Comparative Analysis of DSAS and MobiTC in Coastal Coastline Dynamics of Baguida and Agbodrafo Cantons (South-East Togo) from 1986 to 2017

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Abstract — *This study on the cartography of shoreline evolution presents a diachronic analysis of the evolution of the shoreline near the Baguida and Agbodrafo cantons of 1986 and 2017 by photo-interpretation. The problem underlying the study is the spatial and temporal dynamics of the coastline of the Baguida-Agbodrafo sector. She uses as references the instantaneous shore line. This evolution has been mapped and quantified from Landsat images exploited with the DSAS and MobiTC tools. The observed variations in the position of the instantaneous shoreline between 1986 and 2017 indicate a shoreline eroding at a high rate of about -3 m / year. These developments have not been continuous. In some points opposing dynamics could be observed.*

Keywords — *Coastal erosion; mapping; DSAS; MobiTC; GIS; Baguida-Agbodrafo;Togo.*

I. Introduction

The coastal system is a transitional environment between the continent and the sea [1]. It is a fragile and unstable space characterized by a coastline constantly in regressive evolution. That lead rapid changes characterized by the notions of submersion and erosion hazards [2] (Mallet et al., 2012). This environment, which is home to about 70% of the world's population [1] and whose cities concentrate significant economic activities [3] is in danger [4] due to coastal erosion.

Coastal erosion is a global and global phenomenon that, in a context of climate change, affects all countries that open up to the sea. In the world, 70% of their length, sandy or gravelly coasts are in declin, while only 20% are stable and only 10% in a state of progress [5]. Of the 9788 km estimated from Mauritania to Benin, 67% are of unstable and / or highly dynamic coasts, 30% less dynamic coasts and only 3% rocky coastlines [6]. Thus almost all of the West African coast has a high sensitivity to erosion [7].

On the coast of Togo, the problem of erosion follows the construction of the port of Lomé in 1967 and continues to arise acutely [8] causing human and economic losses. The erosion of the coast has caused Togo to lose two international routes in 40 years. In the perspective of an efficient integrated management of the coastal zone, methodologies and techniques including surveying, photo-interpretation and the use of imagery for which aerial and satelite photography has long been used in studies of the dynamics of the coastline. In the recent past automated tools (DSAS, MobiTC) for coastline processing have been developed. It would be interesting for scientific research to experiment with these tools for better decision-making in the management of the Togolese coast. It is with this in mind that this study is entitled: "Comparative analysis of DSAS and MobiTC in the coastal coastline dynamics of the Baguida and Agbodrafo cantons (South-East of Togo) from 1986 to 2017".

The aim of this study is to make a national cartography of the coastline evolution of the Togolese littoral using MobiTC and DSAS software for an appropriate coastal development that fits into the dural development challenge.

II. PRESENTATION OF THE STUDY AREA

Togo's coastal zone (Fig. 1) is part of the Gulf of Guinea geo-system in West Africa under a subequatorial climate with two rainy seasons and includes a sandy-clay plateau, sandy cords, two lagoons fed by two rivers, the Volta and the Mono and coastal rivers, the mangrove, the savannah [8].

The littoral zone of Togo is limited by the latitudes 6°N to the North and 6°30'N to the South, and parallels 1°E to the East and 1°50'E to the West. However, the actual study area is between longitude 6°8'0" and 6°15'0" North and latitude 1°32'0" and 1°18'0 East.

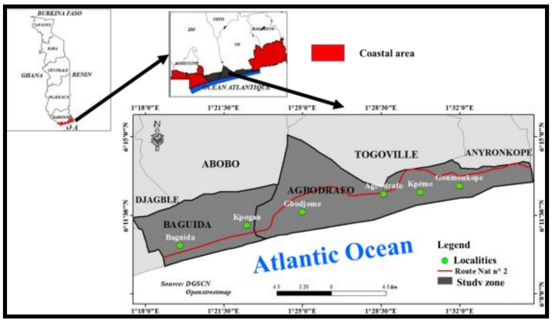

Figure 1: Location map of the study area

III. MATERIALS AND METHODS

Five Landsat images of the 192/56 scene were used for the local analysis of the coastline dynamics of the Baguida and Agbodrafo cantons. It consists of one (1) TM image, two (2) ETM + images and two (2) OLI orthorectified and georeferenced images. The material consisting of Argis, Envi, DSAS, MobiTC, Qgis and Excel was used. The research methodology includes:

- the extraction of coastlines and;
- the estimation of littoral dynamics.

A. *Extractions of shorelines*

The choice of the reference line preceded the actual treatment because there are more than a dozen reference lines embodying the position of the coastline [9]. In this study, the instantaneous shoreline is the only visible reference line. Then a radiometric correction on ENVI was applied on the different images. However, in a classical way, the detection of the instantaneous shoreline is carried out either in the near infrared [10] or in the average infrared [11] because of the low reflectance of water in the infrared range of the electromagnetic spectrum. In this study the extraction of the instantaneous shore line was carried out on the channels 5 and 2 of the TM and ETM + sensors and on the channels 6 and 3 of the OLI sensor. To accomplish such an operation, four (4) steps were necessary:

-first, in the case of Landsat TM and ETM + images, the famous B5/B2 ratio and the corresponding B6/B3 for OLI are used;

-secondly, a reclassification of images from different ratios has been done. Indeed at this level an unsupervised K-means classification is applied and selected two classes taking inspiration from the results of the band ratios;

-thirdly, a vectorization and a conversion into Shapefile of the classified images were carried out. Linear objects are obtained;

-fourthly and finally the shoreline at different dates was obtained under the ArcGis software by digitalization.

Once the different features of coast obtained, they are integrated in software DSAS and MobiTC for the computation of the coastal dynamics.

B. *Calculation of littoral dynamics*

Coastal dynamics was measured automatically through DSAS version 4.4 [12] and MobiTC [13] following transects perpendicular to the TDCs. These transects, spaced 5 m apart, are generated from a baseline. The DSAS and MobiTC tools measure the distances between the intersection points of the transects and shorelines, calculate the evolution rates along each transect and return the results in the form of attribute tables.

***1. Calculation of dynamics with DSAS software*:** Two basic steps are needed to measure coastline dynamics under the DSAS software: creation of a coastline database (geodatabase under Arcgis) and the step of measuring coastal dynamics.

- Creation of a database of shorelines

To create this database, you need to do this under Arcgis: open ArcCatalog and access the location where you want to store the data in the file tree, right-click on the folder where to store the geodatabase and Navigate to "New" and then "Custom Geodatabase" in the context menu. The database (Personal Geodatabase) created is fed by the different coastlines and an imaginary baseline.

- Statistical measurement of coastal dynamics

Once the database and input feature classes were created and properly assigned shorelines, the DSAS application was used to generate transects and calculate the evolution of the dynamics of coastlines. In this study, the transects are generated every 5 m for a fine change in the coastline. The "onshore" option for baseline positioning was chosen in the "Set / Edit default parameters" window. The values of the uncertainties were retained by default at 4.4 m.

Once the transects are created and all the updates made, the calculation of the littoral dynamics and the cartography of the rates of evolution are made on the analysis of the automatically generated attribute tables. To understand the temporal evolution of the position of the coastline, the Linear Regression Rate-of-Change (LRR) index to estimate the rate of evolution of each site over the entire study period was chosen. At the end of this step, a spatialized statistical file is obtained. This file has been reorganized in Excel for the production of graphics. Figure 3 below summarizes the methodology under DSAS.

2. Calculation of dynamics with MobiTC software:

The determination of the evolution of the coastline on MobiTC was done in four (4) fundamental stages: the preparation and formatting of coastlines, the realization of a baseline, the realization of traces and the calculation of the evolution of the coastline traced by trace. The OLS (Ordinary Least Square: linear regression by the least squares method) index is retained. OLS (under

MobiTC) and LRR (under DSAS) express linear regression.

- Preparation and formatting of shorelines

The first step is to configure the shorelines to be usable on the MobiTC software. The coastlines must have the same projection, be in mif / mid format and be named as follows: ANNEE1-MOIS1-JOUR1-ANNEE2-MOIS2-JOUR2-TDC-Fxxxxxxxx-PRJfxxx-LIMxx-LEV/NUM-ERRxxnom_projet.

- Creating a baseline for treatments

In MobiTC, this baseline is realized automatically from the set of different shorelines available, representing a kind of median. For this the principle of skeletonization has been retained.

- Realization of transect

Transect are perpendicular to the baseline. Here we defined a distance of 5 m between the long tracks each of 500 m and give an orientation towards the ground of the baseline. File 20171001T002938-Curat_TDC-Env-C010-T5000-T-S-C001Net-D0100liersimpl-Tra-P005-L0500.mif has been obtained.

- Calculation of the evolution of the coastline transect by transect

The calculation of the evolution of the shoreline traced was carried out in three (3) stages namely: calculation of intersections between coastlines and tracks, the calculation of the evolution transect by transect and the visualization in GIS of the results. The option chosen in this study is to show the evolution of the shoreline in the form of histograms.

IV. RESULTS

A. *Statistical and graphical analysis of shoreline evolution with DSAS* *(Size 10 & Bold & Italic)*

The study of coastal dynamics with the DSAS tool showed either an erosion or a fattening depending on the year studied. Indeed, from 1986 to 2017, the study showed erosion over the entire study area. To obtain this result, the erosion rate (LRR) was determined according to the transects. The negative value indicates an erosion (in orange) and the positive value a fattening (in green). The production of 6250 transects (Table I) to determine the rate of erosion (LRR) on the coasts of Baguida and Agbodrafo cantons led to a negative assessment of shoreline evolution, an average of -2.75 m/year (a loss of 85.25 m). Indeed, 96% of this fringe of the coast is eroding and 4% in fattening with an erosion rate of -2.88 m/year for 0.76 m/year of fattening rate.

TABLE I: STATISTICS GENERATED BY DSAS FROM THE BAGUIDA-AGBODRAFO STUDY AREA

Transects	baseline	Dates of shoreline	Distance	LRR (m/year)
6250	1	13/01/1986 04/04/2001 23/01/2010 25/01/2013 18/01/2017	30000	- 2.75

B. *Statistical and graphical analysis of shoreline evolution with MoboTC*

The production of 6288 transects (Table II) to determine the rate of erosion (OLS) on the coast of Baguida-Agbodrafo led to a negative assessment of shoreline evolution, ie an annual average of -2.71 m/year with a loss of 84.01 m over the study period. Indeed, 96% (Figure 3) of this fringe of the coast is eroding and 4% in fattening with an erosion rate of -2.92 m/year (a loss of 90.52 m) for 0.71 m/year (a gain of 22.01 m) of fattening rate.

TABLE II: STATISTICS GENERATED BY MOBITC OF THE BAGUIDA-AGBODRAFO STUDY AREA

Transects	baseline	Dates of shoreline	Distance	OLS (m/year)
6288	1	13/01/1986 04/04/2001 23/01/2010 25/01/2013 18/01/2017	30 000	- 2.71

C. *Graphical and statistical analysis by sectors*

Tables (III, IV) and fig. (2, 3) below summarize the erosion rate in the different sectors: Baguida-Kpogan, Kpogan-Agbodrafo and Agbodrafo-Goumoukope. The Kpogan-Agbodrafo sector has the highest erosion rate on average -4.38 m/year (DSAS) -4.32 m/year (MobiTC), a loss of about 135 m over the study period. However this rate is average on the Baguida-Kpogan sector of -2.75 m/year (DSAS) and -2.63 m/year (MobiTC) a loss of about 85 m and low on the Agbodrafo-Goumoukope sector. Indeed, in this last sector, the erosion rate is -1.50 m/year (DSAS) and -1.43 m/year (MobiTC), a loss of 47 m over the study period eroding and 4% in fattening with an erosion rate of -2.92 m/year (a loss of 90.52 m) for 0.71 m/year (a gain of 22.01 m) of fattening rate.

TABLE III: STATISTICS GENERATED BY DSAS BY SECTOR

Transect Id	Sectors	baseline	Dates of shoreline	LRR (m/year)
1393	Baguida-Kpogan	1	13/01/1986 04/04/2001	- 2,75
2098	Kpogan-Agbodrafo	1	23/01/2010 25/01/2013	- 4,38
2760	Agbodrafo-Goumoukope	1	18/01/2017	- 1,50

TABLE IV: STATISTICS GENERATED BY MobiTC BY SECTOR

Transect Id	Sectors	baseline	Dates of shoreline	OLS (m/year)

1415	Baguida-Kpogan	1	13/01/1986 04/04/2001	- 2,63
2334	Kpogan-Agbodrafo	1	23/01/2010 25/01/2013	- 4,32
2539	Agbodrafo-Goumoukope	1	18/01/2017	- 1,43

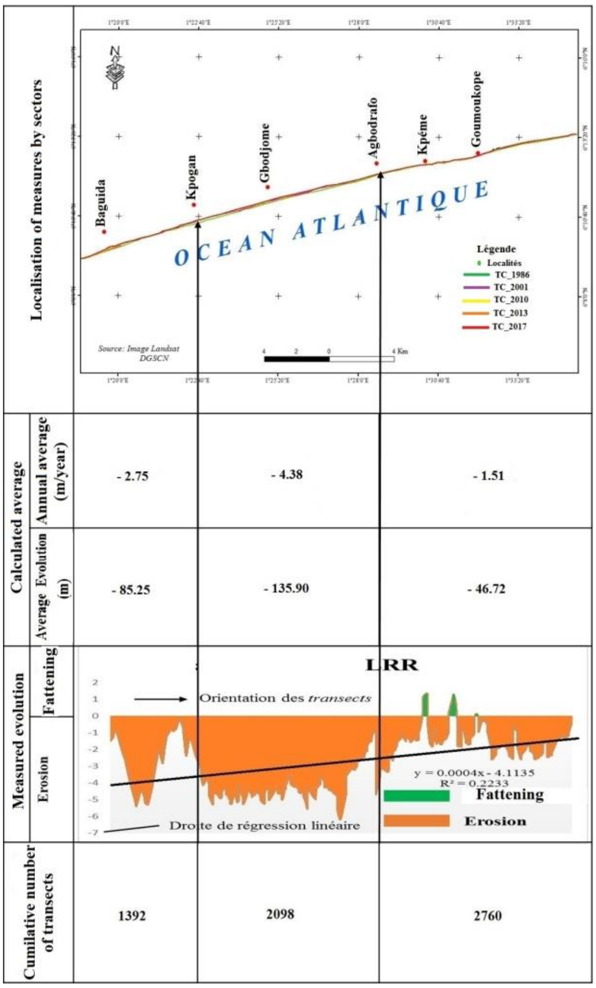

Fig. 2: Baguida-Agbodrafo shoreline erosion and fattening rate map by linear regression method (LRR)

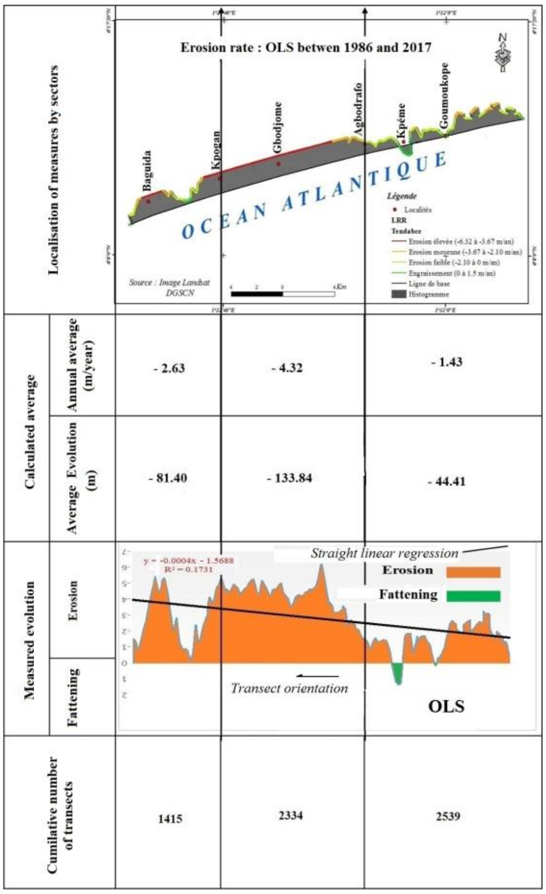

Fig. 3: Evolution of the erosion and fattening rate of the Baguida-Agbodrafo coastline sectors by the linear regression method (OLS)

D. Comparison of results from DSAS and MobiTC software

In comparison, Table V and Fig.4 show that the DSAS and MobiTC tools are designed for the same purpose: determining shoreline evolution. We got almost the same results that reflect the reality on the ground. Through Fig.4 we see that DSAS and MobiTC software highlight the same reality. For example the zone of strong erosion (red box) or that of fattening (green box) identified by MobiTC is the same at the level of DSAS and vice versa.

TABLE V: SOFTWARE STATISTICS BY DSAS AND MOBITC

Software	Transect Id	OLS (m/year)	LRR (m/year)
DASAS	6250		-2.75 (-85.23 m)
MobiTC	6288	-2.71 (-85.94 m)	

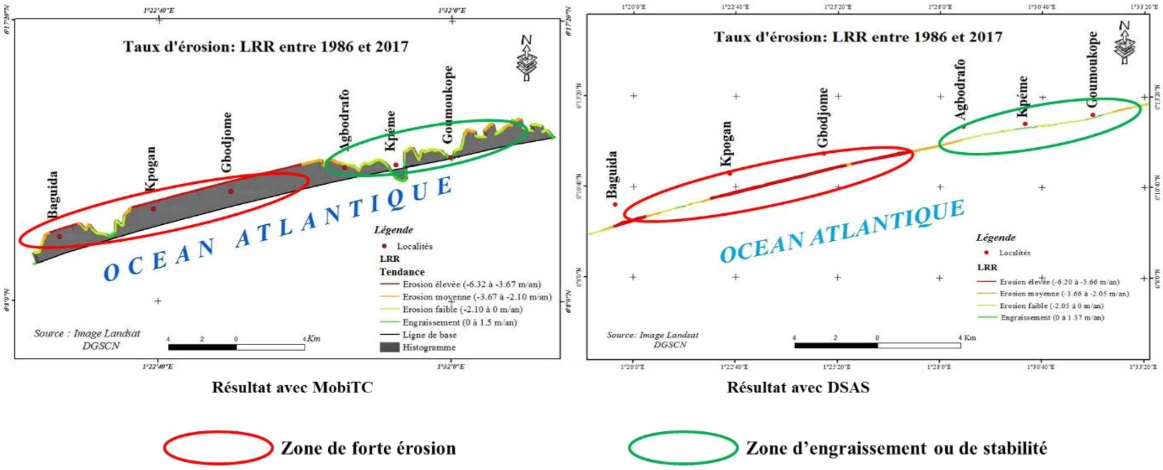

Fig. 4: Card Comparison of DSAS and MobiTC Software

V. DISCUSSION

This study on the cartography of the dynamics of the coastline is based on the use of Landsat satellite data and the geomatic approach with the compilation of coastline data from these images in DSAS and MobiTC software. Indeed, several methodologies are used in the determination of the kinematic of the coastline and none of it is unanimous because what counts is the result. Authors like Faye (2010); Louati et al. (2015); Bakayoko (2016); Yavo (2016) rely on newer and more efficient techniques for mapping the evolution of the coastline. They used satellite images, extracted the different coastlines and integrated them in the DSAS tool designed for mapping the evolution of coastlines.

For this study, the same methodology was used with the only difference that two software: DSAS and MobiTC were exploited. Through their use, the mapping of the evolution of the coastline of the study area was carried out. This mapping expresses a regressive evolution and highlights three major sets of erosion zones. The first set is characterized by a high erosion on which special attention must be paid. It is all covered by Kpogan, Gbodjome and Agbodrafo villages with an erosion rate of about 5 m. The second set is that covered by the villages Baguida and Kpogan characterized by an average erosion rate of about 3 m. The third set is that crossed by the villages Agbodrafo, Kpémé and Goumoukope with a low erosion rate of about 1.5 m. This result comforts because it reflects the reality on the ground and is consistent with the conclusions of the studies already carried out on the Togolese coast. However, there is a slight difference between erosion rates respectively -2.75 m/year for DSAS and -2.71 m/year for MobiTC. This difference, which does not alter the overall result, would be due to the creation of the baseline. It is created automatically by considering the different coastlines under MobiTC and manually by the user under DSAS. This can increase errors and uncertainties (-2.75 m/year > -2.71 m/year).

In comparison with the results of the studies carried out on the same study area, the true study of the coastal dynamics in a geomatic approach that was analyzed is that carried out by Blivi and Adjoussi in 2004. The others are studies and reports of order general about the Togolese coastal zone and all speak of a coastline retreat of the central segment of about 25 km. The results of this study confirm previous studies and report findings. However for the period 1986-2001 Blivi and Adjoussi in 2004 estimated the decline between 6-8 m/year while this study over the 1986-2017 interval estimates erosion at about 3 m/year. These divergences can be explained by the diversity of reference lines, data sources and methodological approaches used.

Finally, the erosion power of the study area can be explained by the construction of the Autonomous Port of Lomé and the presence of spikes between the villages of Kpémé and Goumoukope. These results are comforting because Bamba et al. in 2016 in a similar study on the Jacqueville-Port-Bouët coastline (Côte d'Ivoire) highlighted the erosive character of the Port-Bouët sector located east of the Vridi Canal. The trend of erosion was estimated at -1.06 m/year over the period 1998-2015. In "Evolution of the coastline in Nouakchott (Mauritania) from 1954 to 2005 by photo-interpretation" Faye et al. in 2008 also demonstrated exposure to erosion in the area east of the Autonomous Port of Nouakchott. The coast of this area has decreased by more than 500 m over the period covered by this study.

VI. CONCLUSION

This study on the cartography of the coastline dynamics in Baguida-Agbodrafo: use of DSAS tools "Digital Shoreline Analysis System" and MobiTC has for main objective the realization of a local map of the erosion for a better catch of decisions regarding coastal developments for the protection of property and people. Indeed, this work is based on an important methodical work that has been limited by the spatial resolution of the Landsat images used. However, we were able to focus our study on these. The chosen reference line is the instantaneous shoreline line that is identified on the satellite images thanks to the gray level, whose analysis of the variations of position allowed us to trace the evolution of the coastline in Baguida-Agbodrafo. It appears that the Togolese coastline in Baguida-Agbodrafo is fragile and has unstable areas and more or less stable areas. The evolutionary trend shows an advance from sea level to land with an estimated erosion rate of -2.75 m/year (DSAS) confirm by MobiTC at -2.92 m/year.

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