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Assessment of Shoreline Dynamics at Bonny Island, Nigeria using Geospatial Techniques

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ABSTRACT

Bonny Island is a highly dynamic one as there is a high level of interplay between the forces of erosion and accretion. From previous studies by the Nigerian Institute for Oceanography and Marine Research (NIOMR), the annual rate of erosion has been put at about 20 – 35 metres along the bonny shoreline. This claim was confirmed from the present study carried out along 12 transect points of 500 metres intervals along the Finima section of the Bonny beach. Geospatial techniques were used to carry out the assessment of the state of the bonny shoreline. Satellite imageries from 1976 – 2005 were used in the study and GPS receiver was also used to acquire the shoreline position along the transect points for 2011. From the result of the study, the Finima beach area was found to have the highest rate of shoreline dynamics. Erosion dominated in this area over accretion. This area experienced a total land area loss of 458.04 hectares of land out of which erosion and accretion recorded 280.47 and 177.57 hectares respectively. By this it means erosion claimed about 61.2% of the total land area while accretion recorded a 39.8% land increase. The changes were largely attributed to the presence of oil exploration activities as prior to the commencement of this anthropogenic activities there was lesser impacts of erosion as accretion predominated the area. There is therefore a cogent need to adopt some proactive measures to protect the bonny beach, from further land loss due to erosion and the untold hardship it brings to the coastal residents.
Keywords: Nigeria, Bonny Island, Shorelines Dynamics, GIS, Remote Sensing and Global Positioning System

I. INTRODUCTION

Coastline change is a global phenomenon; it has been in operation for as long as the ocean and land existed. It has occurred in varying degrees around the globe with some areas more vulnerable to these changes than others. Nigeria is not spared from these global phenomenon it has had its own share from the time past. The processes are still in operation till date. The construction of oil refineries and wells, gas and oil pipelines, storage tanks with insufficient setbacks have been a main cause for erosion in the coastal towns of Nigeria (GEF, 2002). The retreat of Nigerian shorelines threatens most of the coastal settlements, recreational grounds and oil export handling facilities which are almost invariably located in coastal towns such as Brass, Bonny, Ibeno-Eket, and Forcados (Ibe and Antia, 1983).

The rates of erosion at 10 stations established along the Nigerian coastline, was determined by NIOMR in 1995. Erosion was found to be most dominant at Bar Beach, Victoria Island, with rates ranging between 25 and 70 metres per annum. Awoye beach on the low-lying Mahin mud-beach in Ondo State recorded 27 metres of erosion. Slight accretion was recorded at the Ugbogoro/Escravos beach. The erosion rate for Bonny was also recorded it was quite high ranging between 20-35metres per annum near the LNG site (NIOMR, 1995). Ibe further confirmed the erosion rate at Bonny station to be ranging between 20-24metres annually.

In Nigeria, there has not been a sustained effort in the study of the national coastline. This has led to the poor management and continuous degradation of the nation's coastline. The major reason for this dearth of studies in this all important area has been provided by Awosike, 1992. According to Awosike "Data acquisition programme for parameters such as winds, nearshore currents, bathymetry and so related to defining beach states are expensive". Developing nations are therefore unable to provide an adequate data pool for studies on shoreline dynamics and coastal management (Hayes, 1984; Awosika, 1992).

In recent time the use of geospatial techniques have been proven to be an extremely useful approach for the studies of shoreline changes, due to synoptic and repetitive data coverage, high resolution, multispectral satellite imageries and its cost effectiveness in comparison to conventional techniques. It is against this backdrop that this study employed geospatial techniques to analyse shoreline dynamics along Bonny Coastline covering a period of about 35years (1976-2011) using three sets of satellite imageries (Landsat MSS, Landsat ETM+ and Spot).

Ground truthing of identified shoreline changes from the imageries were carried out to establish the extent of change.

A. Objectives of the Study

The aim of this research was to analyze trend of shoreline changes along the Bonny coastline over the past 30 years, using geospatial techniques.
The specific objectives of this study are to:

- Estimate shoreline changes (displacement and configuration) in study area over the past 30 years using geospatial models
- Determine the factors responsible for the observed changes occurring along the bonny shoreline.
- Produce a map of shoreline change in the area.
- Recommend appropriate remediation and shoreline management best practices for the area

B. Hypothesis of the Study

H_o: There has been no significant change along the Bonny shoreline over the past 30 years.
H_1: there has been a significant change along the Bonny shoreline over the past 30 years.

C. Significance of the Study

The research reveals the shoreline dynamics along the Bonny coastline in recent times. This achievement would further enhance the effective monitoring and mitigations of the changes that is ongoing in the area.
Furthermore, the result of this research will provide more information for future research on shoreline dynamics.

D. Assumptions of the Study

The following assumptions are made for this research with the hope of all things been equal.

- That the terrain would be easily accessible for the research
- The finance would be made readily available at the time of the research.

E. Study Area

Geographic Location

Bonny Island is situated at the southern edge of Rivers State in the eastern Niger Delta region of Nigeria. It was formally known as Ibani or Ubani town. It lies along the Bonny River (eastern distributaries and 6 miles upstream from the Bight of Biafra. It is located at latitude 4^0 26' 57''N and 4^0 31' 42'' longitude 7^0 3' 8.1'' and 7^0 9' 38''. The Bonny River flows in a southeasterly direction into a large body of water which also flows almost vertically and slightly southeasterly into the Bight of Bonny. It runs in between the two neighboring estuaries of the New Calabar River to the west and the Andoni River to the east. The Cawthome channel links the New Calabar channel and Bonny River estuary. Bonny covers a total land area of about 651.20km^2

II. METHODS AND MATERIAL

A. Research Design

This study concerns itself with the assessment of the rate of shoreline dynamics at Bonny Island within 1976-2011 (i.e. 35years period). Research design as described by Baridam (2001) is "a frame-work or plan that is used as a guide in collecting and analyzing the data for a study. It is a model of proof that allows the researcher to draw inferences concerning casual relations among the variables under investigation". With this in mind the study adopted the One-Shot Case Study Correlational Research Design. Some elements of judgment sampling were also employed in the cause of data collection. Data derived where analyzed using geospatial techniques to assess the rate of change in the shoreline at Bonny Island.

B. Research Population and Sample Size

This study was focused mainly on assessing the shoreline dynamics along the Finima Coastline in Bonny town, stretching from Amariari-Kiri area to the LNG Residential Area (RA). The study area is located at the south-western part of the Bonny Coast (Fig.1). This area covering an approximate distance of 6km was chosen purposively for the study because it was observed to have the highest rate of erosion when compared to the other parts of the Bonny shoreline. Finita-Singi settlement being the high point of erosion activities within the 6km study area was selected for the purpose of administering of questionnaire.

The sample size for the study was based on the availability of data for the study in line with the study objectives. Based on availability of data especially satellite imagery the sample size was restricted to a period of 35 years. Satellite data for the year 1976 to 2005 was available in addition with the GPS transect data acquired from the field in 2011. Although data for equal year interval were not readily available due to some factors some of which include cloud cover on some of the satellite imageries which made it unfit for the accurate delineation of the shoreline of the study area.

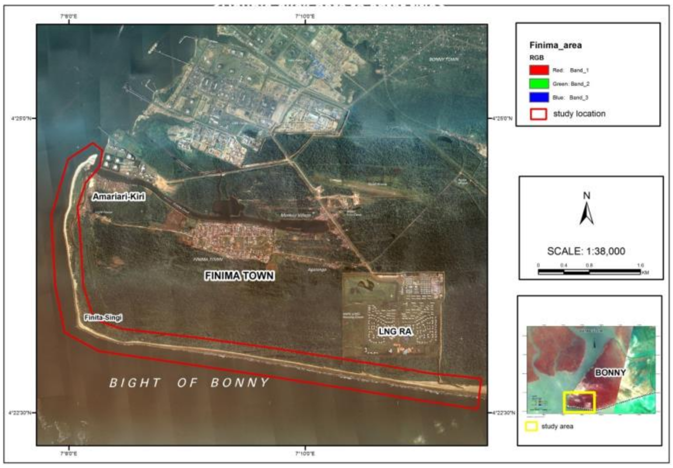

Figure 1 : Finima area showing the study location from Amariari-Kiri to LNG RA beach

Also the high costs of acquiring some of these satellite data were also responsible for the inconsistency in the datasets.

C. Sample Design

The sample design employed in this research was The Grid Cell/Transect Design. The entire shoreline area was gridded, using a grid cell of 500meter interval. A transects was placed at every 500meter interval beginning from the west bank of the southern part of the Bonny Island to the edge of the eastern bank which are all adjacent to the Atlantic Ocean. The total length of the study area was approx. 6km. A total of 12 transects was taken and measurement was carried out at each transect points within the 500meter zone.

The shorelines measured include 1976, 1986, 2000, 2004 and 2005 shorelines delineated from their respective images. The 1976 shoreline was used as the baseline upon which the other shorelines were compared and measured. GPS shoreline positions for 2011 were acquired along the 500m transect locations. The Measurements took place within ArcGIS software.
Fig.2 below shows the gridded shorelines of the study area.

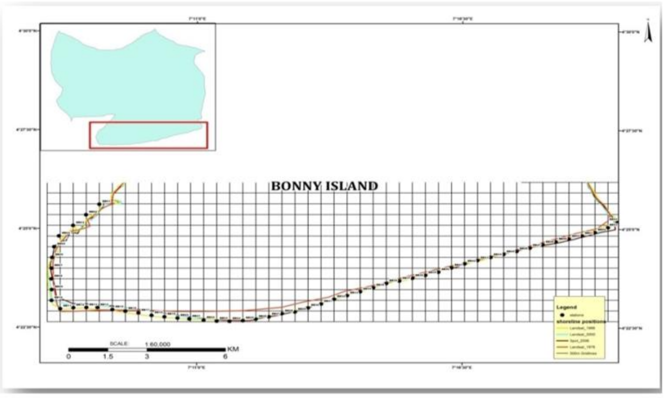

Figure 2: shorelines of the study area showing the grid cell approach used

D. Data Collection and Processing

This study employed both secondary and primary data. The following approaches were utilised to acquire the data for the analysis.

1) Geographic Information System (GIS) & Remote Sensing approach

ArcGIS 9.3 software was used to handle all the GIS processes. The shoreline data from the satellite imageries were extracted for the project. Methods such as georeferencing, creation of a geodatabase and vectorisation were all employed to generate the shorelines for measurement of the change. Using the 1976 shoreline as the baseline all other shorelines were measured for change along the 12 transects points. The measurement tool in ArcGIS 9.3 was used to execute the measurements. A repeated measurement was carried out and the mean was determined. This was to enhance the precision of the measure shorelines

ERDAS Imagine 9.3 software was used to handle all the satellite imagery processing. The bands were stacked in the order of 4+3+2 to form false colour composite.

2) Global Positioning Systems (GPS) Mapping

GPS data for the current shoreline positions were acquired from the study area using a Garmin 12 dual frequency hand-held GPS. The XY coordinates were taken at a regular interval of 500m along the Finima beach area. GPS readings were taken at the same transects points identified from the satellite imageries so as to remove any form of errors that would arise during the analysis of results. The total transect points were 12 and GPS coordinates were all taken at each of them. The data so acquired enable the mapping of the 2011 shoreline position in the ArcGIS 9.3 environment in addition to the previous shoreline positions derived from the satellite imageries.

3) Other Data Collected

Digital photographs showing evidence of shoreline dynamics in the study area were acquired. The photographs were taken at all the 12 transect points. The pictures show areas of erosion and accretion.

The Photographs acquired along the 12 transect points are shown in Plate.1 to 12 below.

Plate 1 Photo at transect 1 (T1) showing erosion site

Plate 2 Photo at transect 2 (T2) showing erosion site

Plate 3 Photo at transect 3 (T3) showing a fishing boats at Finita-Singi

Plate 4 Photo at transect 4 (T4) showing erosion site

Plate 5 Photo at transect 5 (T5) showing an estuary with active erosion

Plate 6 Photo at transect 6 (T6) showing accretion site

Plate 7 Photo at transect 7 (T7) showing erosion site

Plate 8 Photo at transect 8 (T8) showing active erosion site

Plate 9 Photo at transect 9 (T9) showing erosion site

Plate 10 Photo at transect 10 (T10) showing erosion site

Plate 11 Photo at transect 11 (T11) showing erosion site

Plate 12 Photo at transect 12 (T12) showing erosion site

E. Statistical Analysis/Hypothesis Testing

The statistical method of analysis used was the Analysis of Variance (ANOVA). The ANOVA was used to test for differences in the means of the shoreline datasets (1976-1986, 1986-2000, 2000-2005 and 2005-2011).

4) Analysis of Variance (ANOVA)

ANOVA was used to test the hypothesis of the study. The Null hypothesis states that there is no significant change of shoreline along the Bonny Coastline over the past 30 years. The ANOVA table is shown below in Table 1.

Table 1 Analysis of Variance Format for the shoreline studies

In the comparison of the means over the k periods the null hypothesis is stated as:

$H_0: \bar{a}_1 = \bar{a}_2 = \bar{a}_3 = \bar{a}_4 = \bar{a}_n$

$H_1: \bar{a}_1 \neq \bar{a}_2 \neq \bar{a}_3 \neq \bar{a}_4 \neq \bar{a}_n$

The symbol ($\bar{a}$) in the null and alternate hypothesis above represents the means of the different periods. Analysis of variance sets out to compare these means by partitioning variance of dataset from x_1 and y_1 was calculated into two components; viz those that are due to within sample differences and those that are due to variations between samples. Snedecor's F statistics is then computed by comparing the variance due to the two components, also referred to as Error of sum of squares (ESS) and between variables sum of squares (BSS) respectively. Let these be represented by ESS and BSS respectively while the total variance of sum of squares is represented by TSS.

Then, TSS = ESS + BSS

ESS = TSS – BSS

$$TSS = \frac{\Sigma\Sigma\, x^2 jk}{j\ k} - \frac{(\Sigma\Sigma xjk)^2}{N}$$

$$BSS = \Sigma \frac{(\Sigma\, xjk)^2}{j\ k\ n} - \frac{(\Sigma\ \Sigma\, xjk)^2}{j\ k\ N}$$

Table 2 Analysis of Variance Format for the shoreline studies

Location	PERIODS							
	1976-1986		1986-2000		2000-2005		2005-2011	
	Erosion (m)	Accretion (m)	Erosion (m)	Accretion (m)	Erosion (m)	Accretion (m)	Erosion (m)	Accretion (m)
A	X_{11}	Y_{11}	X_{21}	Y_{21}	X_{31}	Y_{31}	X_{41}	Y_{41}
B	X_{12}	Y_{12}	X_{22}	Y_{22}	X_{32}	Y_{32}	X_{42}	Y_{42}
C	X_{13}	Y_{13}	X_{23}	Y_{23}	X_{33}	Y_{33}	X_{43}	Y_{43}
N	X_{1n}	Y_{1n}	X_{2n}	Y_{2n}	X_{3n}	Y_{3n}	X_{4n}	Y_{4n}

X = Erosion Y = Accretion

Table 3 Sums of x and y and sums of square

Locations	PERIODS							
	1976-1986		1986-2000		2000-2005		2005-2011	
	Erosion (m)	Accretion (m)	Erosion (m)	Accretion (m)	Erosion (m)	Accretion (m)	Erosion (m)	Accretion (m)
Sum of x ,y	$\sum x_1$	$\sum y_1$	$\sum x_2$	$\sum y_2$	$\sum x_3$	$\sum y_3$	$\sum x_4$	$\sum y_4$
Sum of x, y squared	$\sum x^2_1$	$\sum y^2_1$	$\sum x^2_2$	$\sum y^2_2$	$\sum x^2_3$	$\sum y^2_3$	$\sum x^2_4$	$\sum x^2_4$

III. RESULT AND DISCUSSION

A. Shoreline Dynamics along Finima Coastline

The data on shoreline changes along section of the Bonny Coastline is presented herein in four different epochs. The extent of shoreline changes were determined through image analyses and field measurement carried out along the 12 transect points established along the shoreline of the Finima beach area. Below are the results of the analysis carried out in the study area within the 1976-2011.

1) *Shoreline Trend Within 1976-1986 periods:*

Table.3 below shows the trend of shoreline change within 1976-1986

Table 4 Showing trend of shoreline change within 1976-1986.

S/N	Locations	Period 1975-1986			
		Erosion (hectares)	%	Accretion (hectares)	%
1	Lighthouse area/ T1	-	-	7.2	10.7
2	Finita-Singi settlement/T2	-	-	10.2	15.1
3	Finita-Singi area/ T3	-	-	10.5	15.6
4	Finita-Singi Area/ T4	-	-	10	14.8
5	Finita-Singi Area/ T5	-	-	4.7	7.0
6	Finita-Singi Area/ T6	5.9	36.0	-	-
7	Finita-Singi Area/ T7	6.5	39.6	-	-
8	Finita-Singi Area/ T8	3.4	20.7	-	-
9	Finita-Singi Area/ T9	0.6	3.7	-	-
10	Near NLNG RA1 beach/ T10	-	-	4	5.9
11	NLNG RA1 beach/ T11	-	-	8.6	12.7
12	NLNG RA1 beach area/ T12	-	-	12.3	18.2
13	Total	16.4	100	67.5	100

(Source: Author's work)

From Table.3 above erosion occurred at only four locations (T6, T7, T8 and T9) this claimed 16.4 hectares of land area. The highest land loss was recorded at Transect T7 around the Finita-Singi area. The areal land loss at this point was approximately 6.5 hectares of land representing 39.6% of the total land loss within the period. Transect T6 within Finita-Singi area recorded land loss of approximately 5.9 hectares of land representing 36.0% of the total land loss within the same period. The other areas are; T8 and T9 which recorded 3.4 and 0.6 hectares land loss respectively. Besides the four locations mentioned above, the rest locations recorded accretions. Fig.3 below shows the chart of the shoreline changes within 1976-1986.

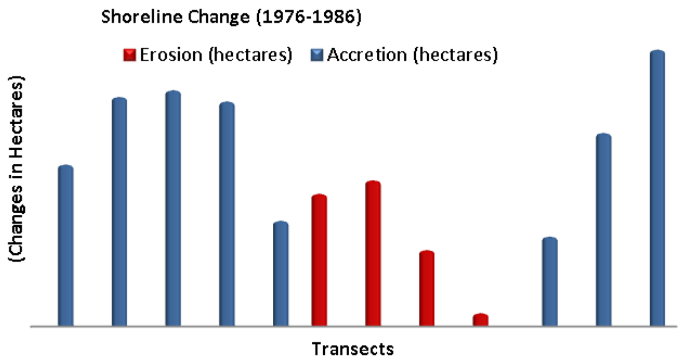

Figure 3 : shoreline change trend along Finima beach area within 1976-1986 periods

The total annual change within this period was recorded as 36.6m from the result of the analysis done in the previous sections. This result agrees with the result of the research carried out by NIOMR, 1995 which showed an annual land loss of 35metres around the LNG site. The highest annual land loss was recorded at Transect T6 with 13 hectares representing 35.5%.

A total of 67.5 hectares of land was gained representing 80.45% of the general shoreline change within this period. The highest point of accretion was at NLNG RA1 beach area (T12) which recorded 12.3 hectares representing 18.2% gain in land area. Overall 8 locations out of the 12 transect points experienced accretion i.e. land gain.

The map below (Fig.4) shows the shoreline change within the 1976 – 1986 epochs.

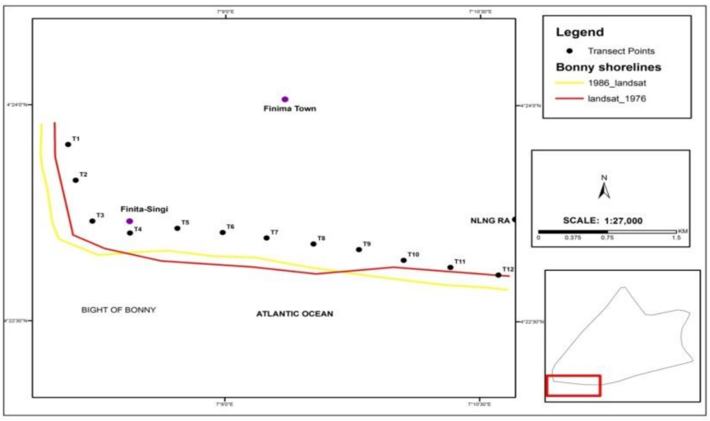

Figure 4 : showing shoreline map of the 1975-1986 period

2) *Shoreline Trend within 1986-2000 periods*

The result of the shoreline trend within this period is presented below.

Table 5 Shoreline change trend within 1986-2000

S/N	Locations	Period 1986-2000			
		Erosion (Hectares)	%	Accretion (Hectares)	%
1	Lighthouse area/ T1	10	10.1	0	0
2	Finita-Singi settlement/T2	3.9	4.0	0	0
3	Finita-Singi area/ T3	2.7	2.7	0	0
4	Finita-Singi Area/ T4	6.4	6.5	0	0
5	Finita-Singi Area/ T5	12.1	12.3	0	0
6	Finita-Singi Area/ T6	6.2	6.3	0	0
7	Finita-Singi Area/ T7	7.6	7.5	0	0
8	Finita-Singi Area/ T8	7.8	7.9	0	0
9	Finita-Singi Area/ T9	10.1	10.2	0	0
10	Near NLNG RA1 beach/ T10	11.3	11.4	0	0
11	NLNG RA1 beach/ T11	11	11.1	0	0
12	NLNG RA1 beach area/ T12	9.7	9.8	0	0
13	Total	98.8	100	0	0

(Source: Author's work)

The table above indicates that a total of 98.8 hectares of land was lost to erosion within this period. All the 12 transect points within this period experienced erosion unlike the previous period presented above that had more of accretion than erosion. The highest point of erosion within this period was at Transect point T5 located around Finita-Singi beach area. This recorded an approximately 12.1 hectares of land loss representing 12.3% loss. The lowest point of erosion from our data was recorded at transect T3 with a value of 2.7 hectares loss within the period. Figure.5 illustrates the shoreline erosion within this period.

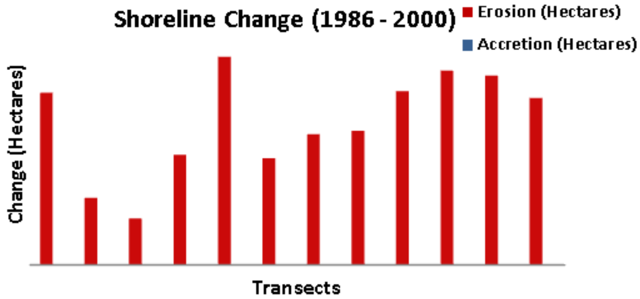

Figure 5: Shoreline change trend within 1986-2000

The result in Table.4 shows that there was no accretion within the 12 transects points measured within this epoch. All the transect points recorded a zero value which indicates no accretion. Base on this result it means this epochs was predominantly erosional.

Figure.6 below shows the shoreline map of this period.

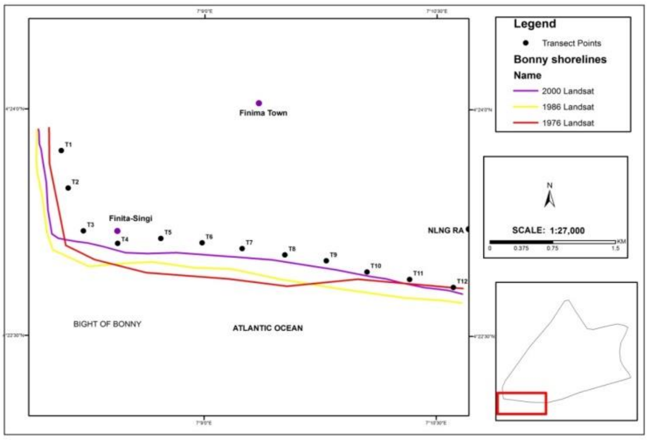

Figure 6 : showing shorelines of the two periods discussed above

3) *Shoreline Trend within 2000-2005 epochs*

The result of the shoreline within this period is shown below.

Table 6 Shoreline erosion trend within 2000-2005 periods

S/N	Locations	Period 2000-2005			
		Erosion (Hectares)	%	Accretion (Hectares)	%
1	Lighthouse area/ T1	5.9	12.6	0	0
2	Finita-Singi/T2	7.2	15.3	0	0
3	Finita-Singi area/ T3	10.1	21.5	0	0
4	Finita-Singi Area/ T4	2.3	4.9	0	0
5	Finita-Singi Area/ T5	6.3	13.4	0	0
6	Finita-Singi Area/ T6	5.1	10.9	0	0
7	Finita-Singi Area/ T7	3.3	7.0	0	0
8	Finita-Singi Area/ T8	2.6	5.5	0	0
9	Finita-Singi Area/ T9	1.4	3	0	0
10	Near NLNG RA1 beach/ T10	1.1	2.3	0	0
11	NLNG RA1 beach/ T11	0.9	1.9	0	0
12	NLNG RA1 beach area/ T12	0.8	1.7	0	0
13	Total	47	100	0	0

(Source: Author's work)

From Table.5 a total of 47 hectares of land was lost to erosion within this period. The highpoint of erosion was at transects T3 around Finita-Singi area recording 10.1 hectares of land loss which represents 21.5% of the total loss. The range of the erosion was within period was between 0.8 to 10.1 hectares. This result indicates that erosion occurred at the 12 transect points along the study area. Fig.7 below shows a chart of the erosion trend within this period.

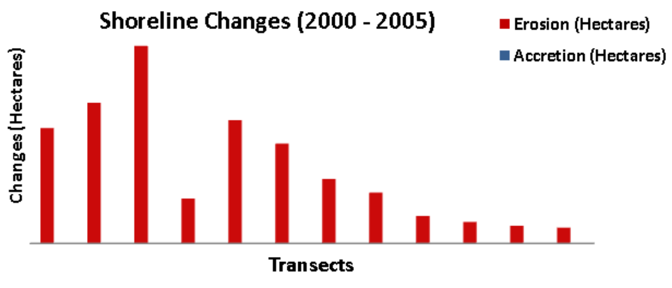

Figure 7 : showing shoreline changes trend within 2000-2005 epoch

From Fig.7 above transect point 3 recorded the highest annual rate of erosion while T10 recorded the least annual erosion.

The result presented above in Table.5 shows that there was no accretion within this period rather there were prevalence of erosion at all the transect points.

The shoreline trend for this period is represented in Fig.8 which shows the variations in the positions of the various shorelines.

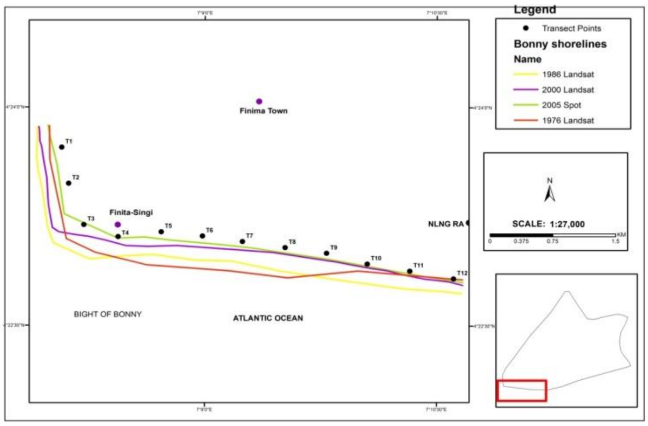

Figure 8 : showing the shoreline positions within 1976-2005

4) *Shoreline Trend within 2005-2011 epoch*

The result of the shoreline trend within this period is presented below.

Table.6 below shows the result of the shoreline erosion trend within this period.

Table 7 Shoreline Erosion trend within 2005-2011 epochs

S/N	Locations	Period 2005-2011			
		Erosion (Hectares)	%	Accretion (Hectares)	%
1	Lighthouse area/ T1	3.64	9.3	0	0
2	Finita-Singi/T2	5.70	14.6	0	0
3	Finita-Singi area/ T3	4.78	12.2	0	0
4	Finita-Singi Area/ T4	0	0	1.86	100
5	Finita-Singi Area/ T5	3.66	9.4	0	0
6	Finita-Singi Area/ T6	4.77	12.2	0	0
7	Finita-Singi Area/ T7	4.12	10.5	0	0
8	Finita-Singi Area/ T8	2.83	7.2	0	0
9	Finita-Singi Area/ T9	3.43	8.8	0	0
10	Near NLNG RA1 beach/ T10	2.54	6.5	0	0
11	NLNG RA1 beach/ T11	2.01	5.4	0	0
12	NLNG RA1 beach area/ T12	1.62	4.1	0	0
13	Total	39.1	100	1.86	100

(Source: Author's work)

From the table above the total land loss in area within the 2005-2011 epochs was recorded as 39.1 hectares. The high point of erosion was at transects T2 which was established along Finita-Singi beach area. Meanwhile the lowest point was at T4 which recorded zero due to the prevalence of accretion at this station. Fig.9 below shows the shoreline erosion in a percentage bar graph.

From the above result accretion occurred at only one location which was at Transect T4 along the Finima beach area. This represented a 100% of the total land accretion within this period. Fig.10 below shows the shoreline map for this period.

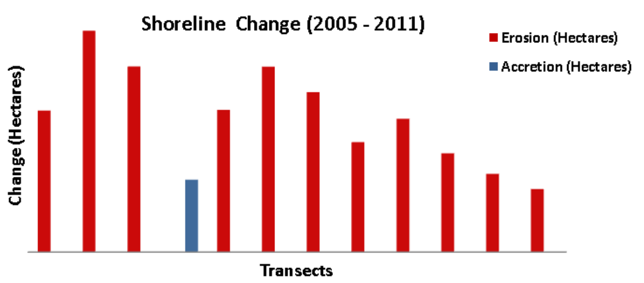

Figure 9 : showing shoreline change trend within the 2005-2011 epoch (Source: Author's work)

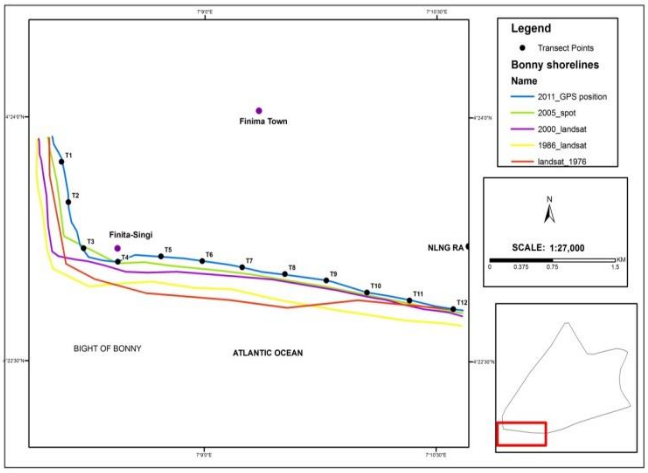

Figure 10: showing the shoreline positions of the different periods as obtained from the analyses

B. Hypothesis Testing

Two statistical methods were used to test for the two hypothesis of the study.
The two hypotheses is briefly stated below

H_{01}: There has been no significant change along the Bonny shoreline over the past 30 years.
H_1: There is.

Table.7 below shows the variance of ANOVA result for Hypothesis One

Table 8 Computing the variance of ANOVA

S/N	SITES	Period							
		1976-1986		1986-2000		2000-2005		2005-2011	
		X	X^2	X	X^2	X	X^2	X	X^2
1	Lighthouse area/ T3	7.2	51.84	-10	-100	-5.9	-34.81	- 3.64	-13.25
2	Finita-Singi settlement/T4	10.2	104.04	-3.9	-15.21	-7.2	-51.84	- 5.70	-32.49
3	Finita-Singi area/ T5	10.5	110.25	-2.7	-7.29	-10.1	-102.01	- 4.78	-22.85
4	Finita-Singi Area/ T6	10	100	-6.4	-40.96	-2.3	-5.29	1.86	3.46
5	Finita-Singi Area/ T7	4.7	22.09	-12.1	-146.41	-6.3	-39.69	- 3.66	-13.4
6	Finita-Singi Area/ T8	- 5.9	-34.81	-6.2	-38.44	-5.1	-26.01	- 4.77	-22.75
7	Finita-Singi Area/ T9	- 6.5	-42.25	-7.6	-57.76	-3.3	-10.89	- 4.12	-16.97
8	Finita-Singi Area/ T10	- 3.4	-11.56	-7.8	-60.84	-2.6	-6.76	- 2.83	-8.01
9	Finita-Singi Area/ T11	- 0.6	-0.36	-10.1	-102.01	-1.4	-1.96	- 3.43	-11.77
10	Near NLNG RA1 beach/ T12	4	16	-11.3	-127.69	-1.1	-1.21	- 2.54	6.45
11	NLNG RA1 beach/ T13	8.6	73.96	-11	-121	-0.9	-0.81	- 2.01	-4.04
12	NLNG RA1 beach area/ T14	12.3	151.29	-9.7	-94.09	-0.8	-0.64	-1.62	-2.62
13	Total	83.9	718.45	101.5	911.7	47	281.92	40.96	158.01

Source: Author's Work

The result of the computations for the sums of squares is presented in Table.8 below.

Table 9 ANOVA Table for shoreline dynamics at Bonny Island

Square of variations	Sum of squares	Degrees of freedom	Mean sum of squares	F
Between Columns (samples)	161.28	3	53.76	**45.76**
Within columns (Error)	352.03	44	8.0	
Total	513.31	47		

(Source: Author's work)

The test statistics gives a value of 45.76 while from a 95% table of the F distribution the critical value at 3 and 44 degrees of freedom is 2.72 i.e.,

$$F_{0.05} = 2.72$$

Decision Rule:

A large maximum difference indicates a wide difference between the distributions, leading to a rejection of the null hypothesis.

From the ANOVA analysis above the critical F value at 95% probability level is less than the calculated F value of 45.76. Based on the rule it means the null hypothesis which states that there is no statistically significant difference in the rate of shoreline change at Bonny Island would be rejected, because there is a statistically significant difference in the rate of shoreline changes at the Bonny Island.

C. Discussions

This study was concerned with the assessment of shoreline dynamics at Bonny Island using GIS and Remote Sensing techniques. The assessment of the shoreline dynamics in Bonny Island was done using satellite imageries and GPS coordinate data acquired from the field. The shoreline positions within the past 35years were determined

The findings of the study reveal that there has been a great change in the shoreline position in Bonny Island over the past 35years. The Finima beach area was found to have the highest rate of shoreline dynamics. Erosion dominated in this area over accretion. This area recorded a total land area loss of 458.04 hectares of land out which erosion and accretion recorded 280.47 and 177.57 hectares respectively. By this it means erosion claimed about 61.2% of the total land area while accretion recorded a 39.8% land increase.

This changes recorded was attributed to the changes in land use in the area. As at 1976 -1986 period there was more of accretion of land around the shorelines in the study area. This was because during this period there were lesser anthropogenic activities within the area. The establishment of oil multinationals such as Nigeria Liquefied Natural Gas (NLNG) came after this epoch. The activities of these companies such as dredging and movement of their ocean liners led to the increased rate of shoreline erosion. This was confirmed by the residents as one of the major causes of erosion in the area.

The study further reveals that there have been several displacements of the settlements along the shoreline in the study area due to the high rate of shoreline erosion in the area. This discovery was ascertained from the residents in the Finita-Singi fishing settlement along the Finima land area. Their response agreed with the research findings which showed a large land loss during the 35years period of investigation

Generally, the research finding shows that the Bonny shoreline is a highly dynamic one and despite this fact no serious adequate measures has been put in place to regulate this impacts. And this has resulted to large loss of land over the area.

The study has shown that geospatial techniques can be effectively used to assess the state of shoreline dynamics in the Bonny Island.

IV. CONCLUSION

The study thus far has shown the state of the Bonny shorelines, which is a very dynamic one. The shoreline has been found to be eroding away at an annual rate of 10m-30m along the Finita-Singi beach area. It is therefore pertinent for adequate measures to be put in place to curtail these incessant changes in the shoreline of the Bonny Island. The Bonny Island is an all-important Island to the Nigerian economy this is because it houses most of the important oil installations upon which the Nigerian Economy depends on. The study has further displayed the capabilities of GIS and Remote

Sensing techniques in the studies of the ever dynamic Nigerian shorelines.

V. RECOMENDATIONS

The Nigerian shoreline is a very dynamic one and for that reason there is the need to pay proper attention to the coastal processes ongoing along our shorelines. With the aim of controlling the impact of human activities that is changing the face of our ever dynamic shoreline. The use of geospatial techniques has proven over the years to be a more effective method of mapping and monitoring of shorelines because of its cost-effectiveness. It is with these problems in mind that the following recommendations are made.

- A constant monitoring of the shorelines through geospatial techniques should be setup in Nigeria. This would enable early detection of any unprecedented changes taking place along the shorelines thereby making it possible for early arrest of such changes. Hence a monitoring unit is recommended that would have it as its responsibility to monitor our shorelines.
- Funds should be made available for researches on this phenomenon; this would help make data readily available for future projects.
- A conscious effort should be employed by the government either by enacting a law to control the activities within the Nigerian Shorelines. There should be an off limit as to where people are permitted to carry out any development project.

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