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Survey of Vegetation cover Changes in Forcados Area of the Niger Delta

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ABSTRACT: Time Lapse Analysis revealed that Water class changed slightly across the three epochs. The water class was 312.39km^2 in 1988, 312.55km^2 in 1998 and 312.81km^2 in 2008. Mature forest (Forest I) occupied 69.96 km^2 1988 and decreased continuously to 55.59 km^2 in 1998 and 41.9km^2 in 2008. Forest II (Secondary forest) was 3.43km^2 in 1988. This increased to 21.56km^2 in 1998 and 31.41km^2 in 2008. Mangrove class which covered 15.97km^2 in 1988 decreased to 10.76 km^2 in 1998 and 10.22km^2 in 2008. Stressed Vegetation occupied 2.42km^2 in 1988, and increased to 2.6 km^2 in 1998 and then increased to 3.33 km^2 in 2008. Urban/Industrial/Sand class increased across the epochs; from 1.94km^2 in 1988 to 3.05 km^2 in 1998, and 6.44km^2 in 2008. The major changes are the decline in the areal coverage of mature forest by about 21% between 1988 and 1998 and 40% from 1988-2008; phenonmenal increase of secondary forest by over 800% between 1988 and 2008; decline in the areal coverage of mangrove vegetation by about 37% from 1988-2008; and progressive increase in the area occupied by stressed vegetation by 7% from 1988-1998 and 38% from 1988-2008. The results of this study underscore the need for a field study to verify the results obtained from the unsupervised image classification carried out in this work. That some major changes have taken in the biophysical environment around Forcados between 1988 and 2008 is not in doubt from this study.© JASEM

Many, many human actions tend to have indelible imprints on landscape in a short time (Briassoulis, 2000; Goldewijk and Ramankutty, 2004; Fabiyi, 2007). Throughout history, human activities have impacted on the natural ecosystem through the aggressive drive for development (Goldewijk and Ramankutty, 2004). It has been estimated that over the last three centuries, more than 1200 million ha of forests and wood lands have been cleared. Grassland and pastures have diminished by about 560 million ha and cropland areas have increased by about 1200 million ha (Richard and Flint, 1994). Human actions especially those involving biomass fuel consumption, land-use change, and agricultural activities have direct interaction with the land surface and negative consequences on vegetation and environmental qualities (Fabiyi, 2011). These interactions are rather complex and have attracted research interest in the last four decades (Goldewijk and Ramankutty, 2004).

The Niger Delta region in Nigeria had its share of negative influence of human activities on the natural landscape. The primary vegetation of the delta is fast changing to secondary and derived vegetation due to aggressive incursion of human activities into the seemingly undisturbed ecosystem that characterized the region about a century ago. Human activities including oil exploration and urban development are causing imbalances in the ecosystems of the region with resultant negative consequences on environmental quality and livability (Fabiyi, 2011). The extent of these environmental alterations has prompted different concerns including political agitations with respect to the social, economic and cultural consequences of the changes that are taking place. The oil multinational companies operating in the Niger Delta area have been fingered as the main change actors by especially the activist and environmentalists. The United Nations Development Programme reported that whereas the Niger Delta has an enormously rich natural endowment in the form of land, water, forests and fauna, these assets, however, have been subjected to extreme degradation due to oil prospecting. For many people, this loss has been a direct route into poverty, as natural resources have traditionally been primary sources of sustenance" (UNDP, Niger Delta Human Development Report, 2006).

Several forces are responsible for the changes in vegetation quality observed in the Niger Delta. Settlement developments, oil prospecting over the years imprint indelibly on the Niger Delta fragile canvas of the ecosystem. The main visible impact is the change in land use and vegetal cover. Human systems is a part of natural ecosystems but the activities that support human enterprises unfortunately damage the natural landscape of the Niger Delta is in the coastal belt of Nigeria, it is characterized by fragile ecosystems including mangrove, nypa palm, fresh water swamp, sheltered tidal flat and large expanse of vegetated bluff. Niger Delta is home

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to different fauna and flora species (some of which are in endangered list of IUCN) yet with about 31 million populations in an area of about – square kilometers. The Niger Delta combined the presence of oil rich hydrocarbon deposit with the rich alluvium and the abundance of aquatic life to make the place attractive to rapid expansion. The intense urbanization and industrialization that followed the discovery of oil at Oloibiri in the present day Bayelsa state in 1956, have many consequences on the landscape of the Niger Delta, for example enlargement of natural coastal inlets and dredging of waterways for navigation, port facilities, and oil and gas pipelines have direct impact on the fragile coastal ecosystems. The visible manifestations of these anthropogenic activities include loss of biodiversity and essentially deforestation, environmental degradation, loss in vegetal qualities and soil nutrient loss. A number of large scale and cottage industries sprang up in the last thirty years thereby contributing to environmental degradation of the Niger Delta (Fabiyi, 2011).

Other activities such as sand mining, hydrocarbon production like oil and gas, introduction of invasive species (nypa Palm) and engineering constructions such as jetty, seawalls and channelization are few among numerous activities taking place in the region. Apart from the various human induced changes in the ecosystems of the Niger Delta, the global climatic change is another significant change factor in the Delta. These drivers are responsible for long term modification of the coastal ecosystem including the Niger Delta. Though deforestation and apparent change in vegetal qualities are major land use/ land cover changes occurring in many coastal regions of African countries. The impacts of human activities within the coastal region, and the climate change effects are difficult to separate into different compartments (Fabiyi, 2011).

On a continental or global level, climatic fluctuations have been linked to the anthropogenic activities through the release of green house gas into the atmosphere, thus depleting the ozone layer. Effects of climate change have been measured in the continental or regional levels through sea level rise, melting of the icecap, increased rainfall and associated flooding in the low lying areas. In the sub local analyses context, the influence of human activities on the landscape can be directly measured through different approaches such as remote sensing and geographic information system (GIS) techniques (Fabiyi, 2011). Recent research discourse focuses on the ways to identify the extent of human influence on the global climate change from the normal perturbation associated with climatic cycle and to what extent will the global warming be reduced with the cutting down of carbon emission by industrialized nations. In the supra local context, it is necessary to separate the impact of the immediate anthropogenic actors on the ecosystems from the changes due to climate changes.

Several methods have been used to measure vegetation cover loss (DeFries et al., 1995). The methods require the definition of the thresholds and classification of the vegetation around the threshold based on some pre-determined schemes. This approach has been fraught with practical inefficiency, especially if there is a need to monitor changes over time. Other methods include the following authors‟ approaches (Copeland et al., 1996; Bonan, 1999; Houghton, 1999; Postel et al., 1996; Vitousek et al., 1997). Normalized difference of the vegetation index (NDVI) became popular in the last three decades to investigating the quality of vegetal cover. The normalized difference of the vegetation index (NDVI) is a non-linear transformation of the visible (red) and near-infrared bands of satellite information. It is an alternative measure of vegetation amount and condition. It is associated with vegetation canopy characteristics such as biomass, leaf area index and percentage of vegetation cover. NDVI is mathematically defined as: nir-red/ nir+red (Near infrared band – red band/ near infrared band + red band) Previous studies have used Channels 1 (0.54 to 0.68 m) and 2 (0.73 to 1.10 mm) which are visible and near infrared of the advanced very high resolution radiometer (AVHRR) data (Groten, 1993; Loveland et al, 1991) other works on the use of NDVI to monitor vegetal changes include. Other studies linked NDVI to plant phenology (Defries et al., 1995; Read and Lam, 2002; Mora and Iverson, 1995). Apart from AVHRR NDVI have been calculated from LANDSAT-TM information using bands 3 (0.63 to 0.69 mm) and 4 (0.76 to 0.90 mm). NDVI values range from -1 to +1 for pixel values ranging between 0 to 255.

NDVI, which is one of the most successful of many attempts to simply and quickly identify vegetated areas and their "condition" is utilized in this study which employs Remote Sensing and Geographic information Systems (GIS) in mapping and analyzing Land use/land cover changes within the Forcados area within the last 20 years. Land use /Land cover change (LCC) which is recognized as one of the most sensitive indicators of environmental change reflects the impacts of human activities on the biophysical environment. The impact of activities relating to oil and gas exploration may generate some significant effects on the environment, such as loss of wildlife habitat, changes in surface and subsoil hydrology that may lead to accelerated soil erosion and land degradation, vegetation changes, air pollution and changes in coastline geomorphology.

ATERIALS AND METHODS

The Forcados area of interest covers an area of approximately 406.11km^2 and it has bounding coordinates of 300695.32E- 322815.32E and 146276.47N-164636.47N in Transverse Mercator Nigerian Westbelt projection and Minna datum. The datasets used for the project were relatively free of negative atmospheric influences such as cloud cover and atmospheric haze. A number of processing algorithms were used to obtain the natural colour composite image, land cover classification and normalized difference vegetation Index. A short description is given of each of the processing methods used and interpretation included. Further processing was carried out to delineate areas of vegetative growth and land cover type in the area of interest.

Scope of Study: The study is limited to baseline information remote sensing and GIS, based on change analysis of areas lying within the Forcados_-Afremo Area of Interest.(AOI) Spatial and satellite data used for the study were sourced from the Shell Petroleum Development Company (SPDC). The scope of the study entailed

Generating a natural colour composite of the Forcados-Afremo area of interest for three epochs

Developing a land cover classification of the Forcados-Afremo area of interest for three epochs.

Developing a normalized difference vegetation Index of the Forcados -Afremo area of interest for three epochs.

Derive a change representation in land use pattern from 1988 to 2008

Landsat TM dataset of 1988, SPOT XI dataset of 1998 and SPOT5 of 2008 datasets were used. These satellite images were processed and the different land cover types obtained.

RESULTS AND DISCUSSION

The Study area covers an area of approximately 406.11 km^2. It lies within the Warri South -West and Buturu Local Government Areas in Delta state. It is topographically relatively flat with a great extent of the AOI lying within the ocean. The land cover consists of six types: Water, Matured forest (Forest I), Secondary forest (Forest II), Mangrove, Stressed Vegetation, and Urban/Industrial/Sand, There are a number of pipelines running through the study area. They include 24" Forcados-Yokri Spur line, Escravos-Forcados Trunk line, Forcados Terminal-Forcados Off shore , Forcados S/B- Forcados Terminal, Afremo A Delivery line (Low Pressure line)- (8" Low Pressure line from Afermo A to ESCB F), Forcados Estuary F/S –Forcados S/B manifold, FODPA replacement gasline, Brass creek manifold-Forcados Terminal, 24" Export Gasline Trunk Line, Otumara manifold - Escravos manifold Forcados-Rapele Trunk line.

There are two SPDC fields: Forcados-Yokri and Afremo fields. A section of Urmeme – Yokri forest reserve lies within the study area. The settlements within the study area include York, Olusumere, Obabebe, Yorki Sobo, Ijaw fish, Kontu, Akantu, Yorki Sobo, Yorki egbe, kuku camp, Oguagbene, Abora, Oguliaga, Okuntu, Yobebe, and Oguligba.

The study area has average daily temperature of 30^{o}C with an average annual area precipitation of 210mm with two rainfall peak months in June and September.

Land cover Classification: A Land cover classification was carried out over the Forcados - Afremo project area for three epochs using the Landsat TM 1988, SPOT XI 1998, and SPOT5 of 2008. An unsupervised classification process, which uses an iterative ISOclass algorithm to generate a number of classes pre-defined by the processor, was used. This unsupervised classification technique, groups similar pixels based on the spectral characteristics of the image datasets. This method does not require any prior knowledge of the land cover types in the area of interest. The following parameters were used for the unsupervised classification process: 98% unchanged, maximum standard deviation 4.5, minimum distance between class means 3.2. The iterative ISOclass processes were carried out on the Landsat TM, SPOT XI, and SPOT5 datasets. Six main classes were identified using the unsupervised classification technique. These are Water, Forest I (Mature forest), Forest II (Secondary forest), Mangrove, Stressed Vegetation and Urban/Industrial/sand.

The landcover statistics of the Forcados area for 1998 is as shown by Table 4 and Figure 3.

This was used in highlighting areas showing the different levels of vegetation health. This process can be achieved by applying the vegetation formula to the image. A normalized difference vegetation index is a ratio of Near Infrared (NIR) and Red bands. The formula is presented below DN (out) = (band 1 – band 4)/ (band 1 + band 4)

An NDVI lookup table was applied to the image. It was observed that The areas with high NDVI values for the entire epochs are Mangrove, Mature forest (forest I); and Secondary forests (forest II) depicted in green, yellow and orange. The water, Mangrove Stressed vegetation and Urban/Industrial are in purple and blue showing low NDVI.

Land-us: The Forcados area has gradually become very prominent for several petroleum E and P related activities, both in the up and down stream sectors. Agriculture is only a pastime occupation in the area. Generally, agricultural and fishing sectors are fast giving way to petroleum industry even though the potentials for the former abound in the area. Although there is a high concentration of economic trees such as Oil palm, large timber trees and coconut, the demand on land for agricultural purposes is very minimal with less than 0.5% of the land having cultivated crops. Only a very negligible percentage of the people are involved in fishing. This trend will be much reduced with further petroleum development projects coming on stream in the area.

Soil As Support System: Generally the soils have relatively very good physical features that would sustain foundations and other structural developments. The soils are moderately to imperfectly drained with texture of sandy loam to silty loam on top and changing to sandy loam in the subsoil. Landscape and pedological features of the area make the soils easy to manage. There are no had pan layers within 1.5m making the soil deep and penetrable. Threats of erosion and flooding are minimal.

Vegetation: The vegetation is a function of the soil type, relief pattern and prevailing climatic condition. The status of the vegetation plays a prominent role in the environmental quality of an area. Various oil exploration and production activities and processes in turn affect the properties of the surrounding vegetation in the area.

The objectives of the investigation on vegetation are to establish the status of the existing vegetation in the North Bank area, to highlight the resource use/potentials, and to evaluate the vulnerability of the vegetation to the activities associated with the FYIP in the area.

The vegetation and wildlife assessment was restricted to the 81.1 hectares proposed CPF and CCP site in the North Bank. An inventory of the dominant plant and wildlife species within this area was conducted.

Characterisation, identification, classification and study on the structure of plant communities were made on – sight. A checklist of common forest trees / plants in the study area are shown in Table 6. Photographs of some vegetation types in the area are shown in Plates 1 – 4.

Structure, Floristic Composition and Distribution of Vegetation: The study area is a rain forest area of between 40 –50m high. Though the forest is dominated by *Elaeis guineensis* (Oil palm), its floristic composition is diverse in species and consists of typical genera of the transitional and wet series, and also several shrubby lianes and herbaceous species. Representative species include *Ceiba pentandra, Lophira alata, Chlorophora excelsa, Bombax buonopozense, Sterculia tragacantha, Bligha sapida, Piptadeniastrum africanum, Cleiostopholis patens, Alstonia boonei, Acio bateri, Dichrostachys cinerea* and *Cynometra megalophylla.* Others are *Harungana madagascariensis, Musanga cecropioides*, *Symphonia globulifera, Uapaca heudelotii, Entandrophragma cylindicum*, *Terminalia superba* and *Cola* sp. The forest has suffered a lot of disturbances from occasional transect line cuttings and other oil related activities, lumbering, felling of trees by locals and such economic activities as hunting. However, the structure and physiognomy of the forest is still distinctly similar to most tropical rain forest.

The forest is characterised by three distinct canopy layers. The first canopy layer (stratum) consists of very large and tall trees reaching 50m high and above and with crowns up to 30m wide. The floristic composition of this layer is represented by *Piptadeniasatrum africanum*, *Ceiba pentandra, Lophira alata, Bombax buonopozense, Irvingia sp., E. cyclindricum, Terminalia superba* and *Alstonia boonei*. Species in this stratum mostly possess plank-like buttresses, and are visibly raised above other species and scattered in occurrence throughout the forest. They have flattened or umbrellashaped canopies (crowns) which are rarely in lateral contact with each other.

The second stratum is characterised by tree species 35 – 40m high. The stratum is open though occasional contacts of crowns of some species do occur. Characteristic species of this stratum (canopy layer) include S*ymphonia globulifera, Funtumia elastica, Parinari sp, Cleiostopholis patens, Nauclea pobegunii, Funtumia africana* and few stands of *E. guineensis*. Species of this stratum have narrower crowns and are more diverse in floristic composition than the first stratum.

The third stratum is characterised by trees 20 – 30m high with closed canopies (there is canopy to canopy contact) between species. This layer is dominated by *E. guineensis,* which formed a mosaic at several places especially along the edges or fringes of the right-of-way. The tree species characteristically possess small conical and continuous crowns which visibly touch each other. Other common species are *Mitragyna ciliata, Sterculia tragacantha, Bligha sapida, Baphia nitida, Chrysobalanus orbicularis, Musanga cecropioids* and *Anthocleista vogelii*. Others include *Uapaca heudelotii, Cynometra megalophylla* and some young species of the second stratum.

The forest is complete by a layer of shrubs, climbing lianes and other herbaceous perennials which associate with others at very close ranges to produce a thick, crowded and easily inaccessible layer. Many species in this stratum offer several medicinal uses, industrial ropes, utensils and also provide forest stabilization. They include *Alchornea cordifolia, Anthocleista vogelii, Mussaenda erythrophylla, Psychortria sp., Baphia sp., Diplazium sp., Aframomum sp., Palisota hisurta, Maranthoclea sp.* and some young stands of *E. guineensis.*

The utilisation potentials of the brackish and freshwater swamp forests of Nigeria have been documented by Okigbo (1984), Kinako (1970, 1977). These authors have reported that the forests of the Nigerian coastline, including the Forcados Yokri, are stores of commercial and economic fuel and timber, industrial dyes and tannins trees, vegetable, edible fruits, nuts and seed trees, economic wine and gin plants, medicinal plants, weeds and other household and furniture utensils.

time-lapse change analysis: Time-lapse analysis is used for assessing changes in an area within a period of time with respect to the land cover classification, and Normalized Difference Vegetation Index. Time-lapse analysis was carried out on Forcado-Afremo area of interest using Landsat TM of 1988, SPOT XI of 1998 and SPOT5 of 2008. Statistical changes that have occurred within the past years in the form of transformations from one land cover class to another is given in Table 1.

The NDVI results show that areas which were covered by mangrove in 1988 and 1998 and had High NDVI now have low NDVI because the land cover class has changed to stressed vegetation while the areas initially occupied by mature and secondary forest but later changed to Urban/Industrial/Sand class now have low NDVI.

Conclusions: The land cover change detection summary over area of study between 1988 and 2008 is as follows:

The Time Lapse Analysis revealed that Water class increased slightly across the three epochs. The water class was 312.39km^2 in 1988, 312.55km^2 in 1998 and 312.81km^2 in 2008.The increase from 312.55km^2 to 312.81km^2 is due to some area covered by stressed vegetation that changed to water logged area and some forest 1 (mature forest) vegetation also changed to water logged area (see Table 8 Change 2 and Change 1).When flooding occurs, the flooded area will be recorded as water body by the satellite imagery.

Forest I (Mature forest) was 69.96 km^2 1988 and decreased to 55.59 km^2 in 1998 then decreased further to 41.9km^2 in 2008.This was due to human activities such as settlement development around Yokri Egbe and Yokri Sobo (See Table 8: Change 3 and Change 5).

Forest II (Secondary Forest) was 3.43km^2 in 1988, it increased to 21.56km^2 in 1998 and further increased to 31.41km^2 in 2008. This is due to Forest 1(Mature forest) being depleted to Secondary forest as a result of human activities.

Mangrove class which covered 15.97km^2 in 1988 decreased to 10.76 km^2 in 1998 and then decreased further to 10.22km^2 to 2008. The progressive reduction in the mangrove class is as a result of the mangrove changing to stressed vegetation (See Table 8: Change 3 and Change 4).

Stressed Vegetation occupied 2.42km^2 in 1988, and increased to 2.6 km^2 in 1998 and then increased to 3.33 km^2 in 2008.The increase in stressed vegetation is due to Mangrove class around Olusumere and Yokri Egbe changing to Stressed vegetation. (See Table 8: Change 3 and Change 6).

Urban/Industrial/Sand class increased across the epochs. It occupied 1.94km^2 1988, 3.05 km^2 in 1998, and 6.44km^2 in 2008. This is due to Urban/Industrial/Sand class increase around Yokri Egbe and Yokri Sobo (See Change 2 and Change 5).

Normalized Difference Vegetation Index, showed that areas whose spectral signatures are green, orange and yellow are Mangrove, Mature forest, Secondary forest and Mangrove. The areas with spectral signatures in purple and blue are water, Stressed vegetation and Urban/industrial/Sand.

This study of spatial trend analysis of Forcados area shows that the major changes are the decline in the areal coverage of mature forest by about 21% between 1988 and 1998 and 40% from 1988-2008; phenonmenal increase of secondary forest by over 800% between 1988 and 2008; decline in the areal coverage of mangrove vegetation by about 37% from 1988-2008; and progressive increase in the area occupied by stressed vegetation by 7% from 1988-1998 and 38% from 1988-2008.

Table 1: The spatial trend analysis of Forcados Area (1988-2008)

Land cover Types	1988 (in km$^{2)}$	1998(in Km$^{2)}$	2008 (in km$^{2)}$	% Increase/Decrease (1988-2008)*	% Increase/Decrease 1988-1998*
Water	312.39	312.55	312.81	0.13	0.05
Forest I(Mature Forest)	69.96	55.59	41.9	-40.11	-20.54
Forest II(secondary Forest)	3.43	21.56	31.41	815.74	528.57
Mangrove	15.97	10.76	10.22	-36.01	-32.62
Stressed Vegetation	2.42	2.6	3.33	37.60	7.44
Sand/Urban/Industrial	1.94	3.05	6.44	231.96	57.22
Total	406.11	406.11	406.11		

*Percentage increase is depicted by + while Percentage decrease is depicted by –

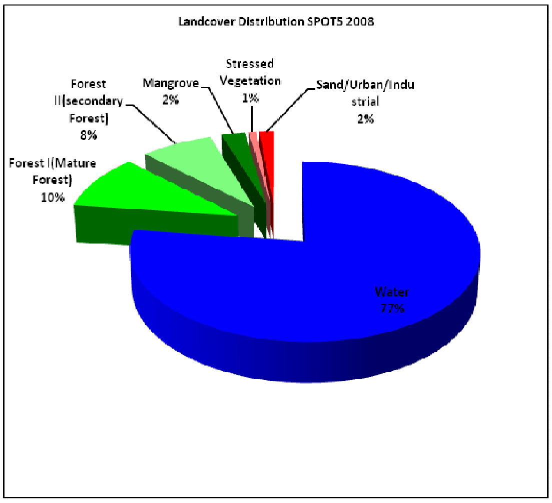


Fig: 3. Areal Extent of cover types in 1988

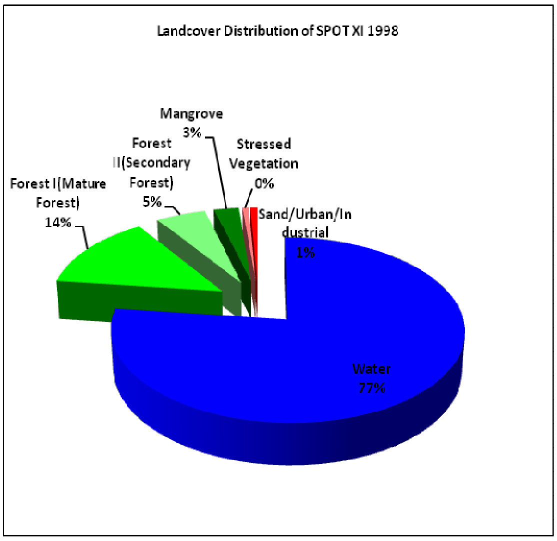


Fig: 4. Areal Extent of cover types in 1988

Table 2: Datasets used for the Study

Data Type	Description	Date of Acquisition
Satellite Image Dataset	Landsat TM scenes covering the delta. The dataset has a Ground Pixel Dimension of 25 meters and the spectral range of the land sat TM dataset covers the red and green of the visible part of the electromagnetic spectrum, NIR, Near Infra-Red and SWIR, Short Wave Infra-Red. Band 1: 0.45-0.52 µm Band 2: 0.52-0.60 µm Band 3: 0.63-0.69 µm Band 4:NIR:0.76-0.90 µm Band 5:SWIR: 1.55-1.75 µm Band 7:SWIR: 2.08-2.35 µm	6th January, 1988
	SPOT XI scenes covering the delta. The dataset has a Ground Pixel Dimension of 20 metres and the spectral range of the SPOT XI dataset covers the red and green of the visible part of the electromagnetic spectrum, NIR, Near Infra-Red and SWIR, Short Wave Infra-Red. Band 1: 0.50-0.59 µm (Green) Band 2: 0.61-0.68 µm(red) Band 3:NIR:0.79-0.89 µm Band 4:SWIR: 1.58-1.75 µm	20th December, 1998
	SPOT5 scenes covering dataset and 10m Ground Pixel Dimension for the 2007 datasets and the spectral range of the land sat ETM dataset covers the red and green of the visible part of the electromagnetic spectrum, NIR, Near Infra-Red and SWIR, Short Wave Infra-Red. Band 1: 0.45-0.52 µm (blue) Band 2: 0.52-0.60 µm (green) Band 3: 0.63-0.69 µm(red) Band 4:NIR:0.76-0.90 µm Band 5:SWIR: 1.55-1.75 µm Band 7:SWIR: 2.08-2.35 µm	29th,January,2008
GIS datasets	Vector dataset in ER Mapper erv format of town names and SPDC right of way data for area of interest and location purposes. Derived from SPDC master geo-database.	Historical & ongoing

Table 3: Landcover area summary for the 2008 analysis

Land cover Types	Area km^2	%
Water	312.81	77.03
Forest I(Mature Forest)	41.9	10.32
Forest II(secondary Forest)	31.41	7.73
Mangrove	10.22	2.52
Stressed Vegetation	3.33	0.82
Sand/Urban/Industrial	6.44	1.58
Total	406.11	100

Table 4: Land cover area summary for the 1998 Analysis

Land cover Types	Area km^2	%
Water	312.55	76.96
Forest I (Mature Forest)	55.59	13.69
Forest II (Secondary Forest)	21.56	5.31
Mangrove	10.76	2.65
Stressed Vegetation	2.60	0.64
Sand/Urban/Industrial	3.05	0.75
Total	406.11	100

Table 5: Land cover area summary for the 1988 Analysis

Land cover Types	Area km^2	%
Water	312.39	76.82
Forest I (Mature Forest)	69.96	17.22
Forest II (Secondary Forest)	3.43	0.85
Mangrove	15.97	3.93
Stressed Vegetation	2.42	0.25
Urban\Industrial\Sand	1.94	0.48
Total	406.11	100

Fig 5a: Natural Colour Composite (1988)

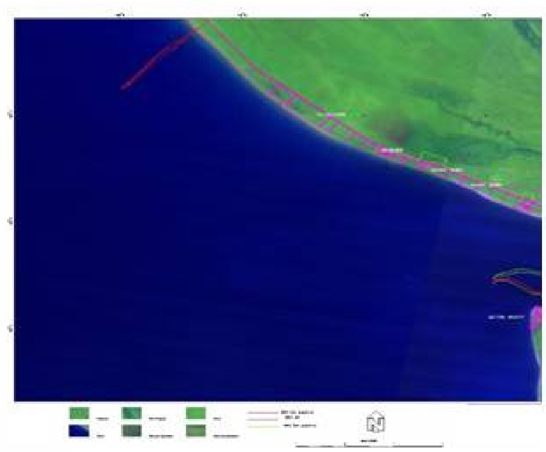


Fig 5b: Natural Colour Composite (1988)

Table 6: Checklist of Common Forest Trees / Plants in the Forcados Area

SPECIES	COMMON NAME	USES / ECONOMIC IMPORTANCE.
Elaeis guineensis	Oil palm	Source of red palm oil, palm wine, fiber and soap manufacture.
Uapaca heudelotii	Uapaca	Edible fruits, carpentry and general construction, commercial charcoal.
Dichrostachys cinera	Marabou thorn	For making tool handler, walking sticks and cudgels.
Parinari excelsa	Rough –skinned plum	Hard and heavy timber, for furniture; excellent for railway sleepers; commercial tannin.
Acio barteri	Monkey fruit	Fire wood; fruits eaten by wild animals.
Sterculia tragacantha	African tragacanth	Good softwood and source of different adhesives and gum.
Bligha sapida	Akee apple	Source of akee apple and wood.
Ceiba pentandra	Kapok or cotton tree	Produces Kapok (cotton); canoe and boat building.
Piptadeniastrum africanum	False sasswood	Wood for construction and joinery wood; medicinal.
Terminalia superba	Afara	Soft wood for general furniture.
Bombax buonopozense	Red silk cotton tree / bombax	Soft wood used to make canoes and water troughs; proposed for aircraft construction, source of pulp and paper.
Cleostopholis patens	Canoe wood	Sold as timber; for canoe making.
Alstonia boonei	Pattern wood / alstonia	Timber of commerce; canoe carving and general furniture.
Cynometra megalophylla	-	Termite-proof wood used in house building, frames, posts.
Harungana madagascariensis	Hog gum tree	For fire wood
Musanga cecropioides	Umbrella tree	Soft wood sold as timber, used for making household utensils.
Chlorophora excelsa	Iroko	Commercial timber wood.
Cola sp.	-	Timber species
Entandrophragma cyclindricum	Sapele mahogany	Economic important and commercial timber wood
Funtumia sp.	Bush rubber tree	For household utensils, match manufacture, commercial latex.
Mitragyna stipulosa	Abura timber	For electricity poles; house hold utensils, timber.
Anthocleista vogelii	Cabbage tree	Medicinal; leaves used locally and commercially for wrapping.
Lophira alata	Red iron tree	Hard wood used for heavy constructional works, making laboratory benches; seed produces an important oil "Meni oil" used in soap manufacture & lamp oil.
Alchornea cordifolia	Christmas bush	Medicinal plant.
Ancistrophyllum secondifolia	Climbing palm	For commercial rope manufacture, constructing cane chairs and racks.
Rauvolfia sp.	-	Medicinal plant; bark contains fiber used in making bow-strings.
Baphia sp.	Camwood tree	Source of dye and medicine.
Nauclea pobeguinii	Opepe	Medicinal; valuable commercial and industrial wood.
Carapa procera	Crab wood	Produces gum resin; medicinal.
Chrysobalanus orbicularis	Coco plum / icaco	Source of heavy timber; used in erosion control.
Spondias mombin	Hog plum	Highly medicinal; edible fruits; wood ash used in making soap.

Table 7: Land cover area summary for the three Epochs

Land cover Types	1988(km^2)	1998(km^2)	2008(km^2)
Water	312.39	312.55	312.81
Forest I(Mature Forest)	69.96	55.59	41.9
Forest II(secondary Forest)	3.43	21.56	31.41
Mangrove	15.97	10.761	10.22
Stressed Vegetation	2.42	2.599	3.33
Sand/Urban/Industrial	1.94	3.05	6.44
Total	406.11	406.11	406.11

Table 8: Land use and Land cover Profile changes

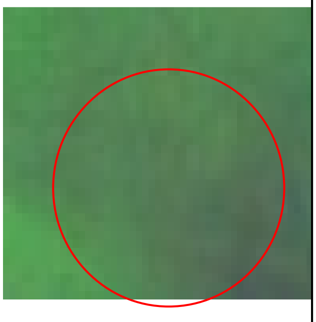
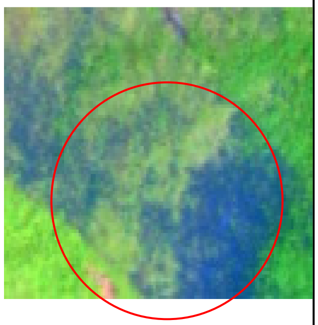
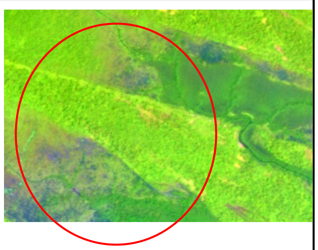
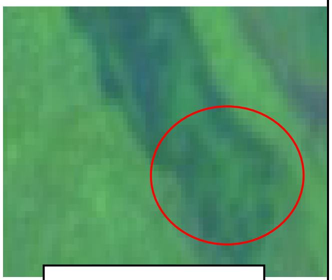
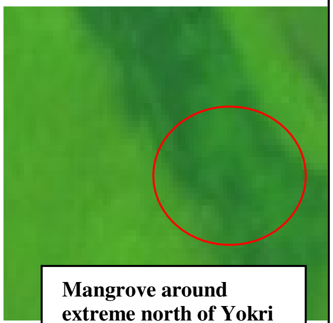
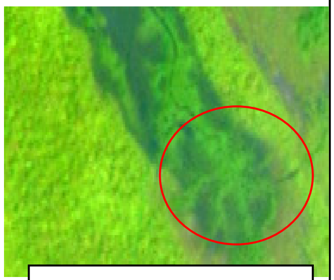
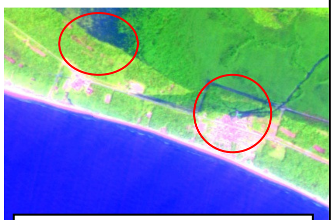
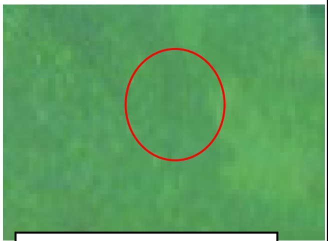
Change 1	 **Stressed vegetation around Mbabane (1988).**	 **Stressed vegetation around Mbabane (1998).**	 **Stressed vegetation around Mbabane turned to water logged area (2008).**
Change 2	 **1. Mature forest around Yokri Egbe** **2. Sparse settlement around Yokri (1988).**	 **1. Mature forest around Yokri Egbe** **2. Sparse settlement around Yokri (1998).**	 **1. Mature forest around Yokri Egbe turns water logged** **2. Increased settlement around Yokri (2008).**
Change 3	 **Mangrove Vegetation around Olusumere (1988).**	 **Mangrove Vegetation around Olusumere gradually turns to stressed vegetation (1998).**	 **Mangrove Vegetation Olusumere turns to stressed vegetation (2008).**

Table 8 Cont': Land use and Land cover Profile changes

Change 4	 **Mangrove around extreme north of Yokri Egbe (1988).**	 **Mangrove around extreme north of Yokri Egbe (1998).**	 **Mangrove around extreme north of Yokri Egbe turns to stressed vegetation (2008).**
Change 5	 **1. Stressed Vegetation around north of Obababe** **2. Settlement around Yokri Sobo (1988).**	 **1. Stressed Vegetation around north of Obababe** **2. Settlement around Yokri Sobo (1998).**	 **1. Stressed Vegetation around north of Obababe becomes water logged.** **2. Settlement around**
Change 6	 **Mangrove around Yokki Egbe (1988).**	 **Mangrove around Yokki Egbe (1998).**	 **Mangrove around changes Yokki Egbe to Open vegetation (2008).**

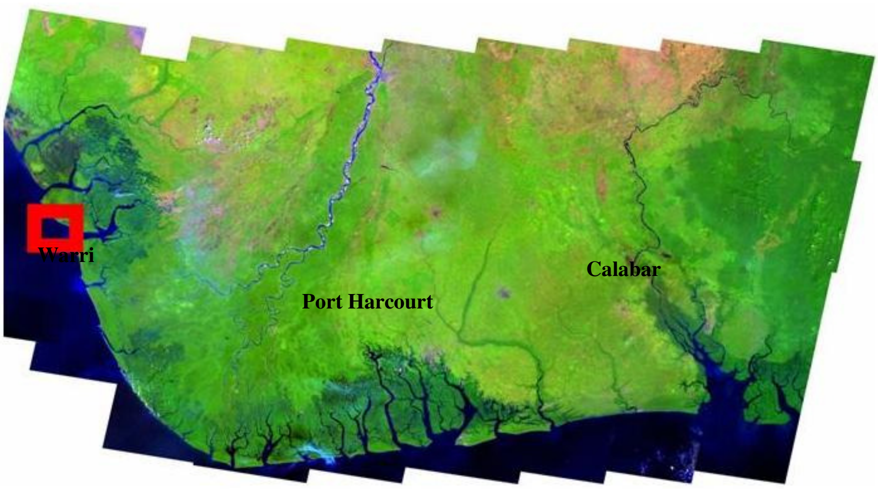


Fig 1: Mosaiced Satellite Images of Niger Delta showing the study area.

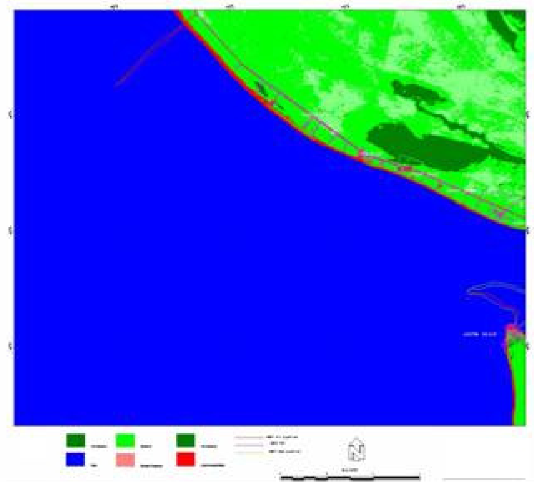


Fig 5c Natural Colour Composite (2008)

Fig 6a Natural Colour Composite (2008)

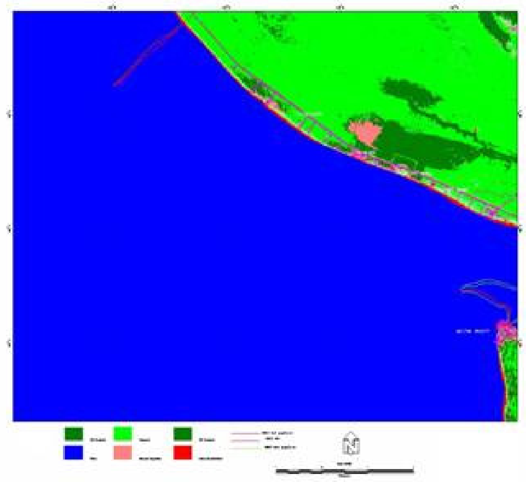


Fig 6b: Land Cover Classifaication (1998)

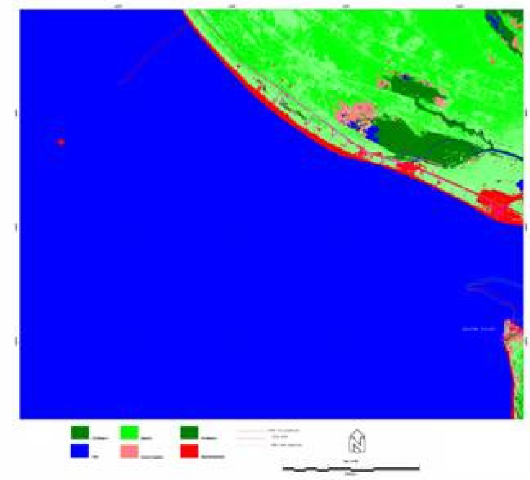


Fig 6c: NDVI Classification (1988)

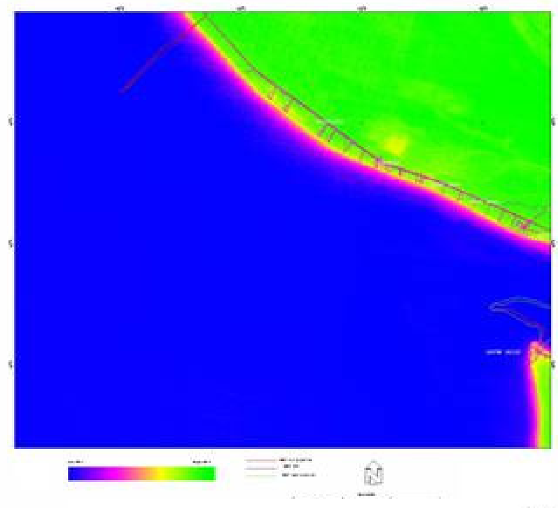


Fig 7a: NDVI Classification (1988)

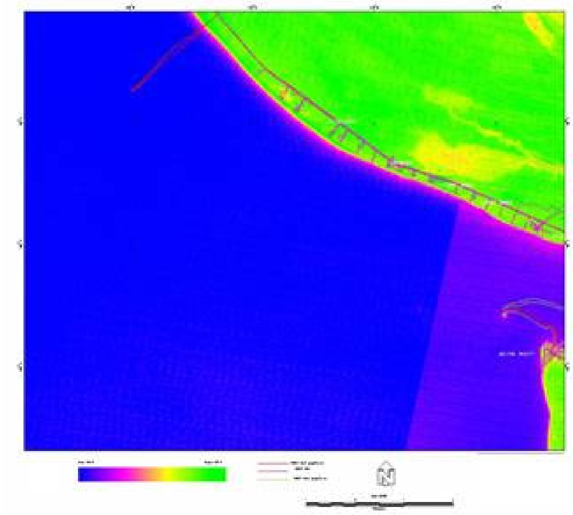


Fig 7b: NDVI Classification (1998)

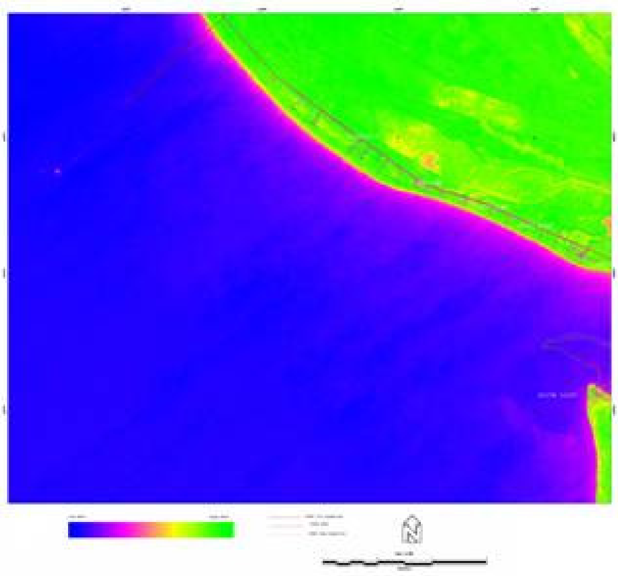


Fig 7c: NDVI Classification (2008)

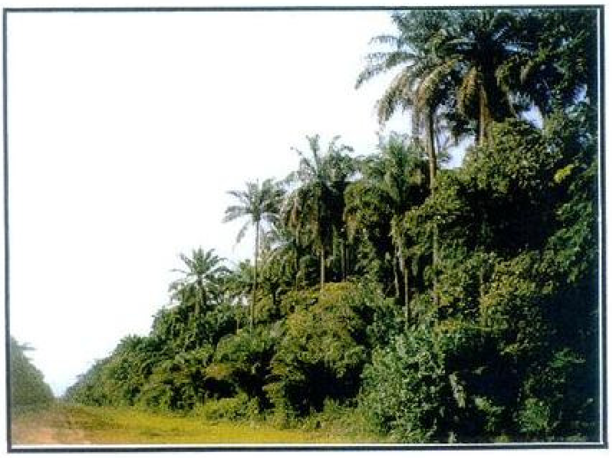


Plate 1

Plate 2

Plate 3

Plate 4

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