Mapping the Impact of Anthropogenic Processes on the Port Harcourt Shoreline Using Remote Sensing and Global Positioning Techniques

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Abstract:- The Shore experiences periodic and seasonal changes caused by both natural and anthropogenic processes which include tidal inundation, rain and wave actions, sea level rise occasioned by climate change, dredging, reclamation, erosion and flooding activities. Shoreline mapping and change detection is essential for safe navigation, resource management, environmental protection and sustainable coastal development and planning. This study mapped the shoreline to determine the impact of human activities along the Port Harcourt shoreline from the year 1986-2015 using Satellite imageries and Real Time Kinematics Global Positioning System. Multi-temporal Landsat imageries of the study area for the years 1986, 2000, and 2013 were pre-processed and interpreted in ENVI4.5 software while the GIS operations were carried out using ArcGIS10 software, to identify the linear changes along the shoreline of the study area, using change detection method of image analyses. The RTK-GPS instrument was used to obtain the direct co-ordinates of specific portions along the Port Harcourt Shoreline in 2015.This was compared with those obtained with satellite data. The results show linear changes of between 66m to 209m at the specific portions observed from 1986 to 2015. The study showed that the techniques of Satellite Remote Sensing and RTK-GPS can be adequately used in mapping the impact of human activities on the shoreline. It is therefore recommended that the shoreline be monitored regularly to ascertain impacts of anthropogenic processes on the shore.

***Keywords**:- Mapping, Impact, Anthropogenic, Shoreline.*

I. INTRODUCTION

The shore is the land next to or near the river. It is the divide between land and a large body of water be it lake, river, or sea. Shorelines have been defined by different coastal management and regulatory agencies, but most coastal zone studies describe the shoreline as the interface between land and water (Bird, 1967; Dolan et al, 1980). It is an area that is always experiencing substantial amount of physical, commercial, and economic activities arising from tidal inundation, wave actions, sea level rise occasioned by climate change, rain, land subsidence, dredging, and reclamation activities. These processes play an important role in the changing shoreline and coastal landscape development. The changes result in erosion of coastal areas or accretion of sediments, depending on the dominant processes acting on the coastline (Pidwirnyi 2006b). The location of the coastline and the changing position of its boundary overtime are of elemental importance to coastal scientists, engineers, and managers (Douglas & Conwell 2000, National Research Council 1999). Borrego (1994) also noted that two thirds of the World cities with a population of over 2.5 million lie within the fragile coastal area.

The shoreline is also the bridge between the aquatic life and the terrestrial life. Marine authorities like the Coastal Zone Managers require up-to-date and accurate information about the coastal geomorphology vegetation, sediment deposition and erosion of the coastline.

The effect of global warming and the subsequent melting of ice at the poles resulting to sea level rises, coupled with heavy rainfall as well as run-off water from domestic uses impart greatly on the shoreline.

The activities of oil and gas exploration and exploitation and the continuous dredging of major rivers, for navigation inland as well as the cyclical actions of ocean currents and waves have largely contributed to the dynamic changes of sediment transport and erosion along the coastline and shoreline. The result is the constant flooding of coastline and shoreline communities with monumental socio-economic impacts such as loss of lives and properties. Anthropogenic processes or Human activities of dredging, construction of break water infrastructures and physical development, mineral exploration and exploitation, ports construction, removal of backshore vegetation, construction of barges and control works and reclamation deface the shoreline tremendously (Franos et al, 1995: Berger and Lams 1996: Ibe 1988; Pandian et al 2004).

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Shorelines are widely used as ports for navigation and marine commerce and therefore of economic value and critical to the socio-economic development of coastal nations. The study of shoreline changes is therefore of paramount importance and value to humanity.

An analysis of shoreline information is required in the design of coastal protection(Coastal Engineering Research Centre 1984); to calibrate and verify numerical methods(Hanson ,Graven and Krauss,1988); to assess sea level rises(Leartherman,2001);to formulate polices to regulate coastal development(National Research Council1990); to assist with legal property boundaries definition(Morton and Speed,1998); for coastal research and monitoring(Smith and Jackson 1992); to provide information in regard to shoreline re-orientation adjacent to structures(Komar 1998) and beach width and volume(Smith and Jackson,1992); to quantify historical rates of change (Dolan, Fenster and Holme, 1991).

Analysis of coastline changes can be carried out using survey maps (Kadib, 1969), historical coastline mapping and comparison of beach profiles over a period of time (Inman and Jenkins, 1984; Ibe, 1998). More recent methods include simulating of coastline changes using numerical models (El-Serafy 1984), combination of coastline survey using GPS receivers.

The purpose of this study is to determine the impact of human activities on portions of the Port-Harcourt Shoreline to ascertain changes that had taken place since the year 1986 to 2015 by comparing Landsat imageries of 1986, 2000, and 2013 and the RTK-GPS observations of 2015.

Several methods have been adopted by many authors to study and monitor shorelines over the years. They range from the traditional survey methods to the most recent remote sensing, GIS and GPS techniques. Boak & co (2005) had enumerated some common methods of mapping coastlines and shorelines and their associated data sources. All these methods can be used with varying accuracy to determine the position and configuration of coastlines and shorelines at specific period and to detect coastal changes over time.

➢ *The Study Area*

The study area (fig.2) of this research is the Port Harcourt Shoreline comprising Port Harcourt City and Obio/Akpor Local Government Areas of Rivers State. The study area is the most densely populated areas of the State and covers 32,781 Ha of land. The National Population Commission (NPC, 2006) gives the population of the study area as 1,382,592 and the Greater Port Harcourt Urban area which spans eight local government areas of Port Harcourt City, Obio/Akpor, Okrika, Ikwerre, Oyigbo, Ogu/Bolo, Tai and Eleme has an estimated population of 1,947,000 by 2012, The study area lies between Latitudes 4° 43' 20" N and 4 °56 '40" N and Longitudes 6° 57' 30" E and 7° 09' 10" E.

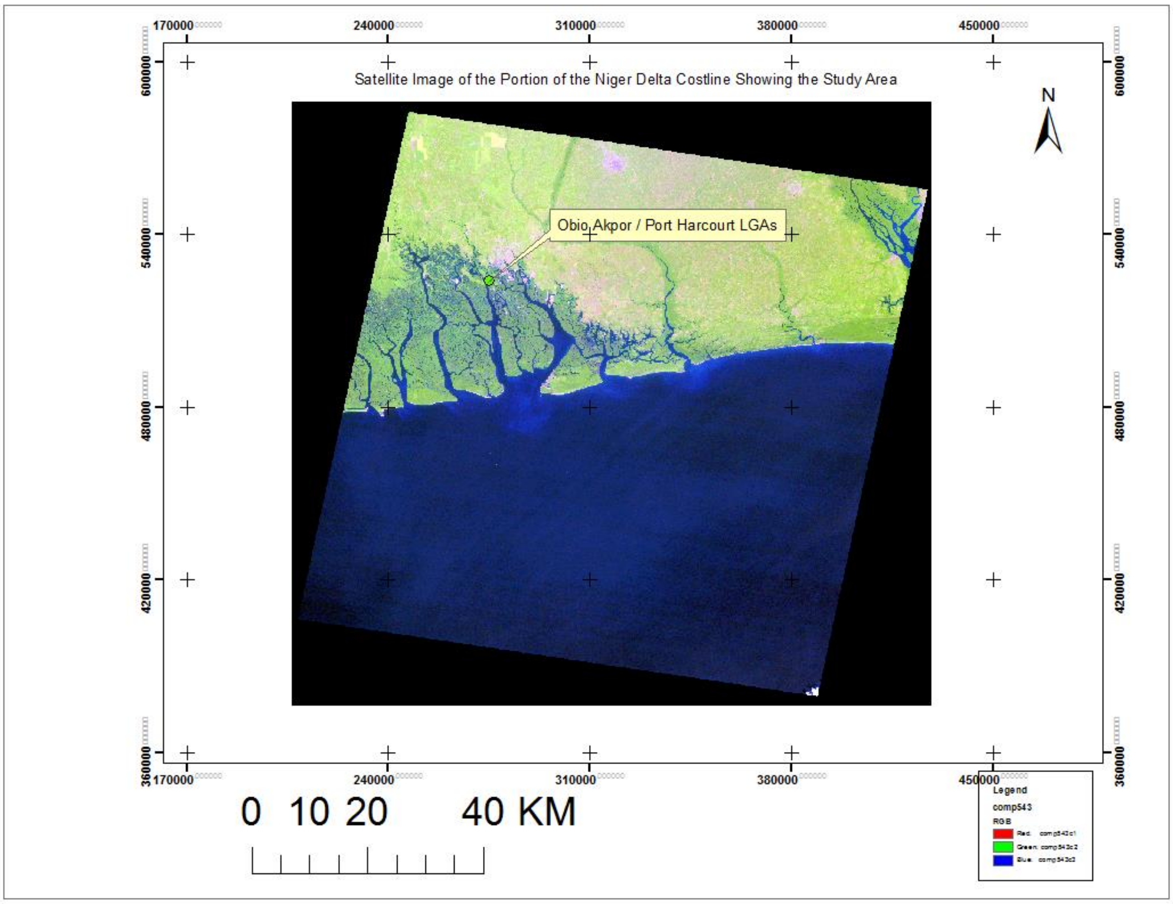

Fig 1: Satellite Image of part of Niger Delta Coastline showing the Study Area.

II. METHODOLOGY

➢ *Data Requirement*

The data available and used for this work was mainly a 30m Landsat ETM5+ satellite image of 1986, Landsat ETM5+ satellite image of 2000, and Landsat ETM7+ satellite image of 2013 covering Port Harcourt and Obio/Akpor Local Government Areas of Rivers State.

Northings and Easting Co-ordinates obtained using RTK-GPS. Other data include co-ordinates obtained using hand held GPS for field verification and capture.

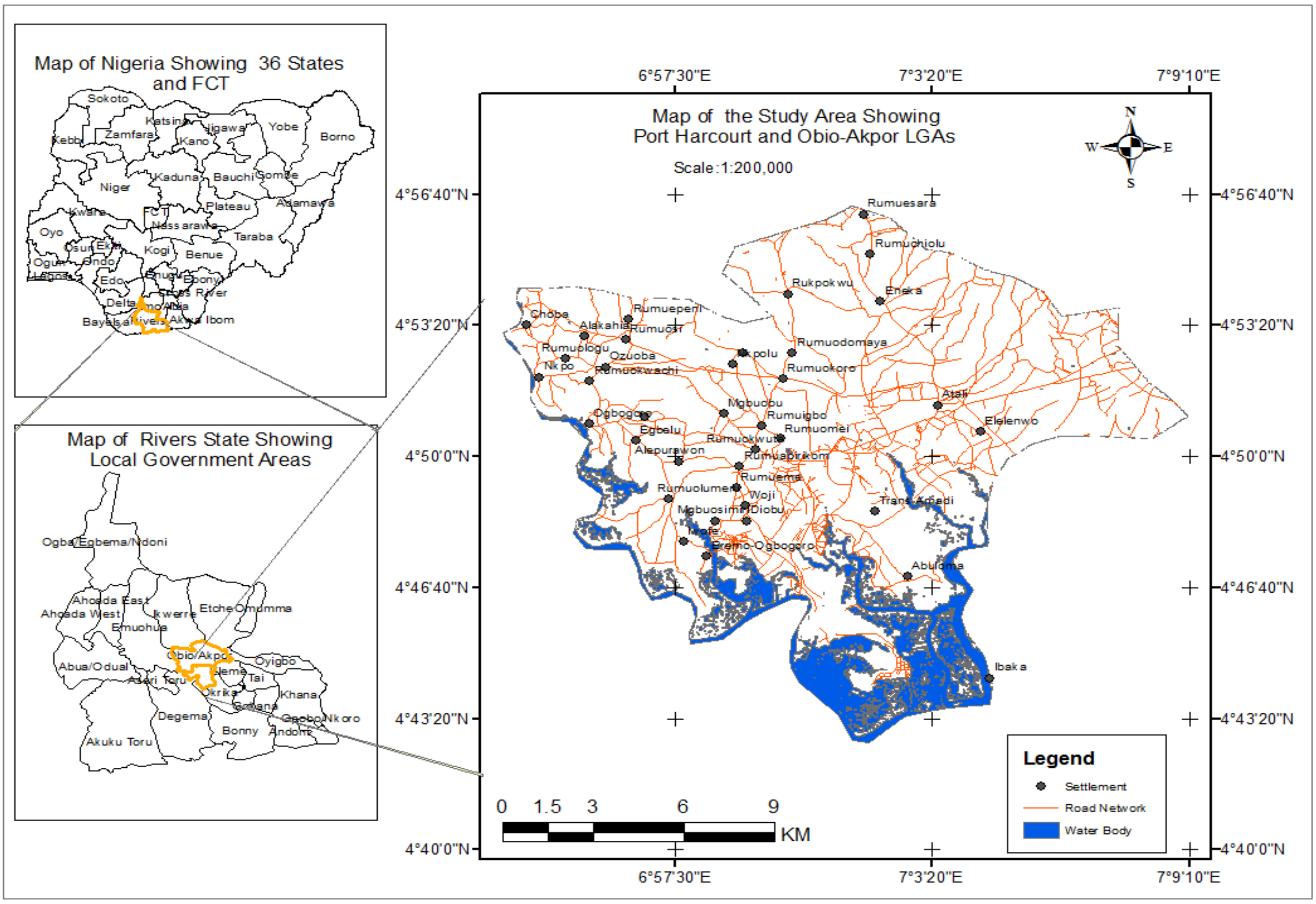

Fig 2: Map of the Study Area

➢ *Sources of Data/Data Acquisition*

Data used for this work emanated from different sources namely

(i) Landsat ETM5+ of 1986 and 2000 covering the study area were acquired form the Global Land Cover Facility (GLCF), while the Landsat ETM7+ of 2013 was also acquired from GCLF. The Landsat ETM5+ image for 1986 was acquired in May 1986, Landsat ETM5+ image for 2000 was acquired in July 2000 and the Landsat ETM7+ image of 2013 was acquired in March 2013.

(ii) Co-ordinates of points along the shoreline was obtained real time in June 2015 using the RTK-GPS

(iii) Others sources of data include Hand held GPS observations of some salient points within the study area to aid Ground Truthing

➢ *Data Processing*

➢ *RTK-GPS Data Acquisition and Processing*

The RTK-GPS data were obtained real time to give direct observations of Northings and Easting co-ordinates of points along both sides of the Port Harcourt shoreline as follows;

The Master unit of the RTK-GPS equipment is set on a control point of known co-ordinates of Latitude 4’51’50.94235N, 6’ 59’ 42.825056E and Ellipsoidal height of 34.0586m. The slave or rover unit is then moved from place to place along both sides of the shoreline. Both the master and rover units acquire satellites simultaneously to obtain co-ordinates of points.

➢ *Satellite Data Processing*

➢ *Image Processing*

The medium resolution Landsat imageries covering the study area for 1986, 2000, and 2013 as downloaded from GCLF were already corrected for geometric and radiometric errors. The image processing for the project was carried out using the Environment for Image Visualising (ENVI) version 4.5 which is a computer-based GIS and Remote Sensing software. The band combinations used for the images were bands 5, 4, and 3 for all the images in order to clearly distinguish the water and land boundaries. Bands 5, 4 and 3 were used because the features (built-up areas (red), vegetation (green), water (blue), to be classified appear better in these windows and gives better results for water related classification. Band 5 is in the red portion, band 4 is in green portion and band 3 is in the blue portions of the electromagnetic spectrum. Each of the images was processed and classified separately. After the individual classification, they were crossed and the change was detected. The areas of observed changes were extracted into a GIS database using the ArcGIS 10.1 for image enhancement and display. The GIS operation carried out on the processed image include, the digital extraction of identified areas of change along the shoreline, digitization of the shorelines for the years of study and the statistical area calculations to know the size of changes in km^2.

➢ *Image Classification*

The Mahalanobis Distance supervised image classification technique was used in this study. This technique appeared to give better results than the other two namely: Minimum Distance and Maximum Likelihood. In this method, feature classes are based on mean and standard deviation statistical method, giving a real object classification so that each feature will not be misinterpreted based on the classification method

Three sets of images acquired for the shoreline change detection were captured band by band and imported into ENVI environment for image processing. The images were then classified according to the different classes such as water bodies, shoreline, vegetation, built-up areas, mangrove, bare land etc. Different colours were then assigned to various earth features namely; blue was assigned to water, red to built-up areas, light green to vegetation, dark green to mangrove, whitish sand to bare land, yellow to shoreline and maroon to outside area.

Each classified image was converted to vector format and water body was extracted for further change analysis to give change detection.

➢ *Image Overlaying*

An overlay operation was then carried out where the vectorised shorelines of the respective years were overlaid on the RTK-GPS observed shoreline, as well as between map pairs for post classification change detection.

➢ *Change Detection*

Change Detection is a process of identifying differences in the state of an object or phenomena by observing it at different times (Singh, 1989). Change detection involves the use of multi-temporal data sets to quantitatively analyse the temporal effects of the phenomena. A good change process should provide information on the following.

Area changes and change rate, spatial distributions of changed types, change trajectories of land cover types, and accuracy assessment. Digital change detection provides automatic correlation of the same geographic area at different times and displaying the changes in their locations.

A variety of techniques for change detection based on comparison of multi-temporal digital remote sensed data have been developed. The Image differencing and image overlaying were applied to detect changes in the shorelines.

➢ *Ground Truthing*

On the field, a hand-held GPS, was used to obtain X, Y co-ordinates of six points at different locations of the study area namely Ogbogoro, Eagle Island, Rumuokparaeli, Abuloma and Mgbuosimini- Rumueme.

On the laptop, we set the background for the ground truthing exercise by inserting the right co-ordinate system of the study area (WGS 84 UTM Zone 32). We imported the image into the computer and plotted the ground truth co-ordinates onto the image using XY interface on the ArcMap. The co-ordinates as plotted fall on different features classes of the image. Shoreline had 134 pixels in the red band, 182 in the green band and 225 in the blue band. These pixels are then used to train the image as shoreline, water body, vegetation, mangrove, built-up areas, and bare land. The pixels are summed up together by the computer programme to give the total area of each feature for 1986, 2000, 2013 respectively.

The ground truth percentages (%) from the ground truth pixels determined were then calculated for the various years.

➢ *Error Analysis/Accuracy Assessment*

The error incurred in classifying objects rightly or wrongly are automatically determined by the computer using variance-covariance principles of Least Squares. The computer calculates the total accuracy of the classification using the ground truth information to give overall accuracy and Kappa coefficient. Kappa coefficient compares the total loss/gain (omission/commission) of the classification.

The Overall Accuracies are 79.452 for 1986, 73.0151 for 2000 and 89.1908 for 2013 while the Kappa Coefficients are 0.7410 for 1986, 0 for 2000 and 0.5673 for 2013.

III. RESULTS

The tables express the summary of findings while the graphs reveal the relationship between dependent and independent variables. The result of the analysis shows the state of the land use /land cover of the study area and also the status of the shoreline and the probable changes that had taken place within the shoreline during the specified period of time. The total area of observed changes along the shoreline was also determined. The results of the procedures and processes carried out during the research are presented below.

➢ *Overlay Operation*

The RTK-GPS Shoreline 2015 was then laid over the shoreline of the other years and shown in figures 3, 4, and 5

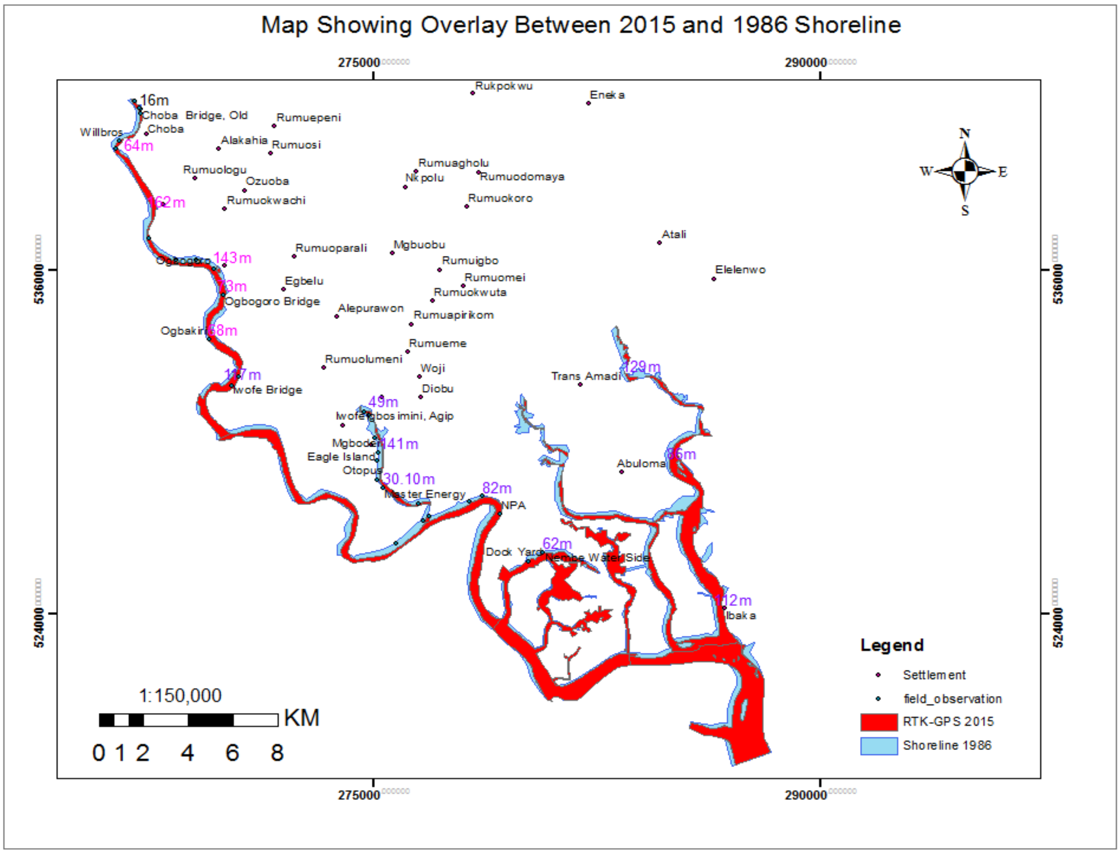

Fig 3: Overlay of 2015 and 1986 Shoreline

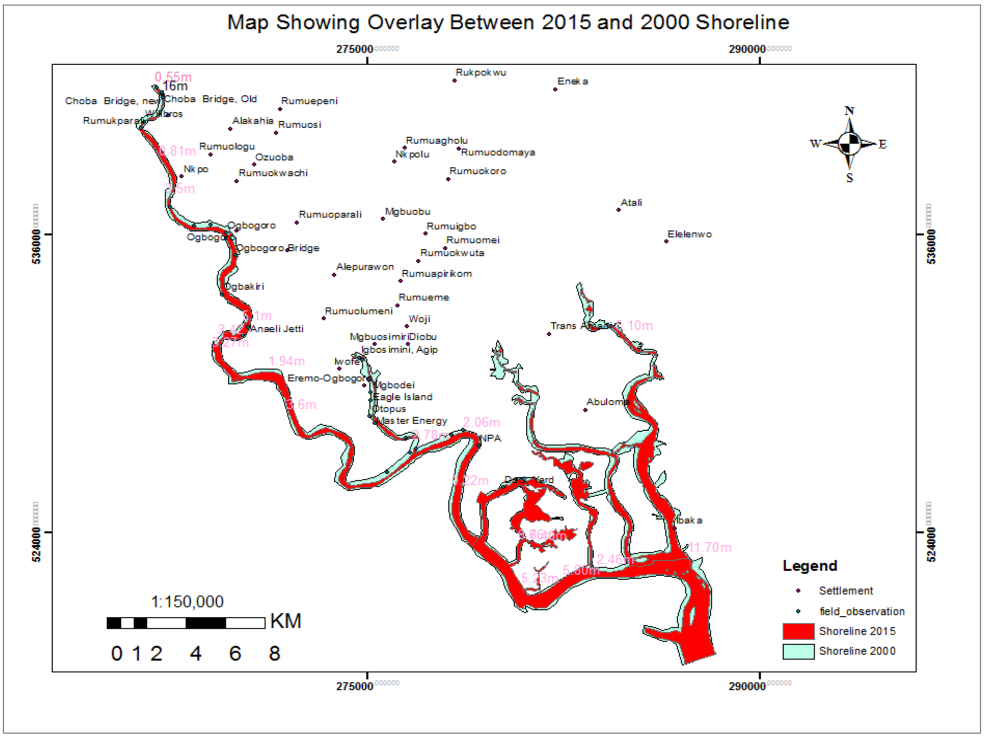

Fig 4: Overlay of 2015 and 2000 Shoreline

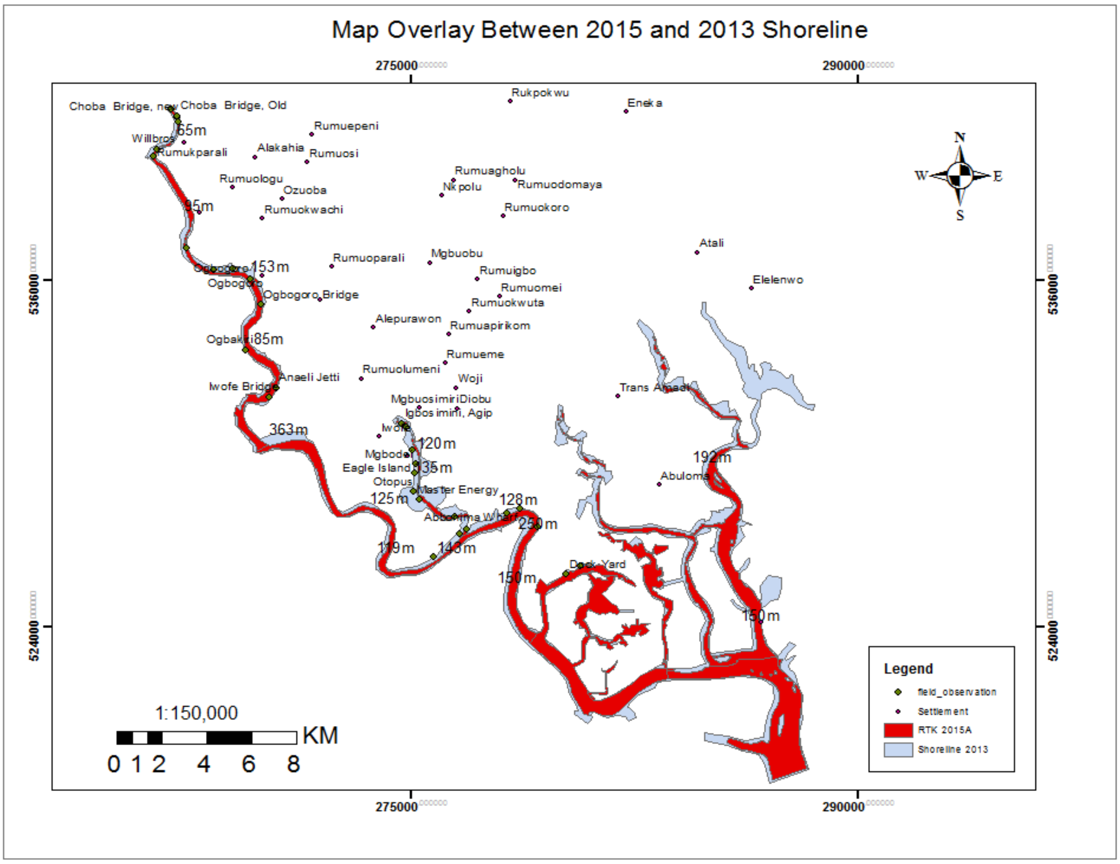

Fig 5: Overlay of 2015 and 2013 Shoreline

We also overlaid the images of 1986, 2000, and 2013 on the RTK-GPS observations of 2015 and highlighted the results at particular locations along the shoreline where we noticed great deal of human activities. They include Choba axis (figure 6), Ogbogoro-Iwofe axis (figure 7), Abuloma axis (figure 8) and Trans Amadi axis (figure 9).

At Choba, we observed the construction of a new bridge and manual dredging of sand using canoes. At Ogbogoro- Iwofe and Rumueme axis, we noticed the generation of high magnitude waves by heavy boats owned by oil companies used for oil/gas activities. At Abuloma, there was excavation for mud used to build houses and for positioning Tug boats. At Woji and Trans Amadi, we witnessed dredging activities.

Map Overlay of 1986 shoreline, 2000, 2013 and RTK at Choba axis

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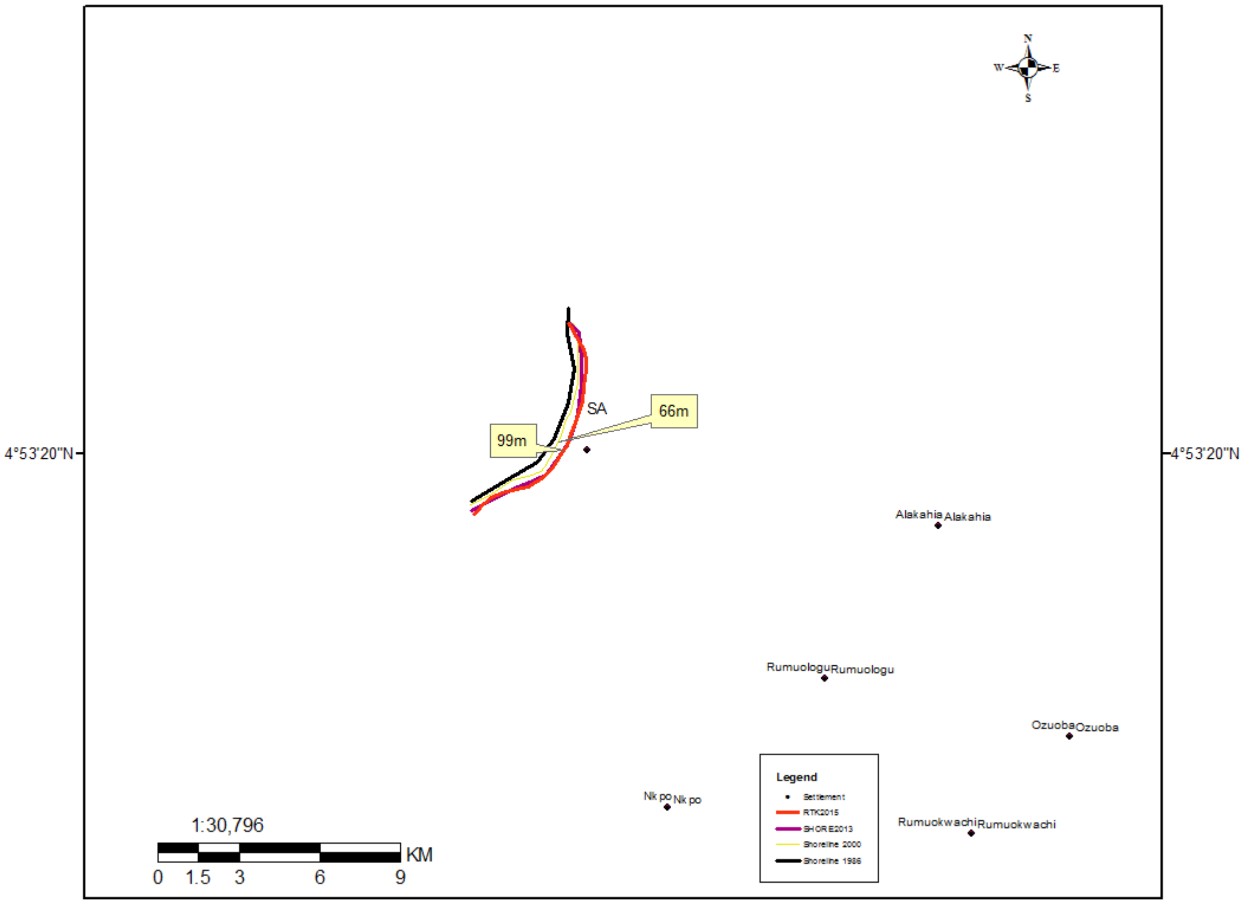

Fig 6: Overlay of 1986 shoreline, 2000, 2013 and RTK at Choba axis

At Choba, we noticed manual and machine sand dredging activities as well as the construction of a new bridge across the Choba River along the East/West Road. The presence of dilapidated tug boats of the defunct Wilbros Company were also indications of serious oil/gas activities in the Choba axis of the study area. The results show a change of 99m between 1986 and 2015, a change of 66m between 2000 and 2015

- *Map Overlay of 1986 shoreline, 2000, 2013 and RTK at Ogbogoro - Iwofe axis*

Beach erosion and accretion are predominant along Iwofe Town and Ogbogoro communities which were observed during field survey. The presence of Oil Companies such as Wilbos and Alico NIG. Ltd. also contribute to these ailing problems where their heavy boats along sea routes produces high magnitude of waves to cause accretion and the afore mentioned erosion. Evidence indicates that these areas of the shoreline are experiencing a seasonal reversal in the sand drift, but with a zero or near zero net drift over several years' span. Thus, shoreline changes call for jetty constructions and other Oil rig platform to enable exploration and exploitation activities within these areas of operation. It is also wholesome to note that other economic factor which developed sand drift is dredging. Dredging jobs are wide spread in the area under investigation because of its importance in the societal world. However, these operations are examined to bring changes in the shoreline. This accretion resulted mainly from the embayment formed between the jetty and the pre-jetty shoreline, the embayment becoming filled until the shoreline is straight and again in equilibrium with the waves such that there is a zero net sand drift. Computer model is developed to simulate the shoreline changes that occurred following construction of the jetties and plate form in the river mouth. The results show that between 2015 and 2000 there is a shift of 104m. More so, additive model is applied between 2015 and 1986, a difference of 209m was obtained (fig 7).

- *Map Overlay of 1986 shoreline, 2000, 2013 and RTK at Ogbogoro - Iwofe axis*

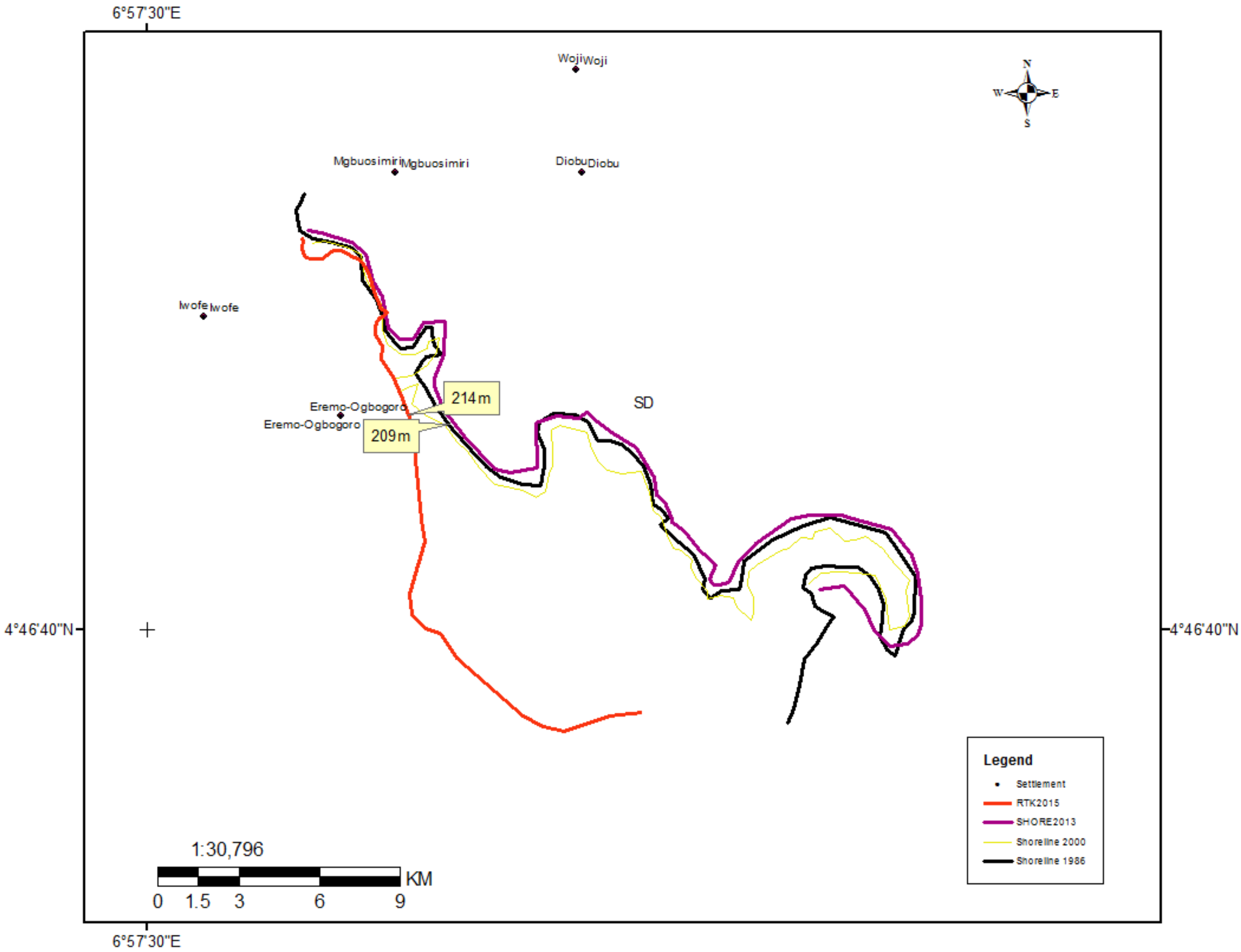

Fig 7: Overlay of 1986 shoreline, 2000, 2013 and RTK at Ogbogoro - Iwofe axis

The impact of human activities of dredging and excavation of earth for various domestic purposes at this axis show a serious change in the configuration of the shoreline. The results show a change of 214m between 1986 and 2015 and 209 m between 2000 and 2015.

Queuing diagrams are applied to model different combinations of shorelines at different periods. These models can be used to estimate shoreline differences applicable to the study to make stochastic revelation. Line weight of colours is assigned to various shorelines to bring a balance justification of real time kinematic analysis. Black stands for shoreline 1986, yellow for 2000, pink for 2013 and red for 2015. Reflection of shorelines from the satellite image considering 1986 to 2013 follow the same pattern of curve formation with little shift in some position shown in fig 8.

➢ *Map Overlay of 1986 shoreline, 2000, 2013 and RTK at Abuloma axis*

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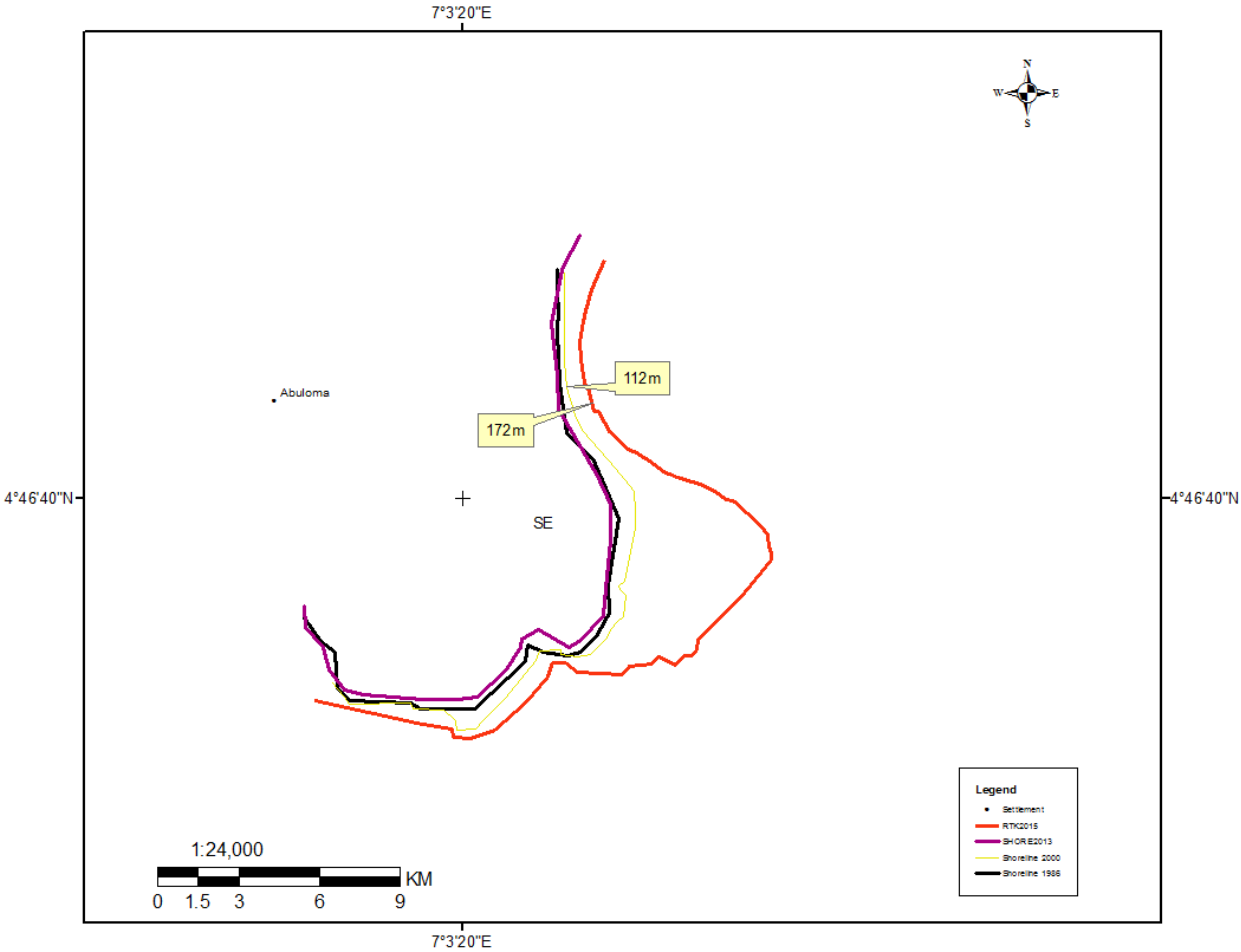

Fig 8: Overlay of 1986 shoreline, 2000, 2013 and RTK at Abuloma axis

RTK-GPS Survey also highlights the same pattern of curve but with a difference in link. Its difference is directed to human activities along the shore. Such activity comprises excavation of mud for thatch buildings for low-income earners and fisher men at Abuloma town. Some Companies within the vicinity also do engage in excavation processes for the purpose of their tug boats positioning. Results show that overlay of RTK and shore 2000 has a difference of 112m and 172m between 2015 and 1986.

- *Map Overlay of 1986 shoreline, 2000, 2013 and RTK at Trans-Amadi axis*

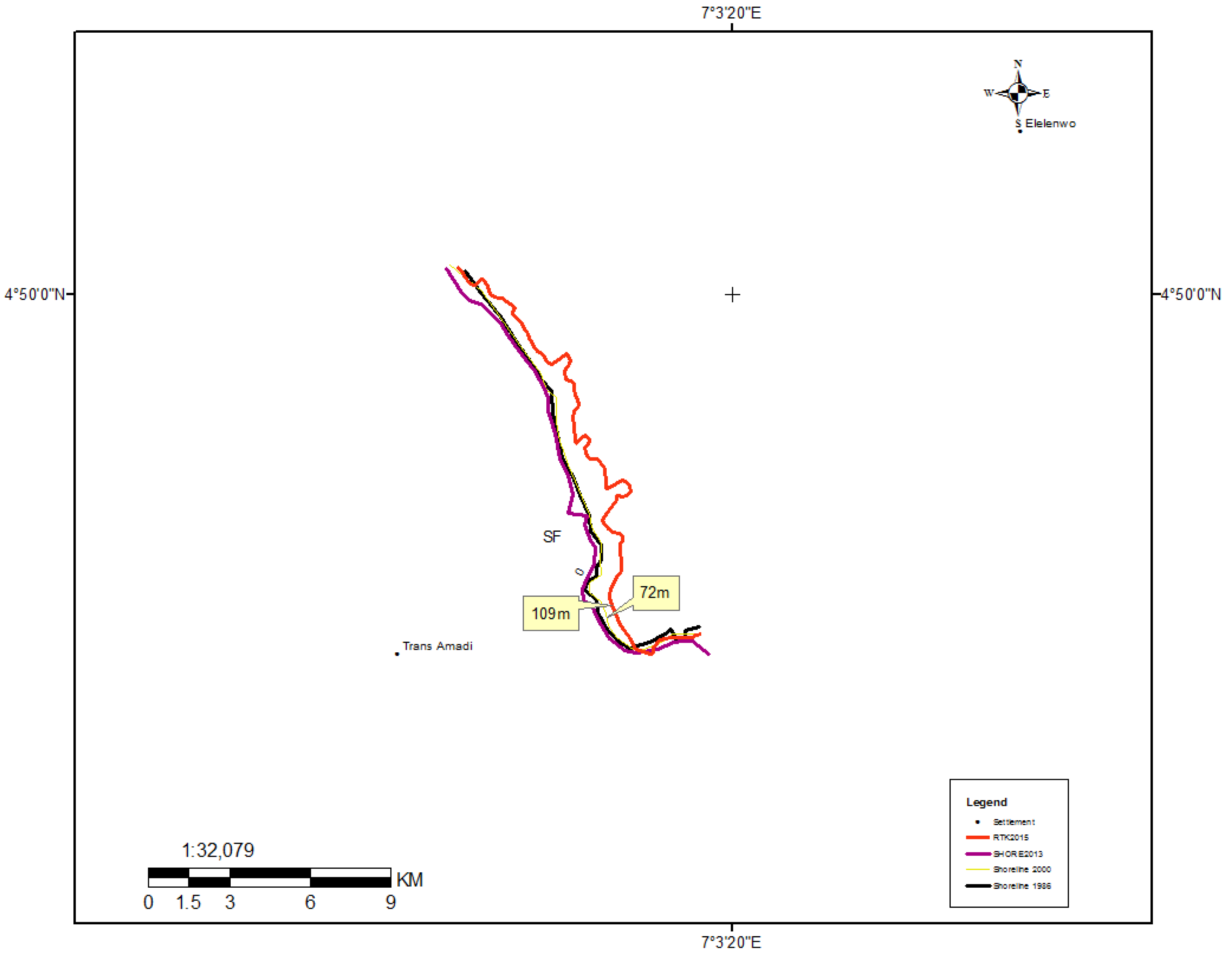

Fig 9: Overlay of 1986 shoreline, 2000, 2013 and RTK at Trans- Amadi axis

At this axis, massive dredging for sand was prevalent. A bridge was also constructed recently across the Woji and TransAmadi axis to link Woji and Elenwo communities of the study area. Results show changes of 72m and 109m between 2000 and 2015, and 1986 and 2015 respectively.

IV. CONCLUSION

The results show that human activities which include extraction of earth, construction of a bridge, dredging as well as waves generated by commercial activities of man have varying impacts on the shape and size of the shoreline.

LIMITATIONS OF THE STUDY

The 30m resolution satellite imagery was not good enough to map the shoreline.
We did not observe tides and could not ascertain tidal time from the imageries.

RECOMMENDATIONS

- High resolution imageries should be used for further studies to enhance accuracy of the project.
- A Shoreline Protection Agency should be set up and empowered to enforce relevant legislations and sanctions against dangerous human activities along the shoreline.
- iii Regular mapping of shorelines should be encouraged to avoid costly location of structures along the shore, and to assist with proper boundary definition especially for Riparian communities.

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