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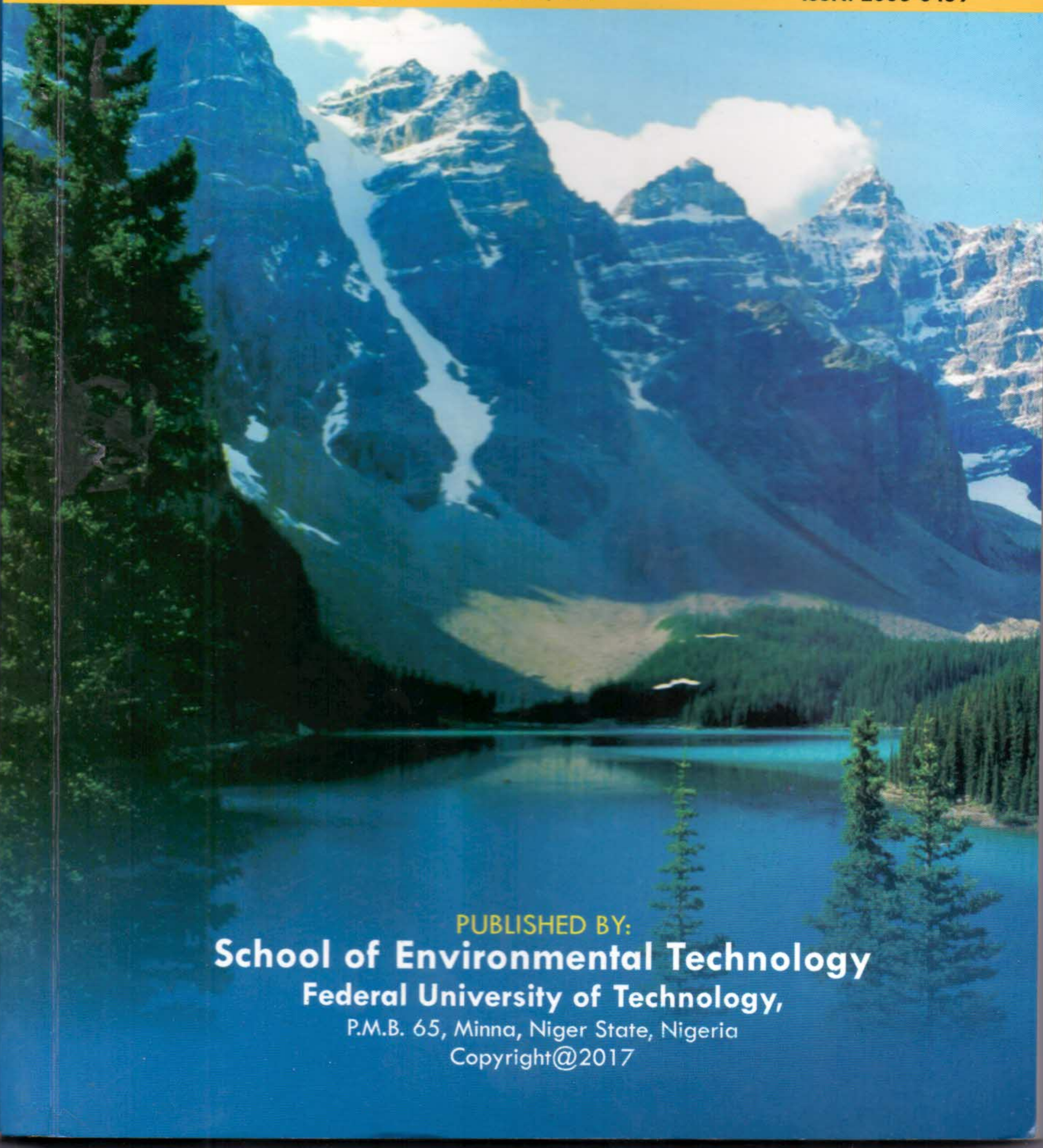

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Contents

A Geospatial Analysis of Coastal Land use/Land Cover Pattern and Shoreline Changes in Akwa-Ibom State, Nigeria

Adebola Abiodun Olufemi [1], Ojoye Shamsideen[2] & Ibitoye Matthew Olomolatan[1]

[1]*Department of Remote Sensing and Geoscience Information System (GIS), Federal University of Technology, Akure, Ondo State*
[2]*Department of Geography, Federal University of Technology, Minna, Niger State.*
[1]*Department of Remote Sensing and Geoscience Information System, Federal University of Technology Akure, Ondo State*
Corresponding E-mail:collinola@gmail.com

Abstract
The shoreline is one of the most important features on earth's surface. They are highly dynamic and ever changing. Changes are over time scales including minutes, hours, decades and Centuries. Spatial scales vary from local to regional to worldwide. Although change is continuously occurring, it doesn't occur in a constant manner. Many factors influence these changes including the type of shoreline (rocky, sandy), wave activity, tidal variations, storms and human impacts. The shoreline change study is necessary for updating the shoreline change maps and management of natural resources. Shorelines are the key element in coastal GIS and provide the most information on coastal landform dynamics. The frequent monitoring of coasts is only to accesses variation of shoreline changes. This study investigates the shoreline changes of Akwa Ibom in Nigeria for three different years 1990, 2000 and 2016, changes that occur in the land use land cover of the area and landforms around the coast. The rate of shoreline change was assessed using Linear Regression (LRR) and End Point Rate (EPR) methods. Landsat imageries for the three years were acquired and processed using Arcgis software by digitizing the shoreline of the coast to determine the changes that occurred in the years under review, maximum likelihood classification was done to classify the study area into different landuse/landcover in order to detect the changes that had also occurred. The shoreline change detection was conducted using the Digital Shoreline Analysis System (DSAS). Based on this result, it was concluded that the shoreline is eroding at -19.03 m/yr and accreting at 15 m/yr.

Keywords: Coasts, End point rate, Accretion, Erosion, shoreline, geospatial.

Introduction
Coastal shorelines worldwide are changing rapidly as a result of natural physical processes and human activities. Natural factors such as sediment supply, wave energy, and sea level are the primary causes of coastal changes, whereas human activities are catalysts causing disequilibrium conditions that accelerate changes. Coastline defined as the line of contact between land and the water body, is one of the most important linear features on the earth's surface, which has a dynamic nature (Winarso *et al*., 2001).

Shoreline shifting is the uncontrollable result of coastal erosion/accretion, the consequence of near shore currents. With reverence to the sediment supply, a certain portion of coastline may have excess, be in balance, or have a discrepancy in its sediment budget.

Enormous drop or boost in the sediment supply, in a little span of time or a stretched period, creates a shortage/excess in the sediment budget which causes shoreline shifting, multi-year shoreline shifting mapping seems to be an important task for coastal monitoring and appraisal, satellite remote sensing data in combination with Geographic Information System (GIS) is being used in shoreline extraction and mapping.

Tides often determine the range over which sediment can be deposited or eroded and the tidal range are influenced by the size and shape of the shoreline. Waves erode shorelines as they break on the shore releasing their energy, the larger the wave the more energy it releases and the more the sediment it moves. Human activities of dredging, reclamation and infrastructural development along shores also deface the shoreline. A coastline or shoreline can be geographically defined as a linear intersection of coastal land and the surface of a water body.

The shoreline is generally considered to be the edge or margin of land next to the sea or river Shorelines have been defined by different coastal management and regulatory agencies but most coastal zone studies describe the coastline as the interface between land and water (Bird, 1967; Dolan *et al.*, 1980). The changes in the coastline largely depend on its geology and geomorphology, the nature of tidal waves impacting on the coastline; changes in sea level; and sediment transport by long-shore currents (Carter and Woodroffe, 1994; Cowel and Thorn, 1994; Pidwirnyi, 2006a). Human activities which include dredging, construction of breakwater infrastructure and physical development; mineral exploration and exploitation, ports construction, removal of backshore vegetation, construction of barges and coastal control works and reclamation also deface the coastline tremendously (Franos *et al.*, 1995; Bergerand 1996; Ibe 1988; Pandian *et al.*, 2004). The shoreline is the bridge between aquatic life and terrestrial life, and it is usually a fragile eco-zone, hence the study of shoreline changes can be of immense benefit to the understanding of complex coastal ecosystems. Shorelines are widely used as ports for navigation and marine commerce and therefore are of economic value and critical to the socio- economic development of non-land locked nations.

The location of the shoreline and the changing position of its boundary over time are of elementary importance to coastal scientists, engineers and managers (Douglass and Crowell 2000; National Research Council, 1990).

Study Area

Akwa ibom is a state in Nigeria, it is located in the coastal southern part of the country, lying between the latitude 4^0 32'N and $5^0$33'N and longitudes $7^0$25'E and $8^0$25'E. The State is bordered on the east by Cross River on the west by Rivers state, on the south by Atlantic Ocean with population of over 5 million people, it was created in 1987 from the former cross river state and is currently the highest oil and gas producing state in the country.

The topography of Akwa Ibom is rugged, consisting of hills and ridges with steep-sided valleys. The hills and ridges of this region which are separated by flood-prone lowlands are remnants of the west-east extension of the Enugu-Okigwe. The slopes are greatly ravaged by erosion during the rainy season. The existing climatic factors in Akwa Ibom would have favoured luxuriant tropical rainforests with teeming populations of fauna and extremely high terrestrial and aquatic biomass. The native vegetation has been almost completely replaced by secondary forests of predominantly wild oil palms, woody shrubs and various grass under growths. Akwa-Ibom state is reputed to hold the highest oil palms per capita in Nigeria. The climate of Akwa-Ibom State is characterized into two seasons, namely, the wet or rainy season and the dry season. In the south central and central parts of the state, the wet or rainy season lasts for about eight months but towards the far north, it is slightly less. The rainy season begins about March-April and lasts until mid-November. Akwa-Ibom State receives relatively higher rainfall totals than other parts of southern Nigeria. The total annual rainfall varies from 4000mm along the coast to 2000mm inland (NIMET, 2014). The whole of Akwa-Ibom State is underlain by sedimentary formations of late tertiary and Holocene ages.

Deposits of recent alluvium and beach ridge sands occur along the coast and estuaries of Imo and Qua Iboe Rivers, and also along the flood-plains of creeks. Inland, a greater part of the state consists of coastal plain sands now weathered into laterictic layers. Ituen *et al.* (2014) remote sensing and Geographic Information System (GIS) based application in the analysis of Shoreline change in Ibeno Local Government. Area [LGA], Akwa Ibom State. Satellite imageries of1986, 2006 and 2008 were used to extract the shoreline through heads-up digitization. The rate of shoreline change was assessed using Linear Regression (LRR) and End Point Rate (EPR) methods. The shoreline change detection was conducted using the Digital Shoreline Analysis System (DSAS). Landsat Thematic Mapper (LTM) of 1986 and Enhanced Thematic Mapper (ETM) of 2006 both of 28.5 X 28.5metres ground resolution were acquired from the United States Geological Surveys (USGS) and actually used for various analysis carried out. A high resolution Ikonos image of 2008 with about 1m ground resolution was obtained and used. These imageries cover a period of 22yrs. The range of time and years chosen was due to data availability. The result however indicated that the rate of erosion is found out to be very high with maximum value of -7.8m/yr recorded at Itak Abasi community. On the other hand, some portions of the shoreline are accreting at an average rate of 2m/yr. Based on this result however, it was concluded that Ibeno shoreline is eroding at an average rate of -3.9m/yr.

collinola@gmail.com

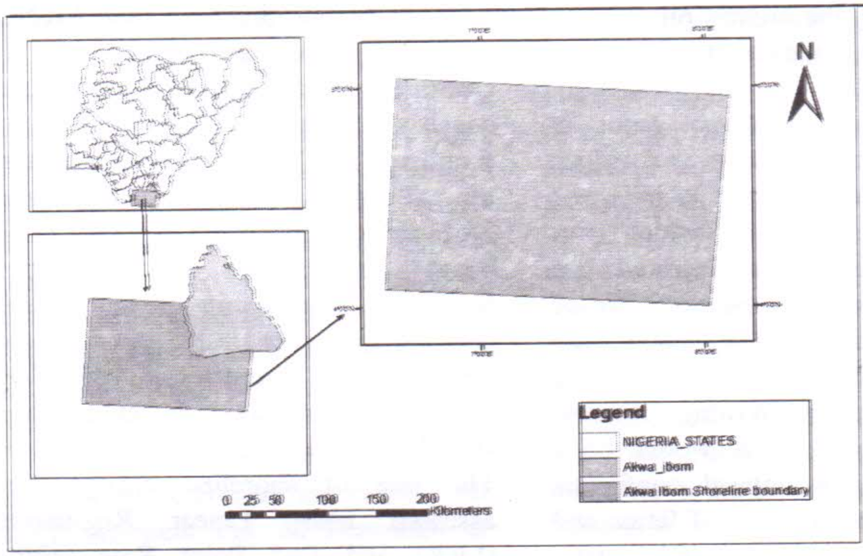

Fig 1: Map of the study area

Areas mostly affected by accretion processes are identified near Qua Iboe River Estuary and ExxonMobil Jetty where sand filling is usually done for settlement purposes. This best explains the reason for the submersion of school buildings, residential buildings and the persistent inundation of large portions of land in the area. Mitra *et al*. (2013) used Change detection analysis of the shoreline using Topo-sheet and Satellite Image in Mandarmani-Shankarpur West Bengal applied remote sensing and GIS techniques on the multi-temporal satellite image and topo-sheets, shoreline extraction using water index and subsequent change detection analysis was carried out to assess the erosion-accretion pattern in the region at both regional and local scale. Depending on the erosional pattern, the entire study area was divided into four erosional-cells, and independent study was carried out in different cells. The results exhibit that this coastal region has been experiencing erosion.

Kumaravel *et al*. (2013) and Saravana *et al*. (2015) used remote sensing and GIS based shoreline change studies in the Cuddalore District, East Coast of Tamilnadu South India, to investigate the spatial as well as quantify the shoreline changes along the coast in the parts of Cuddalore district, east coast of TamilNadu by using geospatial techniques. used Quantitative estimation for shoreline change using Remote Sensing and GIS for South South Andaman Island, India and Andaman Island, India, respectively. Multiyear shoreline mapping is considered as a valuable task for coastal monitoring and assessment and detection of shoreline change and estimation of erosion and accretion along the eastern coast of the South Andaman. The SOI topo-sheet 197, IRS 1D 1998 and IRS P6 2009 satellite pictures were used to delineate the shoreline changes. The results revealed that there is a greatest value of erosion over 30 years of studying. Boatemaa *et al*. (2013) used impacts of shoreline morphological change and sea level rise on mangroves keta coastal zone investigated the effect of sea level rise and shoreline recession on the mangroves at Anyanui, using geospatial data and modeling techniques. The local trend in rising sea level was analysed using data from a tide gauge station in Ghana. The results indicate that Keta coastal zone is eroding at a rate of about 2.32m/yr and the sea level is rising at a historic rate of about3mm/yr. The study revealed that increasing sea level rise will enable the shoreline to migrate about 8 km inland in the next 100 years, which could pose a severe threat to the mangrove forest. It also emerged that there is a significant increase in mangrove cover between 1986 and 2002. Ramanamurthy *et al*. (2016) used Shoreline Change Monitoring in Nellore Coast at East Coast Andhra Pradesh District Using Remote Sensing and GIS to investigate the shoreline changes of Nellore district in Andhra Pradesh coast, as well as the quantity of the erosion and accretion rate. Using multi-temporal resolution satellite data(TM & LISS III, IV) and Geographic information system(GIS) 25 years period i.e, from 1989 to 2015. The resultant coastal maps were used to estimate the geomorphologic changes and shifting of the shoreline position. This integrated study was found useful for exploring accretion and erosion processes in the region. About 87.6 km of coastline was found to be accreting nature with average of +1.40 m/yr followed by 38.4 km of coastal line eroding with average of -1.36 m/yr and stable coastline of 41.4 km was found. This study demonstrates that combined use of satellite imagery and statistical method such as linear regression for shoreline change analysis are helpful for erosion monitoring and preventive measure.

Prukpitikul *et al*. (2012) used shoreline change prediction model for coastal zone management in Thailand to utilize geo-informatics technology to increase accuracy of a shoreline prediction model along two study sites in Samutprakarn province and in Prachuabkirikhan province. The result presents that averaged erosion and accretion rate along Samutprakarn province was 22.30 meters/year and 2.94 meters/year, respectively. On the other hand, the average rate of coastal erosion along Prachuabkirikhan province was much lower, being 2.48 meters/year while the accretion rate was approximately 4.11 meters/year. The predicted shoreline change at Samutprakarn province in 2019 is about -132.69 ± 0.758meters while at Prachuabkirikhan is 40.58 ± 0.0012 meters.

Barman *et al*. (2015) used an approach of future prediction for trends of shoreline position for Balasore Shoreline to analyze the shift in shoreline due to coastal processes and formular available for best estimate of future shoreline positions based on precedent shorelines, simple Linear Regression Model and End Point Rate (EPR) was adopted to takeout the rate of change of shoreline and its future positions, based on empirical observations at 67transects along the Balasore coast.. The rate of shoreline movement calculated from the fixed base line to shoreline position of 1975, 1980, 1990, 1995, 2000, 2005 and 2010 and based on this, the estimated shoreline of 2013 was calculated. The estimated shoreline was compared with the actual shoreline delineated from satellite imagery of 2013. The model error or positional shift at each sample point was observed, the positional error varies from −4.82 m to 212.41 m. It has been found that model prediction error is higher in the left hand side of river Subarnarekha. The overall error for the entire predicted shoreline was found to be 41.88 m by Root Mean Square Error (RMSE). In addition, it was tested by means difference between actual and predicted shoreline positions using "*t*" test and it has been found that predicted shore line is not significantly different from actual shoreline position at ($t132 = 0.278$) $p < 0.01$.

Materials and Method

In the process of carrying out this study, the use of satellite images and GIS tools to extract the shorelines for three different years of 1990, 2000 and 2016 became very necessary. In this case, Landsat Thematic Mapper (LTM) of 1990 and Enhanced Thematic Mapper (ETM) of 2000 both of 28.5 X 28.5metres ground resolution were acquired from the United States Geological Surveys (USGS) site and used for various analysis carried out. These imageries cover a period of 26yrs. The images were processed to delineate the shorelines for 1990, 2000 and 2016 with a view to determining their rate of changes over the study period. ARCGIS was used to perform clipping of the study area, image processing of the areas were done by combining bands together.

Image classification was done on the three images to separable land use/cover categories which are dense, light vegetation, unpolluted, polluted water, settlements and wetlands. Digitizing of the shorelines was done on the three images to detect the changes that occurred over the years. The combined false colour images of the area were used for the identification of geomorphology and landforms around the coast.

a) Processes of Shoreline Extraction

To extract the shorelines from the satellite images, shape files were created in Arc catalog for each of the images. For easy data handling, the three images were spatially re-projected to Universal Transverse Mercator (UTM 1984). This was followed by the determination of shoreline reference feature where measurements were based.

b) Determination of Rate of Shoreline Change

After the shorelines were extracted, a base-line was created parallel to these extracted shorelines in order to cast perpendicular lines to the shorelines and also to serve as the origin for measuring distances of the shorelines in relation to the established base-line.

The base-line was created through buffering method in ArcGIS 10.1 and this served as the starting point for generating transects. In this case, a 600 meter buffer was created just above the lines, resulting in a single buffer of 600 meters around the outermost line. The upper and side sections of the buffer were deleted resulting in a single line 600 meters from the shoreline.

This line served as the base-line and was smoothened to remove the rough side of the line in order to cast perpendicular transects on the shorelines under consideration. The base-line and shoreline data were imported into a geo-database in order for DSAS to recognize the data. Before running the DSAS program, spatial reference and feature type requirements of the shoreline files were reconciled. The multiple shape files of the shorelines were appended into a single feature class by using the Append tool from the Arc Toolbox. The various attribute tables for the baseline and the appended shoreline file were created as shown below. If no accuracy field value exist for a specific shoreline or Zero is used in the accuracy field, a default value specified in the Set data Accuracy section by the user could be used. The ID field was populated to control the order of transect casting along the baseline.

c) Determination of Net Shoreline Movement (NSM)

After the computation of the rate of change in shoreline, the End Point Rate method was used to calculate the distance of shoreline movement by subtracting between the earliest and latest measurements (i.e., the oldest and the most recent shoreline). The major advantage of the EPR is that, it is easy to compute with minimal requirements of shoreline data (two shorelines). The linear regression rate-of change statistic (LRR) was the second rate of change method used. This was done by fitting a least squares regression line to all shoreline points for a particular transects. The rate is the slope of the line. The linear regression method has the advantage that all the data are used, regardless of changes in the trend or accuracy in addition to the method being purely computational.

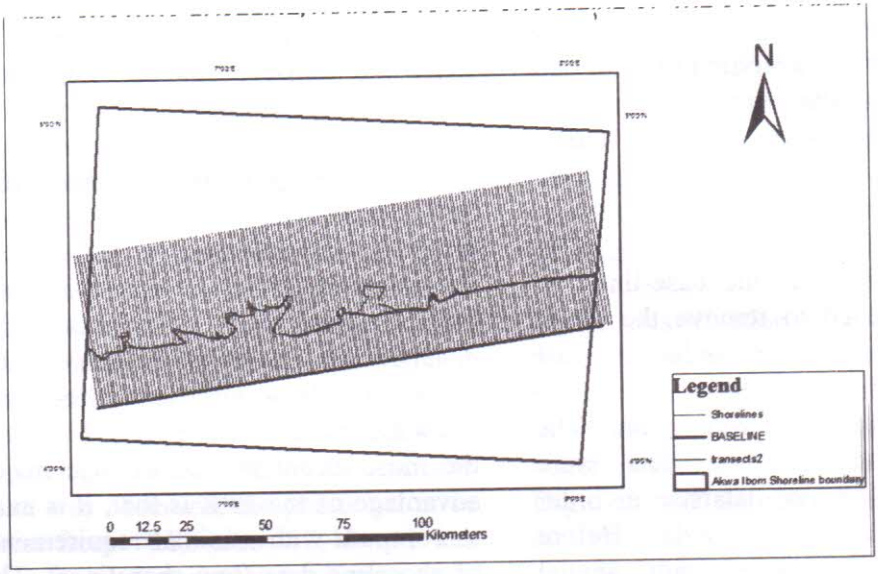

Figure 1: Baseline, Transects and Shoreline of the Study Area

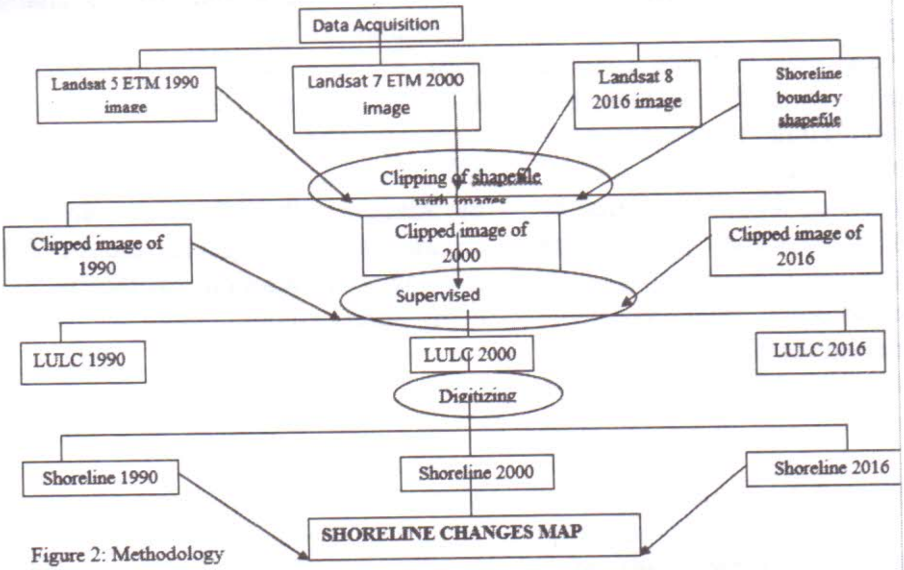

Figure 2: Methodology

Result and Discussion

The rate of shoreline change was assessed using Linear Regression (LRR) and End Point Rate (EPR) methods. The shoreline change detection was conducted using the Digital Shoreline Analysis System (DSAS) an extension of ArcGis.

Shoreline length

From the maps and table, it shows that 1990 shoreline is 246.928 in length; it increased in year 2000 to 257.678 and decreased again in year 2016 to 251.061m.

Table 1: Length in meters of each of the shoreline from 1990-2016

Shoreline Year	Length(m)
1990	246.928
2000	257.678
2016	251.061

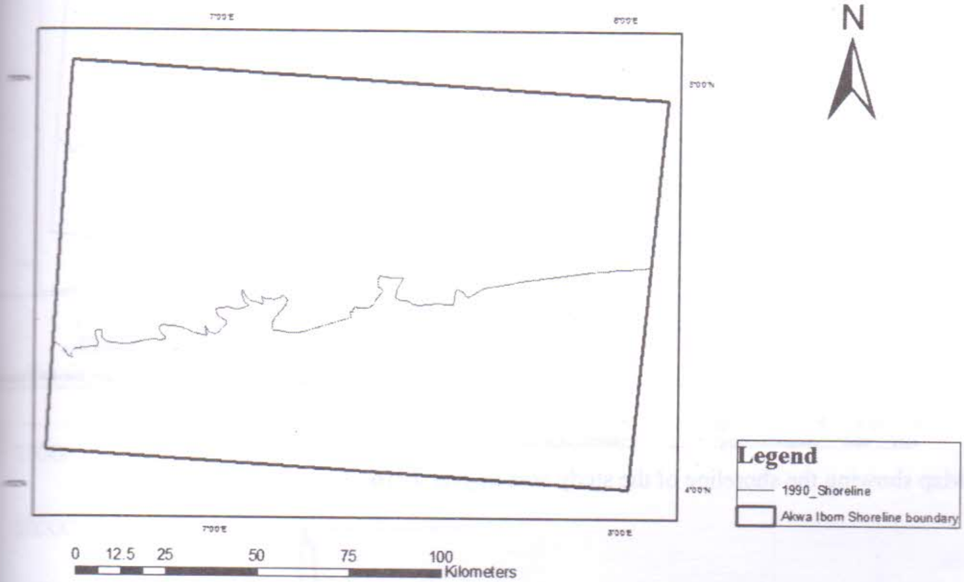

Fig 2: Shoreline of the study area in year 1990

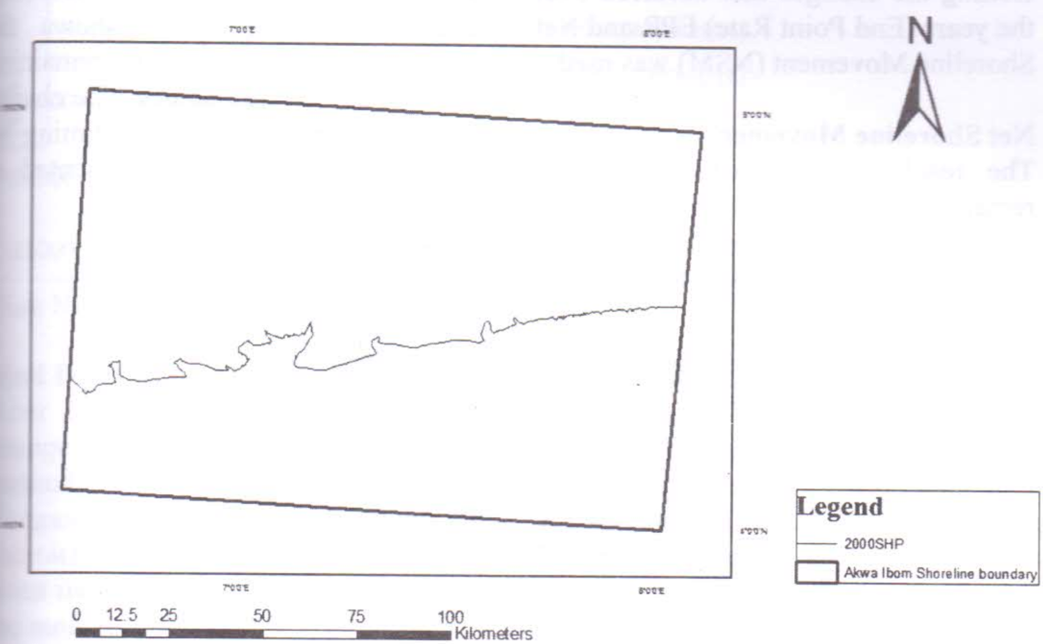

Fig 3: Map showing the shoreline of the study area in year 2000

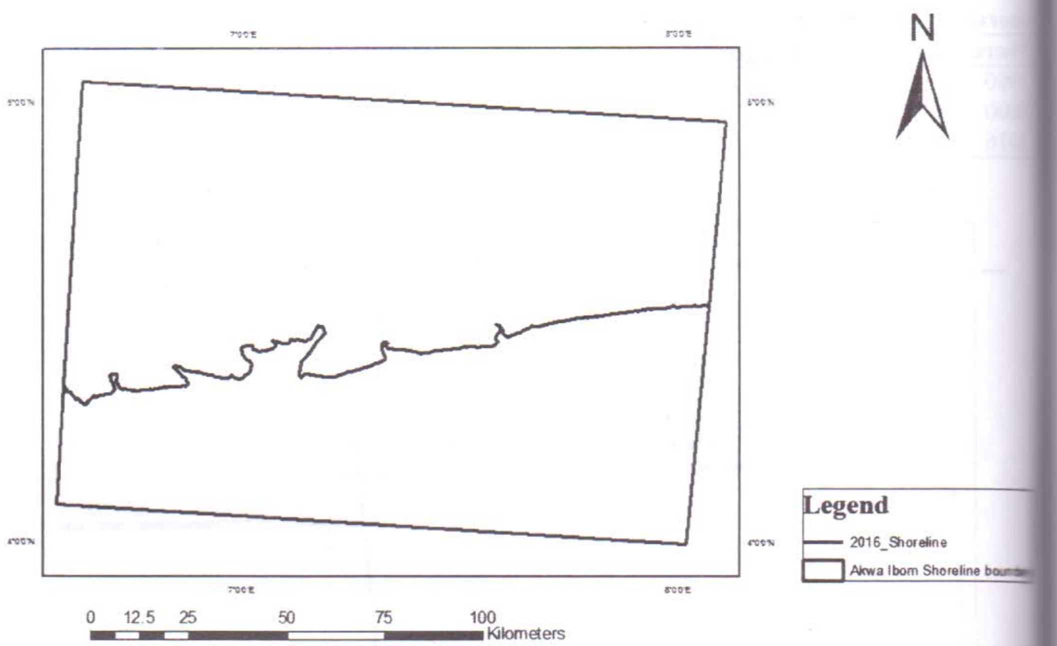

Fig 4: Map showing the shoreline of the study area in year 2016

Changes in Shoreline over Time

Getting the changes that occurred over the years (End Point Rate) EPR and Net Shoreline Movement (NSM) was used.

Net Shoreline Movement

The result of the analysis revealed remarkable changes in the study area Shoreline, the net change measured as the distance between the most recent and earliest shorelines, in this case the 1990, 2000 and the 2016 shorelines changes. 1990 to 2016 shows the highest changes between the remaining years of shore line changes. The change that occurred between the timing of each available image is presented in Figures 6.

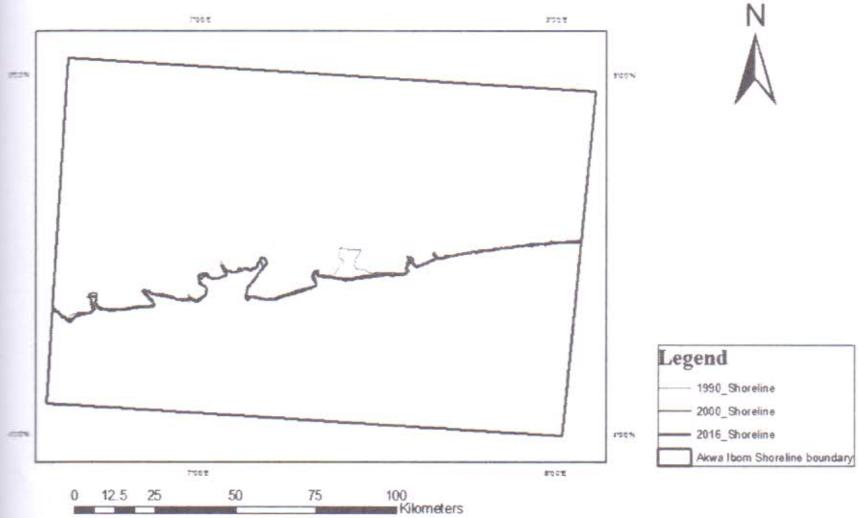

Fig 5: Map showing the shifting in shoreline between 1990-2016

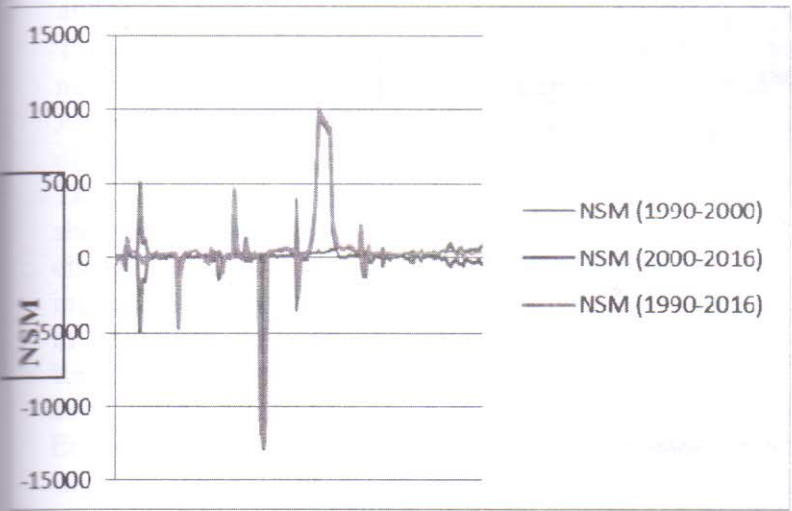

Fig6: Net Shoreline Movement (1990- 2016)

End Point Rate

After the computation of the rate of change in shoreline, the End Point Rate method was used to calculate the distance of shoreline movement by subtracting between the earliest and latest measurements (i.e., the oldest and the most recent shoreline).

From Figure 7, the highest accretion is at the rate of 950 and the erosion is -1300. This shows that in this period erosion was more than accretion. EPR for shoreline 2000-2016 shows that the highest accretion is at the rate of 250 and the erosion is -800. This shows that in this period erosion is more than accretion. It is noticed that there is a decrease in erosion and accretion of

EPR of shoreline 2000-2016 compare to that of 1990-2000.

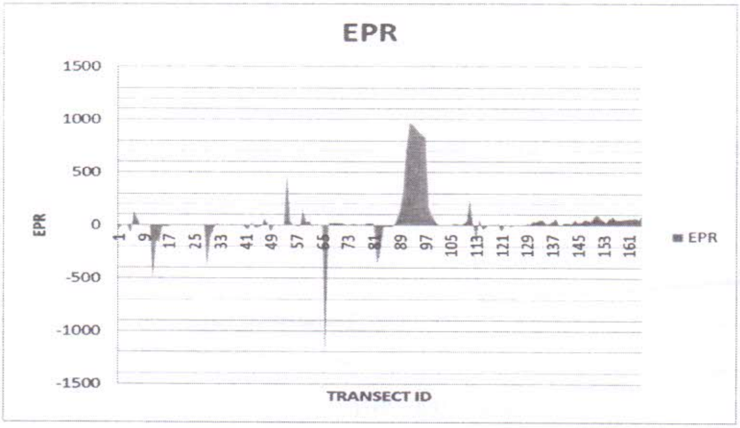

Fig 7: EPR of the shoreline from 1990-2000

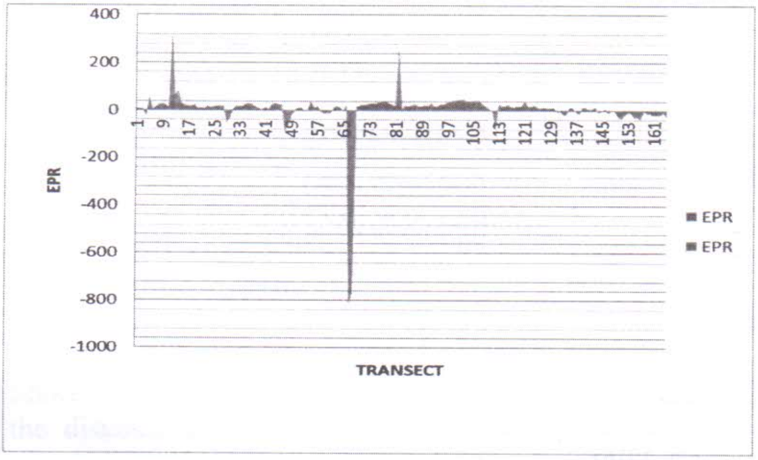

Fig 8: EPR of the shoreline from 2000-2016

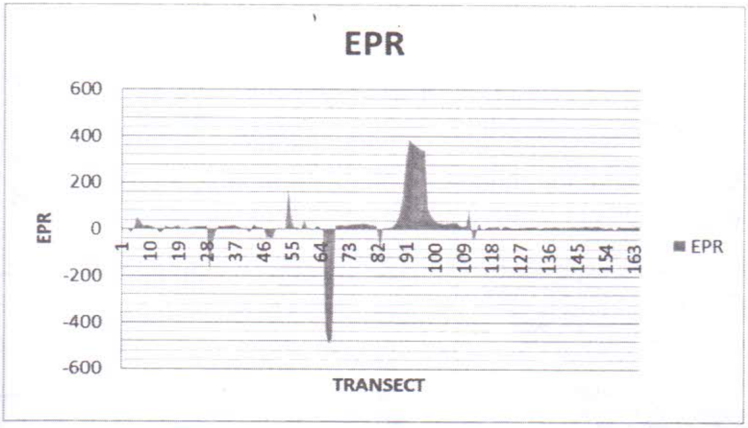

Fig 9: EPR of the shoreline from 1990-2016

From graph, EPR for shoreline 1990-2016 shows that the highest accretion is at the rate of 390 and the erosion is -495

Table 2 shows the sum total of the magnitude of Net Erosion and Accretion that occurred over the different periods under investigation. Table 2 shows the net change of shoreline erosion and accretion. The net change was at -350m in 1990-2000, it increased in 2000-2016 but decreased in 1990-2016 at the rate of -105m.

Rate per year of erosion and accretion over 1990-2016 is calculated as; Erosion or accretion / years from 1990-2016.

Erosion = -495 / 26 = -19.03 m/yr
Accretion = 390 / 26 = 15 m/yr

Table 2: Shoreline Erosion, Accretion and Net Change in Meters

Periods	Accretion (M)	Erosion (M)	Net Change (M)
1990-2000	950	-1300	-350
2000-2016	250	-800	-550
1990-2016	390	-495	-105

Land Use Land Cover Change Analysis

From the classified images of 1990, 2000 and 2016, the area of each land use categories were computed and compared statistically