GEOSPATIAL ANALYSIS OF TEMPORAL DIFFERENCE IN ECOSYSTEMS OF COASTAL AREAS AND THE EFFECTS ON RURAL COMMUNITIES IN NIGERIA

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ABSTRACT

The coastal ecosystem is affected by a number of complexes and inter-connected physical, chemical, anthropogenic and biological processes occurring in the atmosphere, land and ocean. The resultant effects of these processes are modifications of coastal ecosystem, morphology and land masses. This study used remote sensing techniques, GIS analysis, intensive field study and soil type data to examine ecosystem changes taking place in the Nigeria's coastal areas. The implications of these changes on the rain-fed agriculture in particular and rural economy in general were identified. Landsat TM (1985) and Landsat ETM+(2010)were analyzed to identify preliminary ecosystem boundaries. In-depth field studies of selected ecosystem parameters including upper story canopy density, understory characteristics and soil types were used to reclassify and produce final boundaries of ecosystem in the study area. Three inland ecosystems; Freshwater, Tree crop and Agricultural land ecosystems and three shoreline/marine ecosystem; Mangrove, Nypa and Saltmarsh ecosystem were identified and mapped in the study. The results of the analysis showed that Water body and marine ecosystems displaced the inland ecosystem in the western part of the coastal areas around Ogun, Ondo and Delta states while there was an increase in the inland ecosystems in the delta region around Akwa-Ibom and parts of River states. The depletion of cultivated arable agricultural land and Tree crop/forest were also caused by increase in marine ecosystem, the salt water, and Fresh water ecosystem. These changes have negative impacts on the food security of the rural communities. The paper concluded with recommendations of pro-poor policy targeted at the vulnerable groups in the coastal communities.

Keywords: Ecosystem, Agricultural Produce, Fresh Water Agriculture, Marine Ecosystem

INTRODUCTION

The coastal landscape in Nigeria is dynamic due to several natural and anthropogenic processes (Fabiyi, 2011). The processes influence vegetation nutrients, plant productivity, soil fertility, water quality, atmospheric chemistry and many other local and global environmental conditions (Sahid *et al,* 1999). Ultimately the nature, types and the processes taking place in the sub-local ecosystem affect the agricultural productivity of the farming population. Nigeria has a coastal stretch of about 853 kilometers which transverses different sub-local ecosystems types and communities of diverse occupational and cultural orientations. Fabiyi and Oloukoi (2012) noted that Nigerian coastal littoral area comprises of more than 5,000 rural communities whose occupations include fishing, farming art and craft and petty trading. The activities of the rural coastal communities are affected by the changes in the coastal ecosystem since most of the population depend on nature for their survival. The coastal ecosystem is affected by a number of complexes and inter-connected physical, chemical, anthropogenic and biological processes occurring in the atmosphere, land and ocean. Some of these processes can be monitored in short term while others can only be assessed in climatic times at least over 35 years. The processes ultimately lead to modifications of coastal ecosystem, coastal morphology and coastal land masses(Ahmad *et al.,* 1990; Barends *et al*, 1995; Egnerongbe *et al.*, 2006; Fabiyi and Enaruvbe, 2014).

The nature of changes and activities taking place in the Nigeria's coastal area have been identified and documented by many researchers and authors (Awosika, 1995; Dublin green *et al.*, 1997; Ibe,1996, 1998; Etuonovbe, 2007; Fabiyi, 2008,2012, and Fabiyi and Enaruvbe 2014). The implications of changing coastal ecosystem on the agro- based rural coastal communities especially in the less developed countries require more analyses, characterizations and documentations. This will help to develop appropriate policy framework on food security and sustainable rural economy.

At the global and sub-regional scale, some of the notable effects of coastal dynamics in coastal areas are sea level rise and subsidence of coastline, while at the local scale the coastal changes include ecosystem degradation and displacement of freshwater ecosystem by marine vegetation, deposition of sediments and erosion of the coastline (Chambers, 2002; Edafiene *et al.,* 2010; Liu *et al.,* 2004; Putra *et al.,* 2011; Fabiyi & Yesuf, 2013; Fabiyi & Enaruvbe, 2014). This study focuses on the coastal ecosystem dynamics with specific emphasis on the implications on freshwater and rain fed agriculture in the coastal Nigeria.

Nature of Nigerian Coastal Ecosystem and Human Interference

Ecosystem is a joint word for Ecological and Systems. It usually refers to a community of plants, animals and smaller organisms that live, feed, reproduce and interact in the same environment. Though there is no consensus on the boundaries and geographies of ecosystems, however the importance of ecosystem to human welfare cannot be overstressed (Sahid *et al.,* 1999). Ecosystem has been differentiated from, *biomes* which are regional ecosystems, and the *biosphere* which is the largest of all possible ecosystems (Sahid *et al.,* 1999, Hooper and Vitousek, 1997). The changes in Local ecosystem are usually more dramatic in the impacts and effects on local population than the regional ecosystem. The beneficial effects of many organism on local processes are lost long before the species become regionally or globally extinct (Sahid *et al.,*1999, Hooper and Vitousek, 1997).

Ecosystems can be classified on the functional grouping in which case a biological categorization in an ecosystem will compose of organisms that performs mostly the same kind of function in the system. There are many types of ecosystem classification depending on the scale and the focus being considered. Ecosystem depends on the local influence of climatic variables, such as amount of rainfall, temperature, species abundance, microbes, and general biotic life of the environment. Ecosystem can be referred to as habitats or home of biological resources and the fertility of the soil that support the fauna and the flora components. It is therefore indicative to make inferences on the type of ecosystem from the systematic consideration of land cover, Soil types Canopy and understory density.

Apart from few natural secondary vegetation patches in the amazon forest and some restricted parts of the world most ecosystems are a product of human and nature interactions. Therefore, current ecosystems are a product of the anthropogenic activities in the past as man consistently interferes on the environment and modifies the natural landscape. Agriculture is one of man's major activities that impacts on the ecosystem in term of extent and intensity especially in the developing countries where bush burning and wood harvesting are intrinsic part of the rural agricultural practices. Every year extensive land areas are being cleared and put under cultivation, bush burning for land clearing, game hunting and grazing which inevitably reduce biological resources in local ecosystem are part of rural life (Fabiyi, 2011). Human activities and natural processes continue and will continue to exert tremendous influence on ecosystems of the world(Abdulai *et al.,* 2012).

The morphological changes occurring in the coastal area will impact ecosystem boundaries causing some ecosystems to expand while others will become smaller. Ecosystems will change as rainfall and temperatures change and some species will be unable to survive the changes. When salt water incurs into the freshwater ecosystem, it modifies the ecosystem or completely replace the inland rain fed vegetation by marine ecosystem.

In Nigeria, the coastal ecosystems modifications and changes are directs effects of global climate changes, sea level rise, oil exploration in the continental shelf and shoreline oil filed sand poor farming practice (Fabiyi and Enaruvbe 2014). Sea level rise in particular affects coastal ecosystem at different rates, magnitude, and directions depending on the coastal morphology and the marine process taking place at that segments of the coast. Fabiyi and Yesuf (2013) identified the marine processes taking place in the coastal bend of Nigeria. They noted that while coastal erosion is taking place in the western end of the coast causing land loses and settlement displacement, deposition is taking place in the delta region of the coast resulting in land gains and emergence of more fishing camps.

Coastal areas of Nigeria are the homes of many rural dwellers who survive on riverine activities such as boating, fishing, collection of shrimps, and subsistence farming. There is evidence of sea level rise and coastal submergence in Nigerian coast (Fabiyi & Enaruvbe 2014). The implications of sea level rise and coastal submergence on Nigerian coastal area include the incursion of salt water into the brackish and freshwater zones of the coastal areas. Salt water from the sea destroys rain fed agriculture and rural community livelihood.

The techniques of remote sensing have been widely used to map measure and evaluate different aspects of vegetal cover, however, further studies will be required to enable remote sensing expert's captures parameters used in mapping ecosystem in order to fully discriminate ecosystem from remote sensing images. Some of these parameters that are difficult to capture from existing medium to high resolution satellite remote sensing image data include understory vegetation, creepers, shrubs and litter's quality which are part of the ecosystem. In vegetation communities of high diversity and rapidly varying understory characteristics; remote sensing may not be efficient in resolving overlapping canopies of mixed crops and diverse vegetal cover of different layers.

Therefore, this study focused on the integrative approach of remote sensing, GIS, field identification and auxiliary soil data to classifying the ecosystem types and changes taking place in the coastal areas in Nigeria. However, this integrative approach is also limited in identifying and mapping the relative abundance of other biological resources that form parts of the ecosystem such as nematodes, microbes and other fauna species. This study classified ecosystems based on four parameters including types and density of upper story canopy, nature and characteristics of understory vegetation and soil types to map the coastal ecosystem. This is a departure from the usual landuse/land cover classification techniques from remote sensing.

The changes induced in the coastal ecosystems due to change in the shoreline and sea level rise in Nigeria need more investigative analyses and studies especially as it relates to the support it can provide to the biodiversity. In other words, there is a need for accessible information on the likely impacts of shoreline changes on biodiversity as well as to analyze the possible benefits and risks to the agricultural productivity of the coastal rural areas.

Objectives of Study

The central objective of the study was to identify the changes in the ecosystem in the coastal areas of Nigeria with the view to understanding the impact the changes have on rural agricultural communities. The specific objectives are to examine the differences in ecosystem between 1985 and 2010, identify the specific implications of these changes on the rural economy and determine the policy implications of the changes in ecosystem on the rural population. The study considered the ecosystem changes within 50 kilometers of the coast along the approximately 853 kilometers stretch of the Nigerian coast over a period of 25 years. It identified the implications of these changes on the coastal agrarian communities.

Description of Study Area

The study area comprises of the 853kilometers coastal stretch of Nigeria and 50 kilometers inland of the coastal area. It extends from Lagos in the western end to Calabar estuaries in the eastern flange, traversing eight littoral states (see Fig. 1) and more than 5,000 settlements.

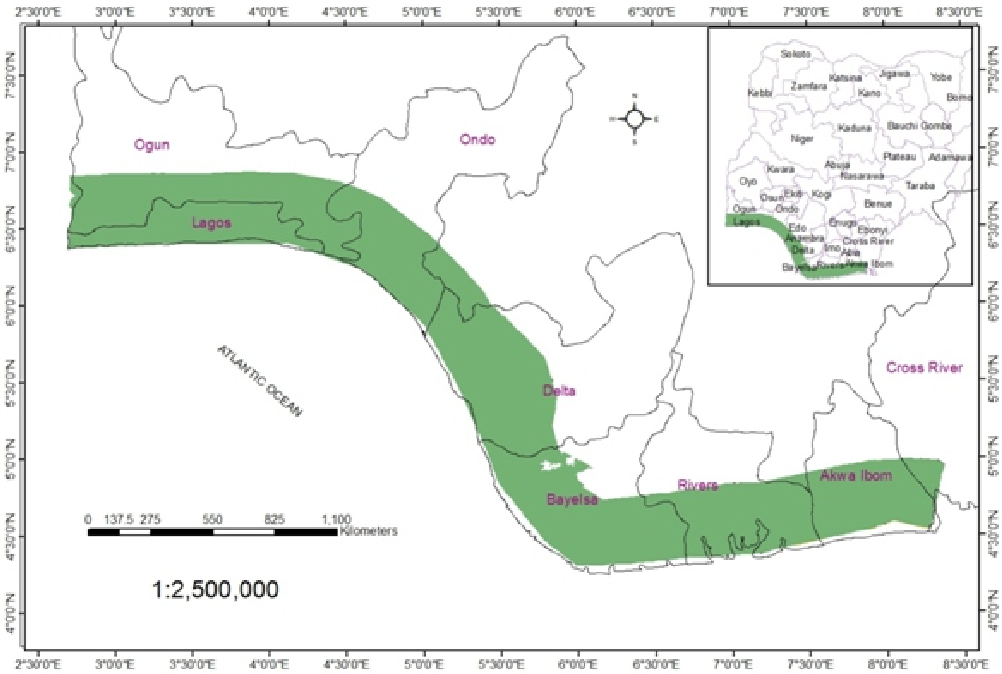

Figure 1: Map of Southern Part of Nigeria Showing the Study Area

The 853 kilometer coastline of Nigeria has been classified into four major geomorphic segments. These are the Barrier Island Coast (220km), the Mahin Transgressive Mud Coast (83km), the Niger Delta Coast (450km) and the Strand Coast (100km) (Awosika and Ibe 1989). These Coastal ecosystems in the segment can be broadly classified into two types which are inland ecosystem and marine ecosystem. The boundary of these two types of ecosystem is fluid and changes with the increase or decrease in the incursion of sea water into coastland and deposition of alluvium in the delta. There are six major ecosystems that dominate the study area and are used in this study. These are Mangrove, Nypa Palm, Salt marsh Agricultural land, Tree-crop and Freshwater .

METHODOLOGY

The differences in ecosystems of Nigerian coastal area were analyzed using Landsat data (1985 TM, and 2010 ETM+) The Landsat TM (1985) images acquired between December and January were mosaicked together to achieve a seamless image of the entire study area. Landsat ETM (2010) images acquired between December and March were downloaded from USGS website (www.landsat.glcf.ftp:/ftp.glcf.umd/glcf/Landsat/.)Visual Interpretation technique was adopted to identify landuse boundaries as preliminary data for use in further demarcation of the ecosystem

This approach was particularly used because the available land use classification techniques failed to appropriately group ecosystems and the images obtained from 2010 Landsat 7 images have scanline errors that make digital image processing error prone on the images. The images were pre-processed to ensure tone balancing. Geometric corrections of the stacked images were carried out through co-registration of the scenes by hand held Global Positioning System Receiver (GPS) and a total of 320 ground control points (GCP). Trimble Juno SC hand held GPS was used to collect Ground Control Points (GPs) to geo-register the images. The mosaicked images of the two date's scenes were georeferenced using permanent features such as major road junctions, rock outcrop, large jetty, shoreline embankment, and other manmade structure along the coastal areas. The choice of using the same GCPs for geometric correction of the images is to ensure that the spatial error levels of the change analysis of the ecosystem is reduced to the barest minimum.

Field Survey for Refined Ecosystem Classification

Each preliminary ecosystem was considered for detailed field study through a stratified random sampling process as follows: A 500 meter by 500 meters grid was placed on the entire study area and a total of 40grid cells that wholly fall within the boundaries of a preliminary ecosystem were randomly selected. Two ecosystems did not have up to 40 sample sites; Nypa palm and Salt Marsh, therefore 20 sample sites were selected for each of the ecosystem. In all a total of 200 sample sites were selected for field investigations. 200 meters straight line transects was placed in the centroid of each selected cell and used for in-depth study of the ecosystem category in each site. A hand held GPS was used to locate the sample sites on the field and motorized speed boat was used to reach creeks and coastal areas. Some of the sites could not be reached due to lack of access. Alternative sites were substituted in such cases while auxiliary data from anecdotal reports from past environmental projects were used in the event where alternative site could not be reached. The field study took place between January 5th and March 28th 2014.

The field investigation, particularly examined the three parameters to confirm the predefined boundaries of the preliminary ecosystem from the remote sensing; the understory canopy types of the vegetation, Soil taxonomy based on FAO classification, and canopy density of the main vegetation types (Table 1). The parameters were used generally to re-group the ecosystem and to adjust the boundaries of the pre-classified ecosystem (from landsat data) based on the relationship $\sum_{i=1}^{n} xei$ in equation 1.

$$ECS = \sum_{i=1}^{n} xei, x_{ci}, x_{si}, x_{ui} \text{..........................Eq 1}$$

Where is the preliminary ecosystem, x_{ci} is the Canopy density of the main ecosystem, x_{si}, is the soil taxonomic types and x_{ui} is the under story vegetation

The ordinal ranks of 1-6 were applied to the parameters which corresponded to the major ecosystem classes. The ranks were based on the typical abundance of biological resources in the ecosystem and it is mainly to modify the fussy boundaries of ecosystems obtained from image analysis through the data collected on the field, Soil map and the application of the equation 1.

Table.1: Hierarchical Classification Ranking of Ecosystem Parameters

Ordinal Ranking score	Ecosystem type	Canopy Density of main vegetal type	Soil Characteristics	Understory Vegetation type
6	Mangrove	Pure stand of very dense canopy	*Arenosol*	Upper story dominate, no understory
5	Freshwater	Very Dense canopy interspersed with other vegetation canopy	*Cambisols*	The understory is the same as upperstory
4	Salt Marsh	Very close canopy with dense overlap	*Fluvisols*	Mostly different from upper story
3	Nypa Palm	Close canopy with very high overlap	*Gleysols*	Diverse but dense
2	Agricultural Land	Close canopy interspersed by other canopy	*Ferrasols*	Diverse but not dense
1	Tree crop	Sparse canopy	*others*	Only shrubs and Creepers

The final ecosystem boundaries were demarcated through modification of pre-classified ecosystem boundaries, while integrating the equation in the map algebra of ArcGIS. The marine ecosystems such as Mangrove, Nypa palm and Salt Marsh were differentiated from the fresh water ecosystem such as Freshwater swamp, Agricultural lands, Tree crop Ecosystems.

Geospatial analysis techniques in the vector GIS platform were used to analyze the difference in the ecosystem between 1985 and 2010. Union overlay option in ArcGIS was applied on the two vector layers and the ecosystem difference from the first date and the second date were identified and captured.

RESULTS AND DISCUSSION

Ecosystem Types in the Study Area

Six main ecosystems were identified and demarcated after a combination of image analysis, field investigation and geospatial analysis (Fig. 2). The final ecosystems demarcated are briefly described as follows:

Fig 2.a: Agricultural Land Ecosystem

Fig 2b: Fresh Water

Fig 2c: Tree Crop Plantation

Fig 2d: Mangrove

Fig 2e: Salt Marsh

Fig 2f: Nypa Palm Ecosystem

Fig2: (a- f) Examples of Coastal Ecosystem Types in the Study Area

Agricultural Land: This represents the food crop agriculture including the cultivated land, bush fallows and other arable lands (see Fig. 2a). The ecosystem includes small holder farmlands and extensive mechanized farmlands. A variety of food crops are found in this ecosystem with different types of weeds and shrubs. The vegetation types found in the agricultural lands include; *Maesobotryra barteri, Ageratum Conyzoides, Emilia Coccinea, Panicum laxum, Dactyloctenum aegyptiaca, Chromolaena odorata, Zea mays, Aspila Africana, Cleome viscose, Manihot esculenta, Manihot esculenta, Euphorbia hirta* and *Fleurya aestuans.* The biological resources in the large scale and subsistence farms are similar. These vegetation types are interspersed by shrubby vegetation species as *Alchornia, cordifolia, Triumfetta sp, Eupatorium odoratum,* and *Dissotis sp*. The soil class often found in this ecosystem is *Arenosol.*

Fresh-water Forest: Freshwater ecosystem according to this study was used to capture rain-fed deltaic vegetation (see Fig. 2b), and other wetlands outside the reach of salty water from the sea and the creeks. They are found in the low lying coastal areas. This ecosystem type usually comprises of multi-layer storey canopy of different vegetation species typical of southern Nigeria. The ecosystem include the lowland fresh water swamp type, fed seasonally by rain. Twilight conditions exist due to interlocking canopies. The undergrowth in some of the selected sites was so rich that penetration into it was difficult. Cushion of dry leaf litters abounded within the ecosystem boundaries. Most of these have *Cambisol* and *Fluvisols* types of soil taxonomy.

Tree-crop and Forest Plantation: Tree crop farmland both large scale and small holder agriculture mostly occupied by economic trees and cash crops. It also includes forest plantation by private investors and Government owned forest reserves. Tree species that are found in this ecosystem include *Heveabraziliensis* and *Elaeis guineensis* (Fig. 2c). The soil type here include *Ferrasols* and *Gleysols.*

Mangrove Ecosystem: This represents mangrove vegetation along the salt water coast and the creeks (See Fig. 2d). The entire mangrove ecosystem observed was characterized by different patterns of forest structure, productivity and biogeochemistry all of which are controlled by a combination of factors such as hydrology (tides, freshwater discharge, and rainfall), soil characteristics, biological interactions and the effects of storms and other disturbance. Tall (*Rhizophora racemosa)* and short red mangroves (*Rhizophora mangle), Pandanus sp* dominated the ecosystem. This ecosystem consists of dense, closed strands which formed a single layer of trees with stilt-rooted pneumatophores / prop roots (breathing roots). Also, the tall mangroves were >30m in height and sparse species of white mangroves (*Avicennia africana)* were observed to be growing behind the *Rhizophora sp*. The soil type is mainly *Arenosol*

Salt Marsh: This include salt marsh, mud flat and fine sand ecosystems in the study area. It comprises of deep mud salt marsh and fine sand ecosystems which can extend over large area often more than 5 square kilometers. It is often found on degraded mangrove coasts and the transgressive mud zone of the coast (See Fig. 2e). Soil type is in the salt marsh is *Arenosol*

Nypa Palm: Nipa palm (*Nypa fruicans) is a type of* ecosystem found in the eastern end of the coast around Calabar estuaries and Akwa Ibom coast. It is spreading from the eastern coast to the delta region of the coastal area (Fig. 2f). The soil types in most Nypa Palm beach are mainly *Arenosol* with some patches of *Fluvisol.*

Waterbody. Represents both fresh water, brackish water and salt water that is bigger in width than 100 meters. Abundant aquatic resources are found in this ecosystem but could not be classified based on the parameters in equation 1.

Other land uses found in the study area but could not be classified as ecosystems are settlements/communities, manmade structures such as platforms, jetty, shoreline embankment, rip-rap and water body.

Settlements and Manmade Structures: The class include communities. Oil facilities. Jetty and other artificial ecosystem in the study area

Ecosystem Characterization and Dynamics in the Coastal Region of Nigeria

Ecosystems change around the coast: The coastal ecosystems recorded significant change during the period of investigation. The most significant change is the incursion of sea water into the creeks and submergence of originally inland ecosystems by the marine salt water ecosystem.

The study showed that Freshwater ecosystem was 9,356.88 km^2 in 1985 but substantially increased by 2,202.36 Square kilometers in 25 years (Table 2). This increase is more in the delta segments as shown in Figures 3 and 4. The alluvium deposit from the River Niger distributaries increased inland rain-fed vegetal cover types which were classified as freshwater ecosystem. The brackish water area in the creeks is turning into fresh water. There are many abandoned farmlands in delta region due to oil exploration and the extensive right of way created for down-stream and up-stream pipelines.

The total study area was 37,210 km^2 and the total ecosystem demarcated in 1985 was 32,609.69 km^2, which accounted for 87.64% of the study area. Inland ecosystems accounted for 58.82% (See Table 3) in 1985 while marine ecosystem accounted for 28.82% in 1985. However in 2010 the total ecosystem covered 82.08% which is 30,543.44 km^2. This represents a reduction by 5.55%compare to the 1985 total ecosystem area. The marine ecosystem decreased by 2.3% while the Inland (non- marine) depleted by 3%. The total marine ecosystem decreased by 831.8 km^2, while the inland ecosystem decreased by 1,234 km^2 in 25 years (Table 3).

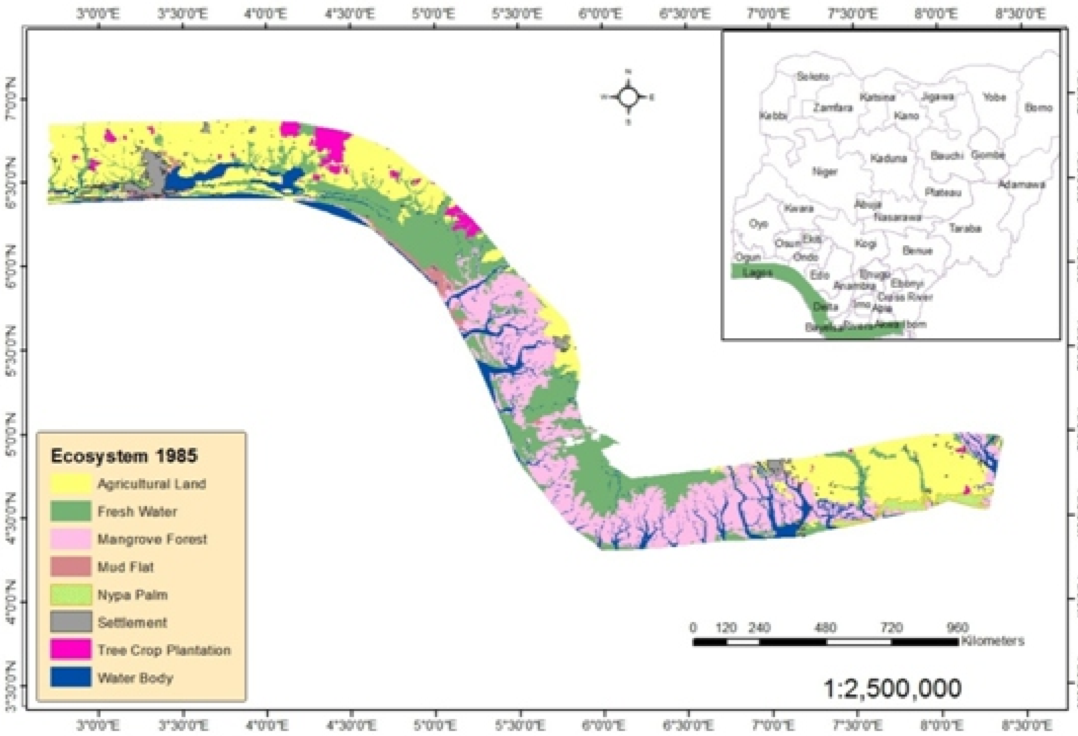

Figure 3: Ecosystem of Nigerian Coast in 1985

Table 2: Ecosystem Analysis in 1985 and 2010

SN	Ecosystem	Ecosystem 1985 in Km^2	Ecosystem 2010 in Km^2	Total Change in Km^2
1	**Freshwater**	**9356.88**	**11559.24**	2202.36
2	**Treecrop**	**982.76**	**311.53**	-671.23
3	**Agricultural land**	**11546.21**	**8780.67**	-2765.54
4	**Mangrove**	**9664.11**	**9400.34**	-263.76
5	**Nypa**	**502.76**	**318.59**	-184.17
6	**Salt Marsh**	**556.97**	**173.07**	-383.90
7	**Settlements**	**1090.43**	**2901.28**	1810.85
8	**Waterbody**	**3510.58**	**3765.97**	255.39
	Total	**37210.70**	**37210.69**	

Table 3: Spatial Difference in Marine and Inland Ecosystems between 1985 and 2010

	1985 Ecosystem Analysis	2010 Ecosystem Analysis	Difference
Total area	**37210.70**	**37210.69**	
Total ecosystem	32609.69	30543.44	-2066.25
% ecosystem	87.64	82.08	-5.55
Total Inland Ecosystem in km^2	21885.85	20651.44	-1234.41
% Inland Ecosystem	58.82	55.50	-3.32
Total marine Ecosystem in km^2	10723.84	9892.00	-831.84
% Marine Ecosystem	28.82	26.58	-2.24

Tree crop ecosystem depleted by -671 km^2 within the period (Table 2). The tree crop such as rubber which formed a significant tree crop ecosystem in 1985 did not have the same economic significance in the study area in 2010, due to replacement of natural rubber latex by synthetic latex in Nigerian and foreign markets. Some of the previous tree crop plantation had been supplanted by secondary vegetation which was classified as fresh water ecosystem in 2010. A lot of the forest plantation have also been encroached upon by agricultural and settlements uses. From Figs. 3 and 4, it is noted that while there are significant depletion of agricultural ecosystem in the western end and coastal bend around Araromi, Awoye (Ondo State) there were increase in agricultural lands in the delta. In all a significant reduction in agricultural land ecosystem (2765 km^2) was extracted in the study area.

On the other hand, the depletion rate of the marine ecosystem was moderate during the 25 year considered. Mangrove depleted by -263 km^2 Nypa palm depleted by a total of -184 km^2 while salt marsh depleted by -383 km^2 (Table 2). The depletion of the marine ecosystem was mainly due to anthropogenic activities and the submergence of the coastline by sea water (See Fabiyi and Enaruvbe, 2014). Settlements and other industrial activities increased significantly during the period by more than 1,810 km^2 during the period (see Table 2) which means high reduction in the habitats for biodiversity. The nature and distribution of these changes are presented in Table 3.

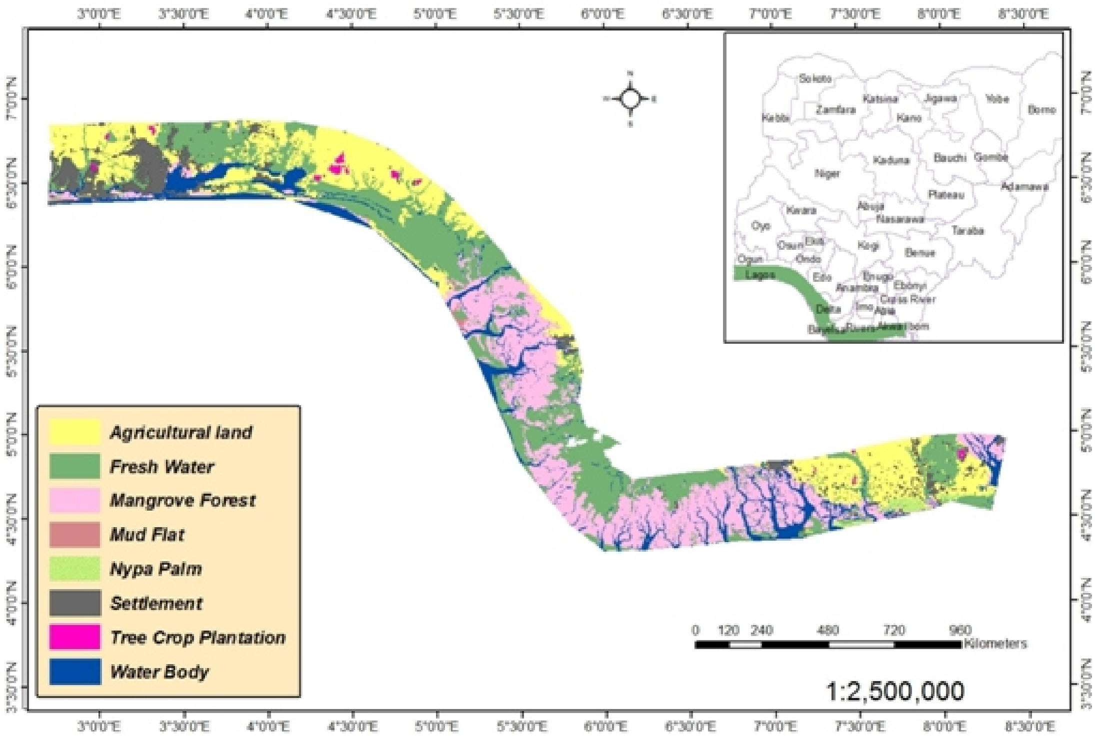

Figure 4: Ecosystem of Nigerian Coast in 2010

Table 4: Spatial Distribution of Ecosystem Difference Between 1985-2010 in Nigerian Coastal Area

Ecosystem 2010 ………… Ecosystem 1985	**Agricultural Land**	**Tree crop**	**Freshwater**	**Mangrove**	**Saltmarsh**	**Nypa**	**Settlement**	**Water Body**	**Total** (Km^2)
Agricultural Land	7946.15	44.88	1581.19	270.14	4.09	45.61	1670.04	29.37	11591.47
Tree crop	658.78	165.07	127	0.78	0.13		24.43		976.19
Freshwater	389.19	0.75	7800.78	904.07	10.12		156.85	92.32	9354.08
Mangrove	120.78		1079.4	7882.01	43.12	24.78	60.12	447.82	9658.03
Saltmarsh	251.383		46.03	123.44	72.27		21.15	41.8	556.073
Nypa	16.44		193.24	37.09	1.9	245.7	7.11	0.8	502.27
Settlement	31.58	0.8	26.58	47.09	3.72		927.29	29.08	1066.14
Water Body	0.07		4.96	427.33	36.79	0.08	1.67	3035.07	3505.97
Total	9414.373	211.5	10859.18	9691.95	172.14	316.2	2868.66	3676.26	**37210.22**

Dynamics of Marine Ecosystems

The changes in the marine ecosystem presented in Table 4 and Figures3 and 4 showed that there is evidence of decrease in the marine ecosystem (Mangrove, Nypa-palm, Water body and salt-marsh) in the western and transgressive mud beaches of the coast while increase of the marine ecosystems and supplanting of previous inland ecosystem are noticed in the eastern end of the coastal region. Mangrove ecosystem is particularly useful for fuel wood and logging. It is massively harvested in the delta for fuel wood, planks and furniture. However there is high regrowth rate among the mangrove except if it is impacted by oil or other obnoxious chemicals. Mangrove degradation and conversion to other ecosystem are pronounced in urbanized part of the coast around Lagos, Bonny and Brass and other areas where there are multiple littoral rural settlements.

Table 4 for instance, shows that a total of 1,079km^2 of mangrove changed to freshwater mainly in the upper delta region of the coast, while 120.78 km^2 was converted to agricultural land. More than 447 km^{2}was overtaken by salty ocean water. Salt marsh ecosystem changed to mangrove (123.4 km^2), water (41.8Km^2) and agricultural land (251.3) km^2. In some areas salt marsh is a very dynamic ecosystem as they can represent degraded mangrove area and after regrowth, the ecosystem returns to mangrove.

Nypa Palm is prominent in the eastern end of the coast but is extending westward supplanting mangrove and freshwater vegetation often found in the barrier island in the coast of Akwa-Ibom and Rivers States. But the Nypa is also depleting in the upper coast.

Dynamics of Inland Ecosystems

Changes in Agricultural Land Ecosystem

Water body submerged a total of 29.37 km^2 of Agricultural land ecosystem within the period under consideration. This took place in the western end of the coastal area around Ondo State and parts of Delta States. Urbanization and settlement development accounted for loss of agricultural ecosystem to the tune of 1,760 km^{2}in the coastal areas of Lagos Ondo, Delta, Bayelsa, Rivers and Akwa Ibom States.

Generally the marine ecosystem and salty ocean water replaced agricultural land by a total of 349.21 km^2 in 25 years. This is about 12.7% of the total Agricultural land ecosystem loss in the study area. The salt laden marine ecosystem is not suitable for the fresh water agriculture usually practiced in the study area and many farmlands are inundated by ocean flood during the growing season. Consequently, many rural farmers abandoned farming due to reduced productivity and damages to croplands. The upsurge in the freshwater vegetation can also account for the depletion in the agricultural land ecosystem as shown in Table 3. Agricultural lands were converted to freshwater ecosystem including secondary vegetation and rainfed-deltaic forest by a total of 1,581.49 km^2 in 25 years. The farmers abandoned farming activities in the coastal areas because of partial or total submergence of the farmlands by ocean water. Some of the farmlands changed to marine ecosystem.

Changes in Freshwater Ecosystem

Freshwater ecosystem covered by salt water from the creeks and the ocean is 92.37 km^{2}while mangrove replaced freshwater ecosystem by 904.07 km^2. A total of 1,006.51 km^2 of marine ecosystem and water replaced freshwater ecosystem in 25 years. In the upper delta of the study area, a total of 389.19 km^2 of freshwater ecosystem was converted to agricultural land ecosystem in 25 years. It was noted in Figure 4 that the bulk of agricultural land in 2010 are found in the Ogun-Ondo States in the western side of the coast and Cross River and Akwa Ibom States in the eastern side of the coast (See Fabiyi and Enaruvbe, 2014). Urbanization accounted for about 156 km^2 of the loss of freshwater ecosystem.

Changes in TreeCrop Plantation Ecosystem

Tree crop Plantation ecosystem is the least affected by the marine ecosystem in the coast. The conversion of tree crop plantation was due largely to conversion to Agricultural land (654.78 km^2) which almost wiped out the tree crop plantation in the study area. This includes encroachment into the forest reserve for farming purposes.

Impacts of the Ecosystem Dynamics on the Agricultural Practice of the Coastal Communities

The spatio-temporal difference analysis showed that Agricultural land ecosystem is the most depleted ecosystem in the study area with a total area loss of 2,765.54 kilometers. The loss is due to conversion of the ecosystem to sea water and marine ecosystem. The results were confirmed during the key informant interview in the selected settlements of the study area in Awoye , Ayetoro and Araromi in Ondo State and Gbekebo, Ogulaha, Ogogoro in Delta state. For instance Mr Princewill in Awoye community opined that:

"Before we used to trek for two hours from the river bank to our village passing several farmlands, but today the sea is with us……"

The secretary of Ayetoro Community Development Association (Mr Adegboyega) also noted that the *community head palace had to be relocated three times in the last 25 years due to land subsidence.*

Some of the negative effects of the ecosystem dynamics on the rural coastal communities in Nigeria are as follows:

i. Salt laden ocean water inundate the coastal areas temporarily or permanently therefore destroying rain fed agricultural crops and sometime the submergence of farmland may take up to 4 months. The farmers are forced to abandon farmlands when the crop yield progressively reduced.

ii. The farming littoral communities suffer considerably from unpredictable tidal movement of the sea. Women and children are often trapped in the farm during raining season when river Niger distributaries overflow their banks and during high tides in the creeks. Farmcrops are often wasted if the flooding occurs during the growing season

iii. Women and children are often constrained indoor during coastal flood thus limiting access to schools, medicare and economic activities. Living in rural coastal settlements at that period is often very precarious.

iv. Several water borne diseases are common in the rural communities during theflooding and very high tides when the brackish water in the creeks has increased salt injection from sea water.

v. The succeeding marine ecosystems have low agricultural and economic values, especially the Nypa palm and salt marsh; some of the previously farming communities have had to abandon farming because sea water had taken over their land either temporarily or permanently. The fish catch in these communities has reduced considerably, therefore many of the able body men and women look for menial jobs in the oil companies or as labourers in the companies in their communities.

vi. The reduced farming opportunity is one of the reasons for youth restiveness in the rural coastal Nigeria. Communal clashes and land related conflicts are very common in the rural coastal Nigeria due to shrinking agricultural lands.

vii. Some communities have been moving upland due to sea level rise (Fabiyi and Yesuf, 2013). In fact some have relocated their villages about 3 times in the last 30 years. The implication is that as they move into other communities' territories they become settlers and will have issues with original owners of territories.

viii. The rural communities have to import food items from the nearby cities and sometimes drinking water. Therefore the cost of living in the rural coastal communities is very high. In fact there are many communities where cost of living is higher than some big cities like Lagos, Ibadan and Port Harcourt.

ix. Fresh water fish farming often fail in the rural coastal communities because of the unpredictable tidal movements especially where shorelines are not protected.

x. The networks of creeks that characterized the coastal area are the major route for transporting goods and services in the rural coastal communities but this also depends on the vagaries of the water volume in the creeks, canals and river channels. Therefore, the routes often become hazardous.

5. CONCLUSION AND RECOMMENDATIONS

Ecosystem conversion and depletion have significant impacts on the agriculture and food security. While desertification is ravaging the northern part of Nigeria, the coastal area is also generally affected by the salt laden water surges on the coastal farmlands. National adaptation policy should be designed, promulgated and implemented to favour the vulnerable farming group especially the coastal rural area that largely depend on subsistence agriculture for survival . Climate change policy should also focus on adaptive coping mechanism from climate change induced ecosystem loses. This can be done through short term and long term plans.

Agricultural insurance policy that is specifically targeted at the rural coastal communities should be encouraged to ameliorate the effects of crop loses during flood disaster that is judged higher than the normal. The submergence of coastal land due to sea level rise will further make living condition in the rural coastal communities more difficult, therefore, funding should also be provided for shoreline protection and the introduction of flood resistant agriculture to boost the economy of the rural coastal settlements. Salt water resistant farming should be introduced and encouraged in the rural coastal Nigeria so that extensive salt marsh in the delta region can be utilized for agricultural purposes.

Climate change mitigation, adaptation and copping strategies should be integrated into other reforms such as agriculture, education, health and income redistributions reform programmes. Climate change impact reduction action plan should also be part of medium and long-term land use development plans. In order to reduce further depletion of marine ecosystem especially mangrove in the study area, it is necessary to provide alternative source of energy for the rural coastal communities and further diversify the rural economy.

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