Shoreline Dynamics: An Assessment of Ndoni-Oguta Axis Shoreline of River Niger in the Southern Region of Nigeria

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Abstract
Shoreline is always very uncertain due to the fact that water level is always in a state of flux, constantly changing and very unstable. The Ndoni location shoreline is an all-important shoreline to the Nigerian economy. The aim of this work is to assess shoreline dynamics along the Ndoni-Oguta axis of River Niger. This work was carried out using remote sensing and geospatial techniques with relevant Landsat imageries that covers the study area. The result showed that there was an in increase in water body of about 680.3ha representing 13.46% increment of water body and a decrease of 51166.4 hectares representing 58% in the vegetation space in Ndoni. This is beside decrease in sand dunes of an area of 258.3 hectares representing 19.4%. There was an in increase in water body of about 680.3ha representing 13.46% increment of water body and a decrease of 51166.4 hectares representing 58% in the vegetation space in Ndoni. This is beside decrease in sand dunes of an area of 258.3 hectares representing 19.4%. We assert that the Ndoni-Oguta axis of River Niger shoreline has experienced significant changes in terms of geometry and pattern.

Key Words: Shoreline, remote sensing, geospatial technology, imageries, land use/cover, water body, vegetation, sand dunes etc.

1.0 Introduction

Shoreline is inherently dynamic features that mark the transition between land and river. Shoreline changes, which is refers to the gradual movement of shorelines and dune features in a landward direction, also move towards the river or sea in some cases. The causes of shoreline changes are both natural and human-induced. Shoreline is generally considered to be the edge or margin of land next to the sea or ocean.

The location of the shoreline and its changing position over time is of fundamental importance to coastal scientists and policy makers. This is also applicable to the shoreline along the River Niger, and in particular, along the Ndoni-Oguta axis in Ogba/Egbema/Ndoni in the Southern Part of Nigeria. Present day shoreline monitoring campaigns provide information about historic shoreline location and movement, and about predictions of future change [26]. More specifically the position of the shoreline in the past, at present and where it is predicted to be in the future is useful in the design of coastal protection, to calibrate and verify numerical models to assess sea level rise, map hazard zones and formulate policies to regulate coastal development. This paper seeks to identify and assess these shoreline changes and its attendant dynamics in the Ndoni-Oguta axis and its environment. Accurate and consistent delineation of the shoreline is integral to all of these tasks. The location of the shoreline also provides information regarding shoreline reorientation adjacent to structures, beach width, volume and rates of historical change.

1.1 Conceptual Background

The changes in any shoreline results to new approaches that is necessary for managing future risks. In recent times, the use of Geographical Information System (GIS) and Remote Sensing for mapping and analyzing shoreline changes over a period of time has gained prominence as high resolution satellite data have become more readily available[1]. Shoreline changes are best studied using Geographical System because of its ability to combine and compare satellite images of different epoch (years) of the same area [13]. Hence, the monitoring of shoreline changes may be derived from historical data that include topographical maps, aerial photographs and satellite images. These data can be easily combined and processed with the use of Geographical Information System giving much input for coastal planning and management.

1.2 Study Area

This study area is located in Ndoni in Ogba/ Egbema/ Ndoni in the southern region of Nigeria. The area is located on latitude 633902mN – 572127mN and longitude 219601mE – 255551mE, in the WGS84 UTM Zone 32N and is bounded with River Niger in the west and Orashi River in the east. The shoreline under study is approximately 11800.03m (11.8km) and form boundary with Ndoni towns. Ndoni is made of four major communities namely Onikwu, Agwe-Obodo, Ndoni and Obiofu, there are other settlements within these communities mentioned above which are Ase-Azaga, Isukwu, Oduri, Ugbaja, Isa-Ase-Imonite, Ogbe-Ogene, Isi-Ala, Utu-Umuoriji and Utu-Echi, these communities make it a total of twelve (12) communities in Ndoni. The climatic condition of the study area is close to that of Port Harcourt with mean temperature ranges from 30.0 - 33.0°C and annual rainfall ranges between 2100 – 4600mm as predicted by (NIMET, 2017).

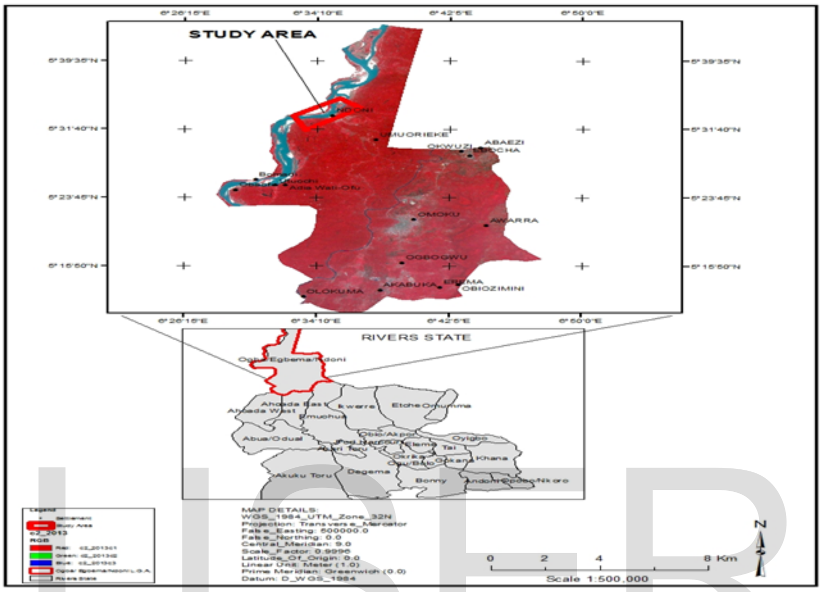

Fig. 1.1 Map of the Study Area

1.3 Shoreline Change Determination Using Remote Sensing Approach.

The purpose of this study was to determine rate-of-change of shoreline positions on a portion of River Niger (Ndoni), Rivers State, Nigeria. It was carried out using Landsat satellite images of two (2) epochs (ETM+ 2011, and 2015) as shorelines and TM 1987 as baseline image. The images have 30m x 30m spatial resolutions and were downloaded using path 189 and row 56 from the www.glovis.us.gov website. The images were process so as to attain the specifications for the research. Two of the images (ETM+ 2011 and 2017) contained gaps which were corrected during image processing using PANCROMA satellite image processing software designed for correcting gaps in remotely sensed image data. Image clipping was performed using ArcGIS 10.1 and clipping operation defines the scope of the study. After clipping, the image was resaved in TIFF file format which was loaded with spatial information in ENVI 5.0 - raster based software. Maximum likelihood classification (MLC) was performed on the composite image (band 4, 3, and 2) and four land use/land cover categories (water body, built up, vegetation and sand dune) were identified and classified after training reasonable numbers of training sites. The classification maps were converted to vector shape file in ENVI and the shape file was reopened in ArcGIS for shorelines extraction. Personal geodatabase containing feature class for shorelines and baseline was created and was used to digitize shoreline positions. The digitized shorelines were validated with the coordinates of ground truth points. The Digital Shoreline Analysis System (DSAS) was used to cast transect at 200m interval and length of 300m from the baseline. From the generated transect, shoreline change statistics which determine rate-of-change of shoreline positions was perform. The statistics selected in DSAS include; Shoreline Change Envelope (SCE), Net Shoreline Movement (NSM), and End Point Rate (EPR).

1.3.1. Software

The software used for the study includes the following;
(a) DSAS version 4.3 software was used to cast transects and compute shoreline rate-of-change [31, 27].
(b) ESRI's ArcGIS 10.1 was used to extract the shoreline and to provide interface for Digital Shoreline Analysis System (DSAS) to give statistics of the changes.
(c) ENVI 5.0 was used to performed image classification from which shoreline boundaries were extracted. The shorelines were extracted from the vectorised shoreline positions.

(d) PANCROMATM satellite image processing software was used to fill gaps [17] in the Landsat images of 2011 and 2017 respectively. The software can be purchase or obtain trial version from the website www.PANCROMA.com. This software was selected based on their needs in the study.

1.3.2 Dataset

Shoreline change (SC) of a portion of River Niger (Ndoni River) was carried out using Landsat satellite imageries obtained at different epochs and settlement data.
(a) Landsat satellite image which was downloaded free of charge from its website (http://glovis.usgs.gov/) after completion of registration as research student. The images were downloaded in zip (compressed) format using path 189 and row 56 image scenes.
(b) Settlement data was obtained from the Office of the Surveyor General of the Federation (OSGOF) - one of the clearing houses in Nigeria. The settlement data was collected in soft copy and as such scanning, geo-referencing, and digitization was not needed. The characteristics of the satellite images used were shown in the table 1.1 below.

Table 1.1 Characteristics of Satellite Images Used.

Sensor	Path/ Raw	Date	Resolution (m)	Band	Product Level
Landsat TM	189/ 56	12-21-1987	30m	B432	L1T
Landsat ETM+	188/ 56	12-02-2011	30m	B432	L1T
Landsat ETM+	188/ 56	12-23-2017	30m	B432	L1T

NOTE: TM= Thematic Mapper, ETM+= Enhanced Thematic Mapper Plus.

1.4 Methods and Processing

The following processes and methods were carried on the imageries to obtain optimal result in line with the aim of this research. They include geo-referencing satellite imageries using ground truthing coordinates, also composite and classification of images. In this study, three bands (infrared, red, green) for each Landsat were used to form composite image of the study area.

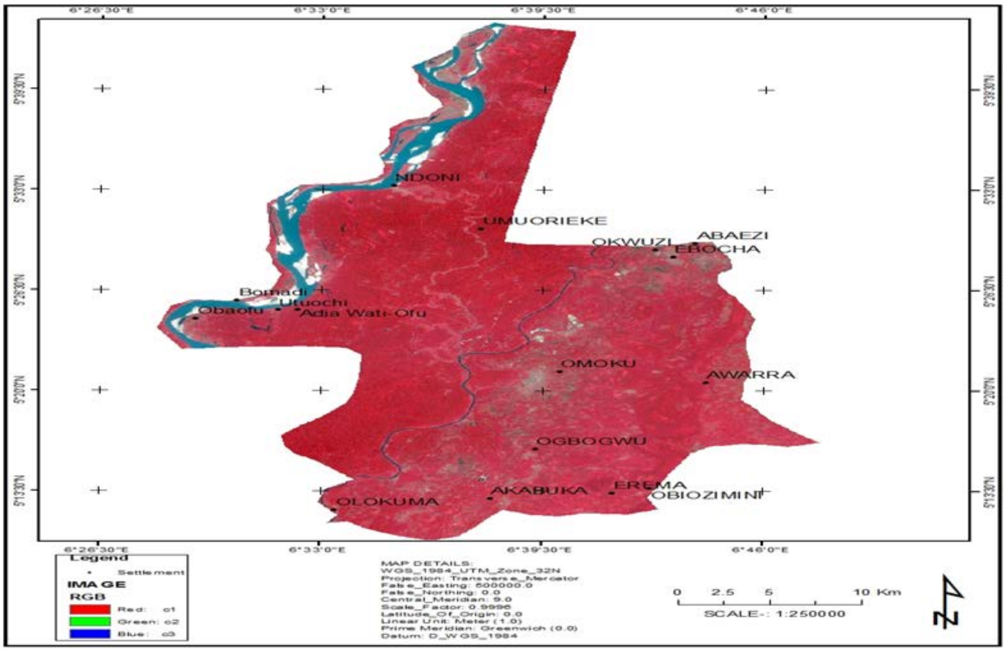

Fig. 1.2: Composite image of 1987 Adopted as Baseline.

1.4.1. Generation of Transect and Rate Statistics

The transect parameters were set in the set and edit dialogue box. The transect spacing (interval along baseline) of 200m and length of 300m was selected. The transect spacing of 200m was selected so that minimum number is required to cover the area. The reported transect was then used to calculate rate-of-change statistics using the statistics toolbar of the Digital Shoreline Analysis System (DSAS). The statistics generated transect intersection and transect rate table are reported in the geo-database. Graphs were also produced from the generated tables.

1.5 Results Presentation and Data Analysis

1.5.1 Land Use/ Land Cover Change

The classification map obtained from MLC for each image is shown in figure 1.3 to 1.5 below. Image classification was carried out in other to established vegetation lines adopted as shoreline boundaries.

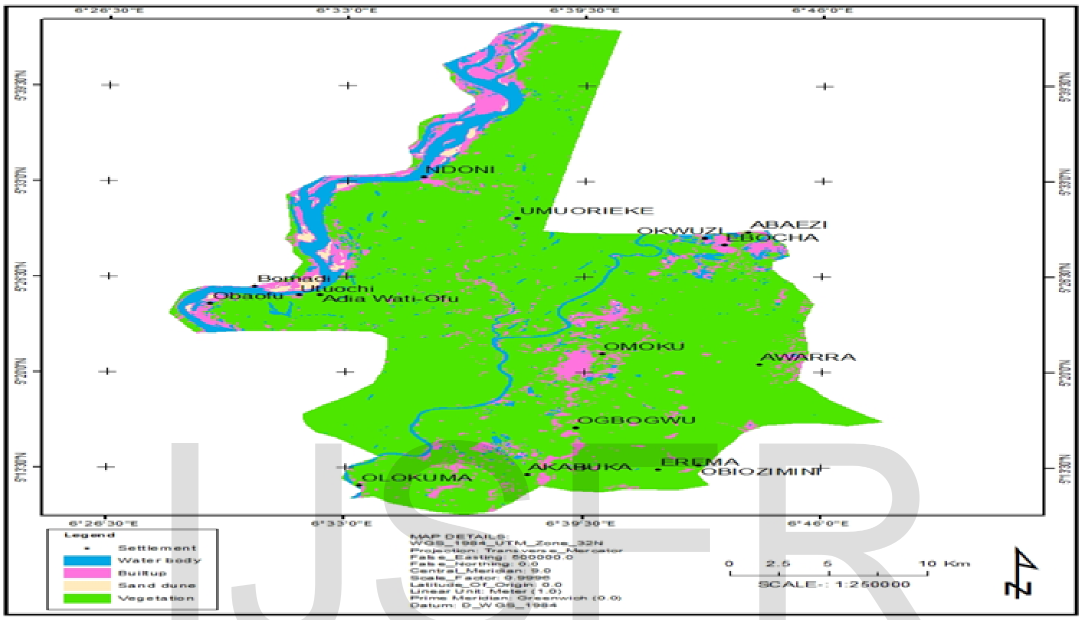

Fig. 1.3: Classification map of Landsat TM 1987 used as baseline.

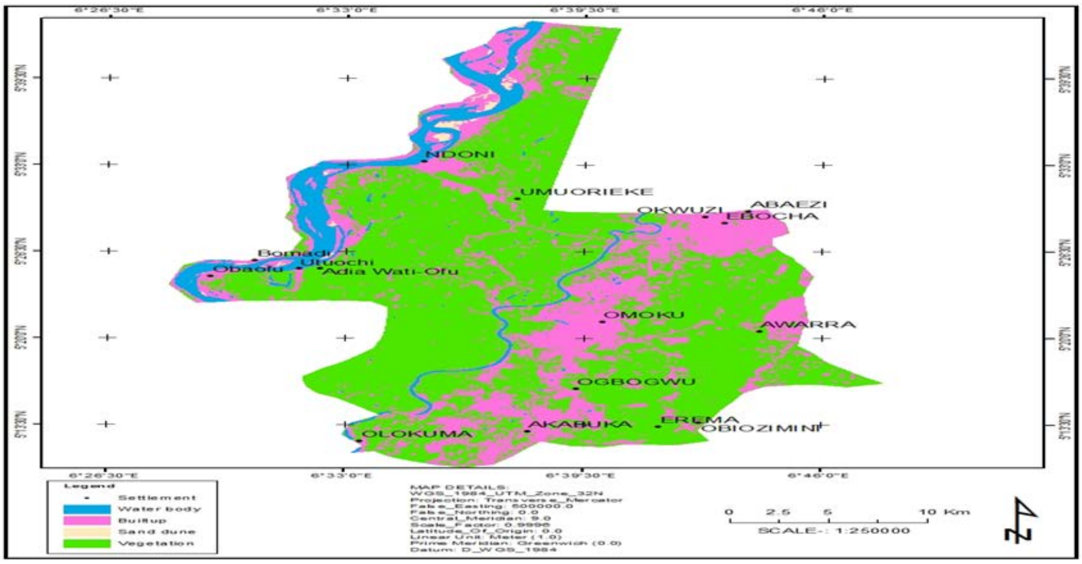

Fig. 1.4: Classification map of Landsat ETM+ 2011.

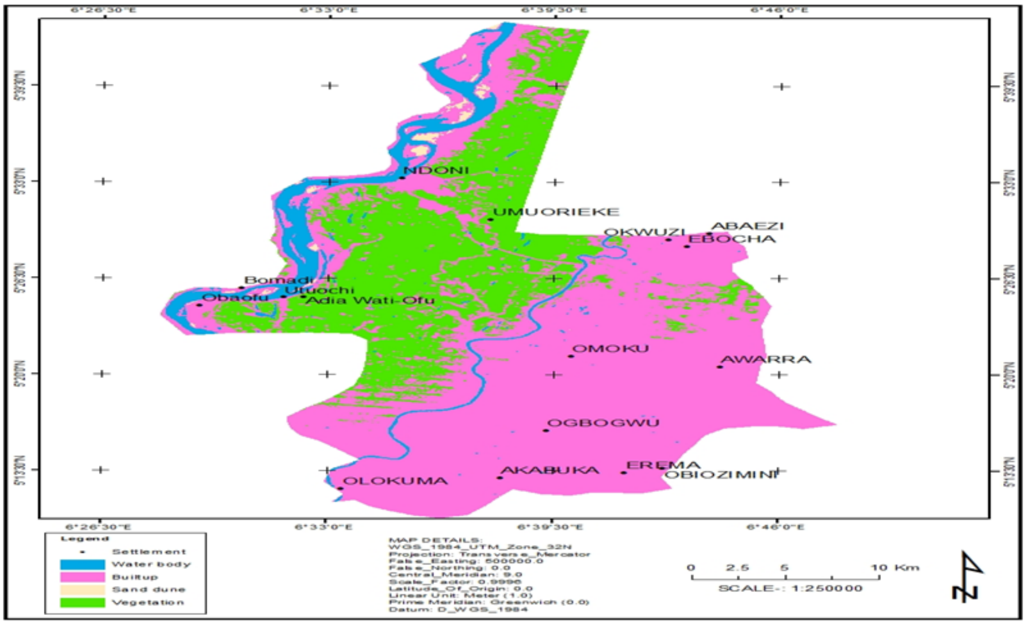

Fig. 1.5: Classification map of Landsat ETM+ 2017.

Table 1.2: Total Area in Hectares per Class of the Classification Map

LU/LC	1987(ha)	2011(ha)	2017(ha)
Water body	5054.2	5309.8	5734.5
Built-up	6962.8	19366.0	27907.3
Vegetation	88811.2	75754.9	37644.7
Sand dune	1328.5	925.9	1070.2
Cloud cover	NA	NA	NA

Table 1.2 above represents the changes in land use and land cover in Ndoni communities; it is observed that from 1987 which is our baseline for this research to 2017, there is an increase in water body of about 680.3ha representing 13.46% increment of water body in the Ndoni-Oguta axis of River Niger.

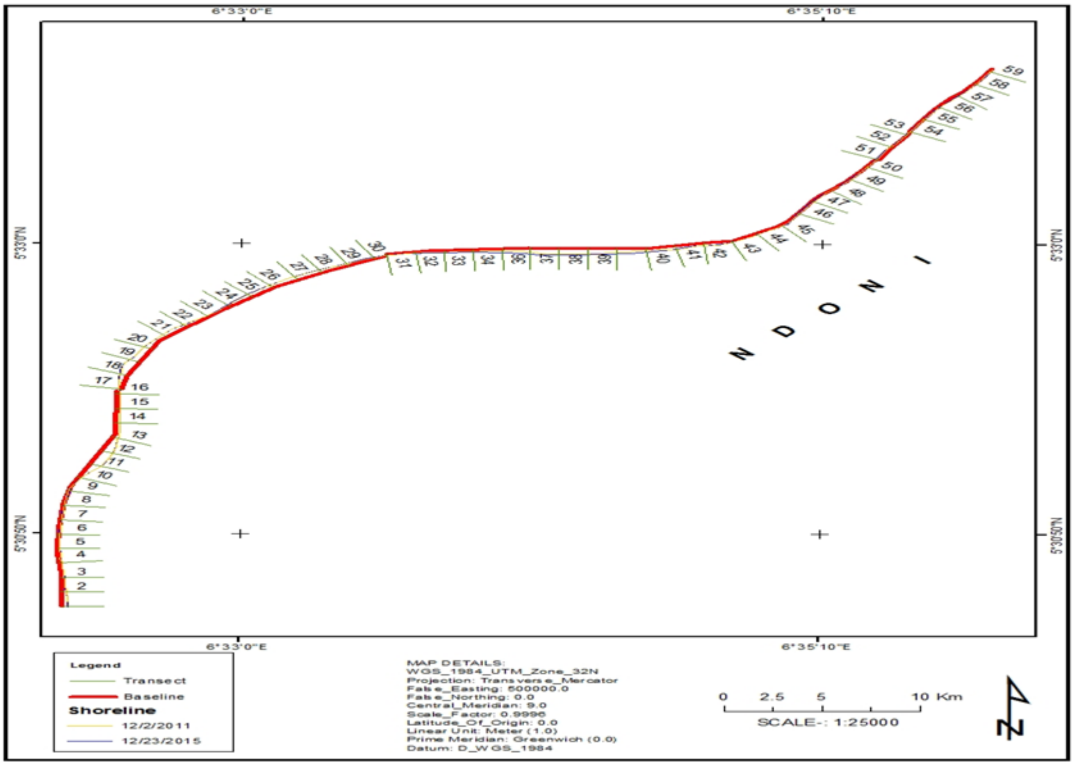

Fig. 1.6: Shoreline Rate-of-Change Map

Figure 1.6 below shows the shorelines transect from the baseline and the baseline produced by DSAS software. The map model is made up of two shorelines represented by different colours, one baseline in red colour, and a total of 59 transects shown in dark green. The transect table also contained object identifier, baseline ID, transect order, process time, start and end coordinates at each shoreline intersection, and the azimuth showing the orientation of the transect.

Table 1.4 Report of a Specimen Section of Transects Intersection on Shoreline.

OBJECTID	TransectId	BaselineId	ShorelineId	Distance	IntersectX	IntersectY
1	2	1	12/2/2011	-32.4288	227354.6	609216.6
2	2	1	12/23/2017	-35.4915	227357.7	609216.6
3	3	1	12/2/2011	-17.7402	227339.6	609416.6
4	3	1	12/23/2017	-19.6943	227341.5	609416.6
5	4	1	12/2/2011	-13.401	227323.6	609617.4
6	4	1	12/23/2017	-13.553	227323.8	609617.4
21	12	1	12/2/2011	-89.3288	227674.8	611130.7
72	37	3	12/23/2017	-90.599	230760.3	613859.3

From table 1.4 above, it shows that there is a change of -89.329m in transect 12 between 1987 to 2011, there is also a change of -90.599m in transect 37 between 1987 to 2017. Which means the Ndoni shoreline is experiencing erosion (recession).

From the same table, transect 20; it is observed that the Ndoni shoreline is experiencing accretion between 1987 to 2011 and 2017. The changes are 79.170m for 2011 and 77.519m for 2017. Subsequently, there is also an increase of about 21744.5ha in built up areas in Ndoni, representing over 353% increment of built up area while in vegetation we have a reduction of -51166.4ha representing -58% reductions in vegetation of Ndoni community. In addition, there are also changes in sand dune of -258.3ha representing 19.4% reduction in sand dune in Ndoni communities.

Table 1.5: Specimen Portion of Transects Rate-of-Change Shoreline.

OBJECTID	TransectId	TCD	EPR	ECI	SCE	NSM	LMS
1	2	200	-0.76	1.112	3.06	-3.06	-0.76
2	3	400	-0.48	1.112	1.95	-1.95	-0.49
3	4	600	-0.04	1.112	0.15	-0.15	-0.03
4	5	800	-0.03	1.112	0.12	-0.12	-0.03
5	6	1000	-0.28	1.112	1.14	-1.14	-0.29
35	36	7000	-6.26	1.112	25.42	-25.42	-6.31
46	47	9200	3.06	1.112	12.41	12.41	3.08

From table 1.5, at transect Id 36, TCD 7000m from the beginning of shoreline, EPR was -6.26m/yr, SCE 25.42m and NSM -25.42m respectively. The EPR -6.26m/yr indicates shoreline accretion at this transect Id from 2011 to 2017 shoreline. Similarly, transect Id 47 with TCD 9200m from the beginning of shoreline, EPR 3.06m/yr, SCE 12.41m and NSM 12.41m respectively. At this transect the shoreline exhibited erosion.

Figures 1.7 – 1.9 below is the graph of End Point Rate (EPR), Shoreline Change Envelop (SCE), and Net Shoreline Movement (NSM) generated from DSAS software. The graphs depict the numbers of count of change in the shoreline geometry.

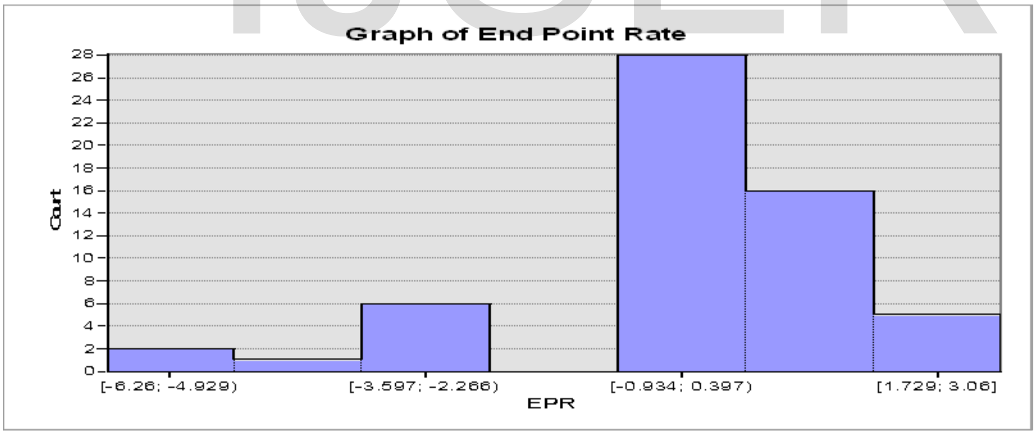

Fig. 1.7: End Point Rate Generated from DSAS.

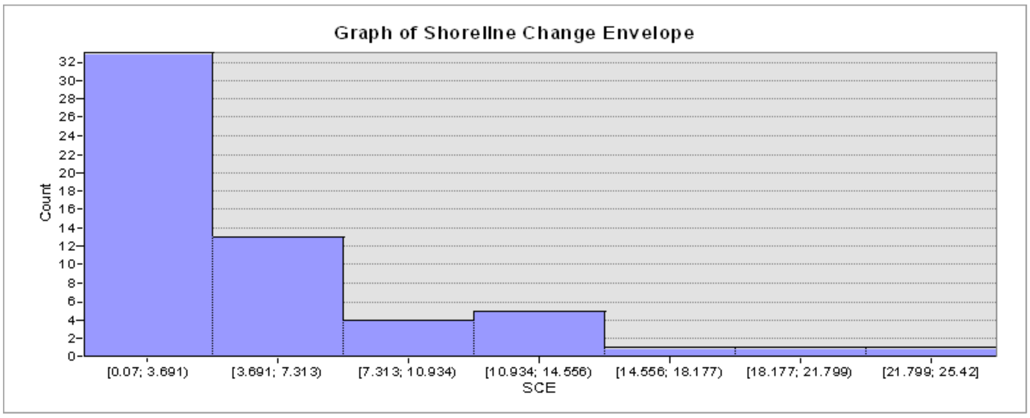

Fig. 1.8: Shoreline Change Envelope Generated from DSAS.

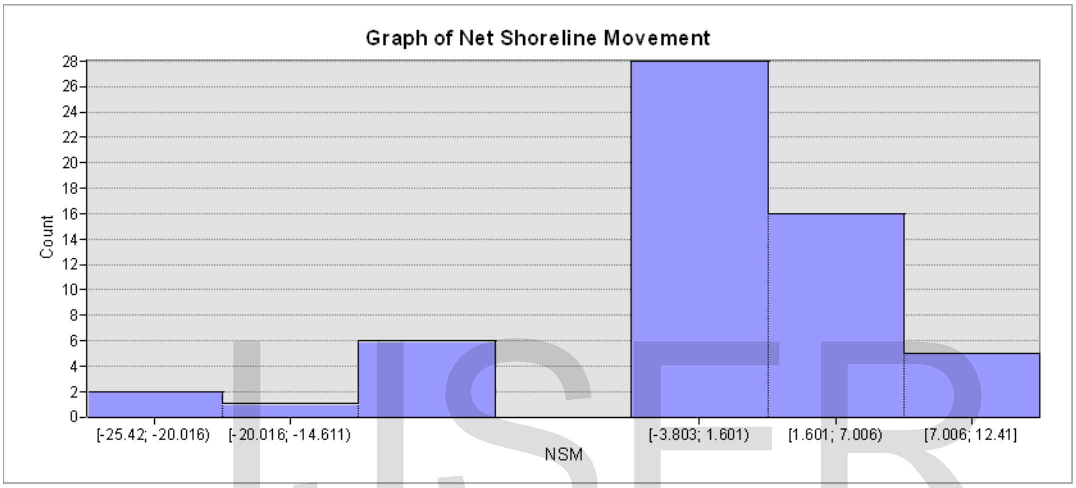

Fig. 1.9: Net Shoreline Movement Generated from DSAS.

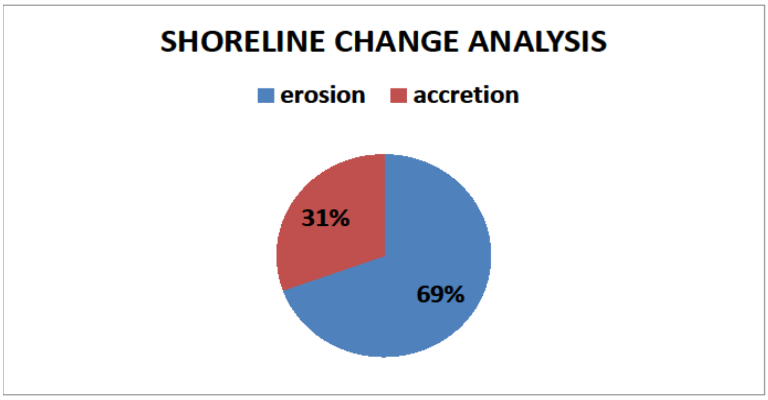

Fig. 1.10: Percentage Change

1.6 Conclusion

The Nigerian shoreline is a very dynamic one and for that reason there is the need to pay proper attention to the shoreline processes ongoing along our rivers with the view of controlling the impact of human and natural activities that is changing the face of our ever dynamic shoreline. The study thus far has shown the state of the Ndoni-Oguta axis of the River Niger shoreline, which is very dynamic. The shoreline has been found to be eroding away at greater rate than accretion. It is therefore pertinent for adequate remediation measures to be put in place to curtail these incessant changes in the form of eroding of the shoreline of Ndoni. The Ndoni location shoreline is an all-important shoreline to the Nigerian economy; this is because it hosts most of the important

Oil and Gas installations for the Multi-National Companies such as Nigerian Agip Oil Company (NAOC), Total Nigeria Limited, operators of the NNPC Joint ventures which the Nigerian Economy depends on. To this end therefore, we advocate for speedy implementation of the shoreline protection project as enunciated by the government in addition to the Dredging of Ndoni River is very paramount because it will increase the depth of the River to accommodate more volume of water, thereby reducing the effect of longshore current in the littoral zone of Ndoni shoreline.

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