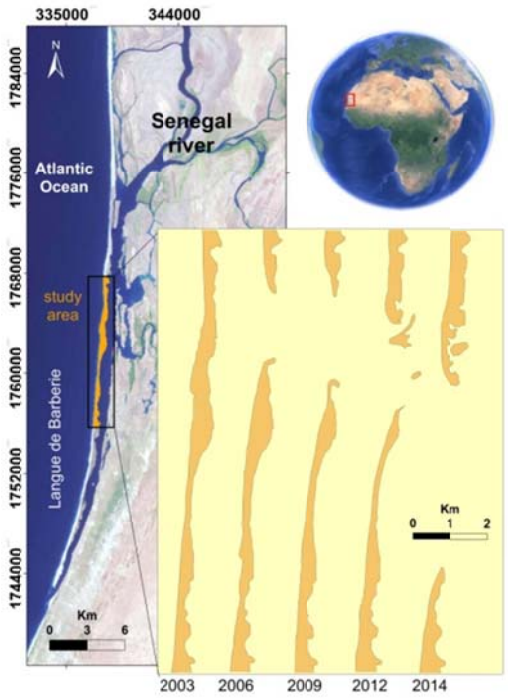

Fig. 1. Location of the study area, showing the changes registered in the new river mouth.

MATERIAL & METHODS

Satellites imagery allow to obtain a synoptic picture of a very large area, thus serving as a basis for obtaining data of interest, without the need of costly field work. Nowadays there is a crowd of operational satellites that provide images of all land areas with high spatial and temporal resolution.

The most frequently used to perform research of shoreline dynamics are the Landsat imagery [2]. They have a spatial resolution of 30 m by pixel and a temporal resolution of 16 days (Landsat has one of the best time series of images around the planet). Each scene covers an area of 108 x 175 km^2.

Images were obtained from the database of the USGS and belong to different Landsat satellites. They are georeferenced to the WGS84 geodetic system.

The study period covers from 2003 (when the opening through the spit was made) to the present. There are about 150 images with acceptable quality to carry out the study. 54 of them were selected as the most relevant and representative ones. The criteria used for selecting them were the absence of cloud cover which may cause errors while digitizing the coastline, and the temporal distribution that successfully cover the work objectives. ArcGIS 10.1 software was used both for the digitization processes as well as for the data analysis.

RESULTS & DISCUSSION

The rate of change of the Senegal River mouth is determined by the position of its northern and southern limits. To estimate that migration rate from 2003 to the present, the distance from both limits of the mouth to Faidherbe Bridge in Saint Louis were measured, and from these data the position of the middle of the channel was calculated.

In the last Landsat image used (February 22, 2014), the centre of the mouth is located 10.8 km southward of Faidherbe Bridge (Saint Louis), while it was only 7 km away when it was opened in 2003.

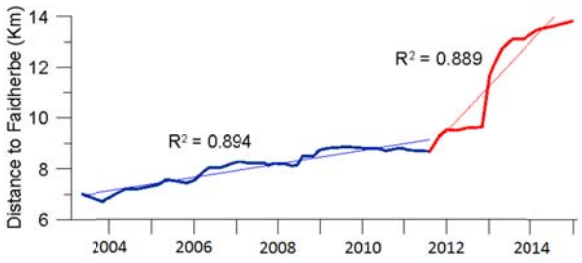

Fig. 2. Displacement at the south end of the mouth.

It can be observed from Fig. 2 that there are two clear periods in the evolution of the mouth measured at its southern end. From 2003 until summer 2011 there is a quite slow migration, which is 0.26 km/y in average. On the other hand, since July 2011 until November 2014 there is a much higher retreat rate (1.78 km/y).

This huge retreat rate is determined by two different process: the normal erosion at the end of the spit, generated from incident waves and the lack of sedimentary inputs from the north, and the extraordinary erosion generated after overwash processes. This later aspect has proved to be extraordinary important, since the overwash processes are key factors in the formation of new breakings along the barrier, which represent quick widening in the mouth amplitude. There are some areas along the Langue de Barbarie so narrow and with low topography that are extremely vulnerable to these phenomena.

Considering only this final period (from 2011 until 2014) the rate of linear growth of the north is 370 m/y, while the rate of retreat at the south is 1780 m/y. These values indicate that the river mouth is getting wider at a rate of 1450 m/y.

The future evolution of this system is clearly determined by the rate of retreat at the southern end of the river mouth.

Assuming that this retreat rate of 1.8 km/y will keep constant in the future, by 2023 the Langue de Barbarie will be completely eroded, severely affecting the population located in the continental coastal zone [3].

ACKOWLEDGEMENTS

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