OBSERVATION OF SANDSPIT ELONGATION AND BREACHING EVENTS AT THE VOLTA-DELTA RIVER MOUTH, ADA, GHANA.

Tohoku University	Student Member	Stephan LAWSON
Tohoku University	Student Member	Nguyen Trong HIEP
Tohoku University	Fellow Member	Hitoshi TANAKA
Tohoku University	Regular Member	Nguyen Xuan TINH

1. INTRODUCTION

The dynamic and geomorphological nature of river mouth sandspits is an attribute of sandspits which has generated immense interest from coastal researchers. The Volta Delta is among several river deltas with vulnerabilities to coastal erosion, droughts, and urban flooding. Located at the Volta river mouth are two well defined sandspits whose development and geomorphic transformation have been described by Anthony (2015). In another study, the vulnerability of coastal communities around the Volta River mouth to shoreline retreat was highlighted by Appeaning et. al., (2020). In this study, the morphological evolution of the Volta River mouth is investigated using satellite images from 1984 to 2020. The study also conducts quantitative analysis of sandspit parameters to understand the morphological trends at the river mouth.

2. STUDY AREA, MATERIALS, AND METHODS

The Volta River mouth serves as the outfall of the Volta basin by draining the river discharge into the Gulf of Guinea (Fig. 1). The river mouth is located at Ada, a coastal community in Ghana which is approximately 100km to the east of the country's capital, Accra. On the western side of the river mouth is a groyne system which was constructed from 2012 to 2017. The groyne system protects a total stretch of 16km of the coast against the intense erosion rates and displacement of coastal communities (Roest, 2018).

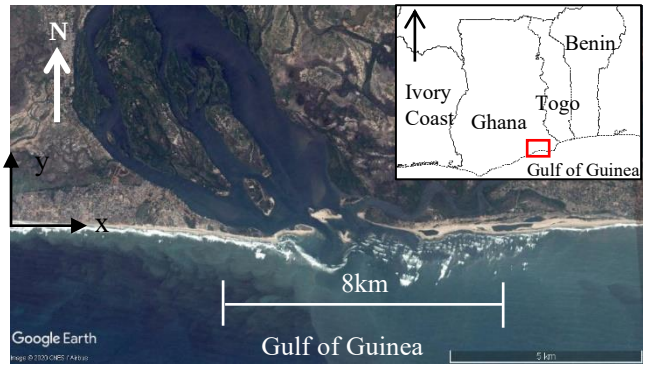


Figure 1: The Volta-Delta River Mouth, Ada, Ghana.

The main source of satellite images used in this research were Landsat (5,7 & 8) and Sentinel-2 images acquired from 1984 to 2020. In addition to these images, Google Earth images were used to supplement the main source of images. The 30m/pixel resolution Landsat images were down sampled to 15m/pixel using bilinear interpolation (Vos et. al., 2019). Similarly, the Sentinel-2 images with a resolution of 20m/pixel were down sampled to 10m/pixel. The pre-processing of satellite images using this method improved the accuracy of detected shorelines.

The water-land boundary of the main source of images was defined using the Modified Normalized Difference Index developed by Xu (2006). In the case of the Google Earth images, all images were rectified into a single coordinate system (World Geodetic System-84) using an affine transformation with the baseline 271 degrees from the North. The shorelines were then detected using the difference in colour intensity of the wet and dry sand.

3. RESULTS AND DISCUSSIONS

3.1 ANALYSIS OF SANDSPIT CHARACTERISTICS

Detailed studies on the morphology of the Volta River mouth were performed through quantitative analysis using the acquired satellite images. Parameters of the sandspit used to achieve this include the alongshore coordinate of the updrift (x_1) and downdrift (x_2) sandspit tips and their corresponding y-coordinate values (y_1 and y_2 respectively). The areas of the updrift (A_1) and downdrift (A_2) sandspits were also defined. Definition of these parameters are shown in Fig. 2 below.

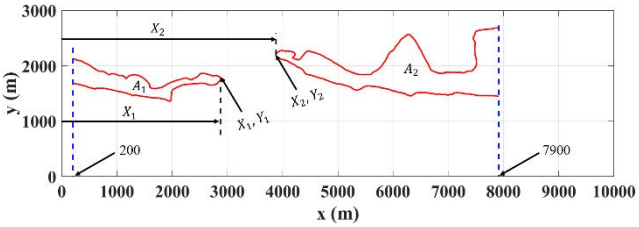


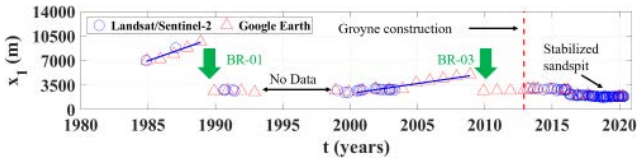
Figure 2: Definition of sandspit parameters used in sandspit analysis

3.1.1 SANDSPIT ELONGATION AND BREACHING

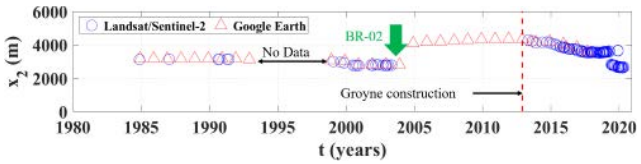
As shown in Fig. 3(a), the elongation of the western sandspit (updrift) is observed up to a maximum length of x_1 = 9672m (1988) where the sandspit was breached (BR-01). This cyclic process was repeated with the sandspit elongating to a length of x_1 = 5013m (2008) where it was breached (BR-03). The cause of breaching of the western sandspit can be attributed to the elongation of the western sandspit and the resulting downdrift migration of the river mouth. This leads to the narrowing of the river mouth which causes the gradual erosion at the neck of the western sandspit. Upon breaching, there is the transfer of sediment from the breached sandspit to the eastern sandspit (downdrift) and other downdrift areas.

Keywords: Breaching, Elongation, Erosion, Groyne system, Sandspit, Volta River
Contact Information: 〒980-8579, Aoba 6-6-06, Aramaki, Aoba-ku, Sendai, Japan. Tel.: 022-795-7453

With respect to the eastern sandspit, it is observed that no appreciable changes in terms of elongation trends occurred making it the non-dominant sandspit at the river mouth. However, a breach (BR-02) occurred after reaching a length of x_2 = 2810m (2003) (Fig. 3(b)).



(a) X_1 coordinates of updrift sandspit

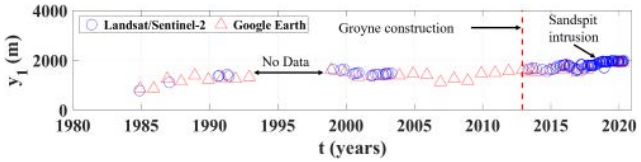


(b) X_2 coordinates of downdrift sandspit

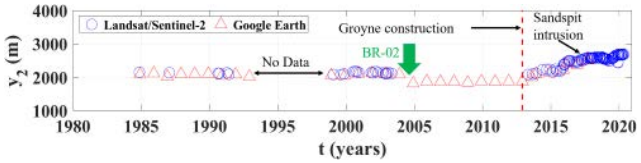
Figure 3: Alongshore x-coordinates of updrift and downdrift sandspits (1984-2020)

3.1.2 SANDSPIT INTRUSION

Analysis of the sandspit tip y-coordinates (y_1 and y_2) revealed sandspit intrusion trends in the post-groyne construction period (2013-2020). As shown in Figs. 4(a) and 4(b), intrusion of both sandspits into the upstream section of the river mouth can be observed. This trend may tend to pose futuristic problems such as narrowing of the river mouth and hence, leading to an inefficient tidal exchange between the estuary and the ocean.



(a) Y_1 coordinates of updrift sandspit tip

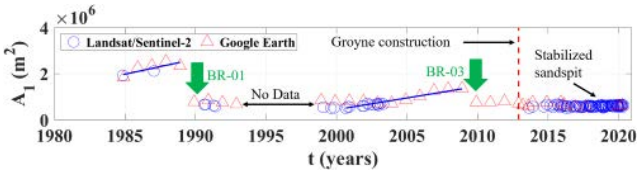


(b) Y_2 coordinates of downdrift sandspit tip

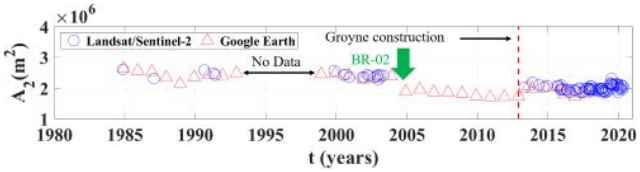
Figure 4: Y-coordinates of updrift and downdrift sandspit tips (1984-2020)

3.1.3 SANDSPIT AREA CHANGES

Another key quantitative parameter investigated was the area of sandspits (A_1 and A_2). In Fig. 5(a), the area changes of the western sandspit follows a similar trend as in the case of elongation trends which further supports the dominance of the western sandspit at the river mouth. Pertaining to the eastern sandspit, its unstable nature is depicted in Fig. 5(b). This is because of the deposition of sediment from the western sandspit when breaching events occur. This condition also leads to the formation of a small lagoon on the eastern sandspit.



(a) Updrift area (A_1) variation



(b) Downdrift area (A_2) variation

Figure 5: Area variation of updrift and downdrift sandspits (1984-2020)

4. CONCLUSIONS

In this study, the morphological trends of the Volta River mouth were analyzed by utilizing freely available remote sensing images from 1984-2020. Typical trends observed were the periodic elongation of the western sandspit in the eastward direction which leads to migration and narrowing of the river mouth and its subsequent breaching. After the construction of the groyne system, a new trend of morphology was observed with the sandspits intruding upstream of the river mouth. The change in morphological trends gives an indication of the response of a river mouth sandspit when the longshore sediment transport is trapped through engineering activities.

REFERENCES

Anthony, E. J. (2015). Patterns of Sand Spit Development and Their Management Implications on Deltaic , Drift-Aligned Coasts : The Cases of the Senegal and Volta River Delta Spits , West Africa.

Appeaning Addo, K., Brempong, E. K., & Jayson-Quashigah, P. N. (2020). Assessment of the dynamics of the Volta river estuary shorelines in Ghana. Geoenvironmental Disasters, 7(1), 1–11.

Roest, L. W. M. (2018). The coastal system of the Volta delta , Ghana Opportunities and strategies for development. TU Delft Delta Infrastrustures amd Mobility Initiative (DIMI).

Vos, K., Splinter, K. D., Harley, M. D., Simmons, J. A., & Turner, I. L. (2019). CoastSat: A Google Earth Engine-enabled Python toolkit to extract shorelines from publicly available satellite imagery. Environmental Modelling and Software, 122.

Xu, H. (2006). Modification of normalised difference water index (NDWI) to enhance open water features in remotely sensed imagery. International Journal of Remote Sensing, 27(14), 3025–3033.