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An Assessment of Land Use/Land Cover Changes in a Section of Niger Delta, Nigeria

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Abstract Remote Sensing and GIS offer quick and efficient approach to the classification and mapping of land use/land cover changes over space and time. Information on changes in resource classes, direction, area and pattern of land use-land cover classes form the basis for future planning. Specifically, the land use/land cover types for the years 1986 and 2008 were studied and compared. The data products used in the study are Landsat TM imagery of 1986 and Nigeriasat-1 imagery of 2008. The data sets were put into Arcview GIS environment for geo-referencing and on-screen digitization of the needed layers. The land use-land cover layers for 1986 and 2008 were therefore generated. The magnitude, trend and annual rate of change analysis were generated from the land use-land covers for the years-1986 and 2008. The annual rate of change was then used as the basis for the projection of the 2050 land use-land cover situation of the study area. The findings show that there was high rate of land use-land cover change leading to decimation of sources of livelihood and resettlement of the people.

Keywords GIS, Imageries, Land Cover, Land Use, Remote Sensing

1. Introduction

Land use-land cover change analysis enable planners and policy makers to have adequate knowledge on what should be done to have equitable development that will be sustainable and eco-friendly[1]. Land which is the ultimate resource of the biosphere refers to a specific area of the earth surface with physical entity encompassing its topography and spatial nature[2]. It is one of the characteristics of space that is significant for planning and management purposes[3]. Land cover refers to the physical cover on the land including both the natural and modified vegetation and artificial constructions[4]. Land use describes the use of the land by the people usually with emphasis on the functional role of land in economic activities[3]; and man's activities which are directly related to the land[5].

When Land use and land cover are treated jointly, they represent both the physical cover and human imprints on the land. Land use/land cover change represents the changes that are occurring over the cover as a result of human modification of its uses. It can also result from human driven natural processes such as climate change. Land use/land cover change can alter the terrestrial ecosystem and its ability to perform its provisioning and support services[6]. It has the potential to modify the presence and distribution of specific ecosystems and species[7]. When unchecked, change in land use/land cover can lead to land degradation with potential to significantly exacerbate disasters[8].

The Mahin transgressive coast in the western Niger Delta of Nigeria (the study area) is associated with a high intensity of both oil mineral exploration and subsistence farming activities which is leading to changes in the pattern of land use/land cover of the area[9].[10] noted that expansion in oil exploitation has increased the incidence of oil spills which impact the natural ecosystems. Records from[11] suggest that 77% of oil spills into the Niger delta environment in Nigeria between 1976 and 1996 was not recovered. The processes involved in oil exploration and transportation in the swamp and mangrove ecosystems degrade the land cover and deplete aquatic fauna in a number of localities[12].

[13] asserted that canalisation resulting from attempts by oil companies to construct canals to shorten travel time and improve access to production facilities has caused saltwater intrusion into freshwater zones, and destroyed ecological systems. The increased accessibility resulting from canalization also aggravates illegal logging activities with adverse environmental consequences. The canals have also provided access for water hyacinth to invade swamps and waterways and so impede navigation. All these factors drive land use/land cover change in the Mahin transgressive coastline.

The aim of the study therefore is to assess land use-land cover changes in the Mahin transgressive coast of the western Niger Delta region. The specific objectives are:

(i). to establish the land use/land cover patterns of the

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study area in 1986 and 2008 using multi-date satellite imageries.

(ii). to analyze land use/land cover magnitude and trend of changes in land use/land cover for the area between 1986 and 2008.

(iii). to project the land use/ land cover pattern for the year 2050 using the 1986-2008 scenario as the basis.

The study area lies approximately between latitudes $5^0 45^1$ and $6°30^1$ north of the Equator and longitudes $4^0 30^1$ and $5^0 07^1$ East of the Greenwich. It covers about 3,310 km^2 and it covers about 88km along the coastline. The distance from the coast inland-wards is about 50km at the farthest and about 19km at the shortest.

2. Materials and Methods

The Landsat imagery of 1986 was downloaded from the website of the Global Land Cover Facility (GLCF) of the University of Maryland, USA[14]. The imagery was used to generate the land use/land cover for 1986.

The Nigeriasat-1 imagery of 2008 was acquired from National Space Research and Development Agency (NASRDA), Abuja. It has 3 spectral bands with spatial resolution of 32m on all the bands. The re-sampled Nigeriasat-1 image was interpreted to generate the static land use /land cover data for 2008.

The images were georeferenced to UTM-31 projection, WGS84 datum and corrected for geometric and radiometric errors from the sources. These data were analyzed using Geographic Information System. Arc view 3.2 GIS software was used for the Interpretation of the Landsat and Nigeriasat-1 satellite imageries that yielded the first set of results which were Land use/land cover data for the years 1986 and 2008 respectively. Field check was conducted using a handheld Garmin S76 Global Positioning Systems (GPS) and digital camera. A total of 185 field checkpoints were established by GPS for accuracy check. According to[12], the ideal number of check points required to be tested in the land use classification map is determined from the binomial probability given in equation 1 as

$$N = 4(p)\ (q\sim)/e^2 \quad (1)$$

Where: N = is the number of points required,

p = is the expected percent accuracy

q~ = the difference between 100 and p

e = is the maximum allowable error

For an expected 90% accuracy and allowable error of 5%, the minimum number of points required was 144. This shows that the number of checkpoints (185) established on the field was far higher than the ideal number of checkpoints required. The checkpoints (stored as GPS waypoints) were downloaded using the Easy GPS program. The coordinates (together with descriptions) were imported into Arcview 3.2 GIS and added to the GIS database as an event theme which was converted into a data layer. This theme of field coordinates was then used as a base for assessing accuracy of the interpreted imageries as described by[15]. Observations of land use-land cover characteristics and human imprints were also made and recorded for verification of the Nigeriasat-1 image features.

The first set of results -land use-land cover data of 1986 that was generated from Landsat TM (1986) and land use land cover of 2008 that was generated from Nigeriasat-1 (2008) within the Arcview GIS environment (as shown in table 1) produced the change statistics in table 2. The change analysis was performed by intersecting the different multi-temporal land use and land cover layers of 1986 and 2008. The overlay of the land use/land cover statistics assisted in identifying the magnitude, trend and rate of change between 1986 and 2008.

The magnitude of change for each land use/land cover class was calculated by subtracting the area coverage of the second year from that of the initial year as shown in equation 2.

$$\text{Magnitude} = \text{Magnitude of the new year} - \text{Magnitude of the previous year} \quad (2)$$

Percentage change (trend) for each LULC type was then calculated by dividing magnitude change by sum of changes between the years concerned and multiplied by 100 as shown in equation 3.

$$\text{Trend} = \frac{\text{magnitude of change}}{\text{Sum of change}} * 100 \quad (3)$$

In obtaining the annual rate of change for each LULC type, the trend (percentage change) was divided by 100 and multiplied by the number of study year 1986 – 2008 (22years) as shown in equation 4.

$$\text{Annual rate of change} = \frac{\text{Trend}}{100} * 22 \quad (4)$$

3. Results and Discussion

3.1. Land Use-Land Cover Statistics for 1986 and 2008

The static LULC statistics for the study area in 1986 and 2008 is presented in table 1. It shows both the primary and the secondary classes' area coverage in hectares and their percentages. Figure 1 shows the graphical display of the trend between 1986 and 2008 LULC. The map representations for 1986 and 2008 are shown in figures 2 and 3 respectively.

The primary LULC classes increased from seven in 1986 to eight in 2008 because cloud was discovered in the Nigeriasat-1 imagery of 2008 and was treated as a cover class for the purposes of statistics generation though it was not actually a land use land cover. The specific classes (level II classes) increased from 16 in 1986 to 20 in 2008 with the addition of cloud cover. In specific terms, additional new level II classes including burrow pit/excavated lands, dredged spoil, mud and cloud cover emerged in 2008; while dredge river canal, submerged areas, bare surface and de-vegetated lands increased in extent. The built up area had increased in 2008 to 7934.11ha (2.18%) due to massive construction works by Niger Delta Development Commission (NDDC) and most especially Ondo State Oil

Producing Areas Development Commission (OSOPADEC) [16].

The area covered by the river increased to 9478.01ha (2.60%), lake/pond had disappeared from the study area, dredged river/canal decreased to 1654.02 (0.54%) bringing the total water bodies' area to 11432.03ha (5.32%). The degraded lands increased to 78111.74ha (25.81%) with the specific levels being submerged areas 40870.14ha (11.23%), burrow pit/excavated land being 246.60ha (0.07%), bare surfaces being 35244.96ha (9.69%) and Devegetated areas being 17552.78ha (4.82%). The wetlands area decreased to 14562.16ha (4.0%) with specific classes of marsh being 3010.17ha (0.83%) and mangrove being 11551.99ha (3.17%).

Table 1. LULC Statistics for 1986 and 2008

Primary Class	Secondary Class	Area (Ha) 2008	Percent 2008	Area (Ha) 1986	Percent 1986
Built-Up Areas	Built Up Area	7934.11	2.39	4,976.13	1.5
Water bodies	River	9478.01	2.87	8,870.26	2.7
	Lake/Pond	0.0	0	595.25	0.2
	Dredged River/Canal	1954.02	0.59	1,873.17	0.6
Total		11432.03	3.36	14,314.68	3.5
Degraded Lands	Submerged Areas	40870.14	12.35	3,887.59	1.2
	Burrow Pit/Excavated Land	534.60	0.16	0	0
	Bare Surfaces	35244.96	10.65	5,473.49	1.7
	Devegetated Areas	17552.78	5.30	12272.66	3.7
Total		94202.48	28.46	21633.74	6.6
Wetlands	Marsh	3010.17	0.90	25,384.62	7.7
	Mangrove	11551.99	3.50	8,175.05	2.5
Total		14562.16	4.4	33,559.67	10.2
Agricultural Lands	Farmland/Fallow	56935.41	17.21	79,209.86	24
	Plantation	108.03	0.03	2,105.71	0.6
Total		57043.44	17.24	81,315.57	24.6
Natural/Semi Natural Vegetation	Heavy Forest	75579.1	22.84	82,434.50	24.9
	Light forest/Thicket	29056.31	8.80	44,091.93	13.3
	Palm Swamp	29882.71	9.04	41,868.34	12.7
	Scrub / Grassland	8885.19	2.44	11,114.99	3.4
Total		144249.91	43.81	179,509.76	54.3
Open Area	Sandbar	1464.31	0.44	484.68	0.1
	Dredged Spoil	201.27	0.06	0	0
	Mud	45.08	0.01	0	0
Total		1710.66	0.52	484.68	0.1
Cloud	Cloud cover	329.64	0.10	-	-
Total		329.64	010	-	-
Ground Total		331464.43	100	331465.23	100

Source: modified from[17] with GIS analysis carried out by the author

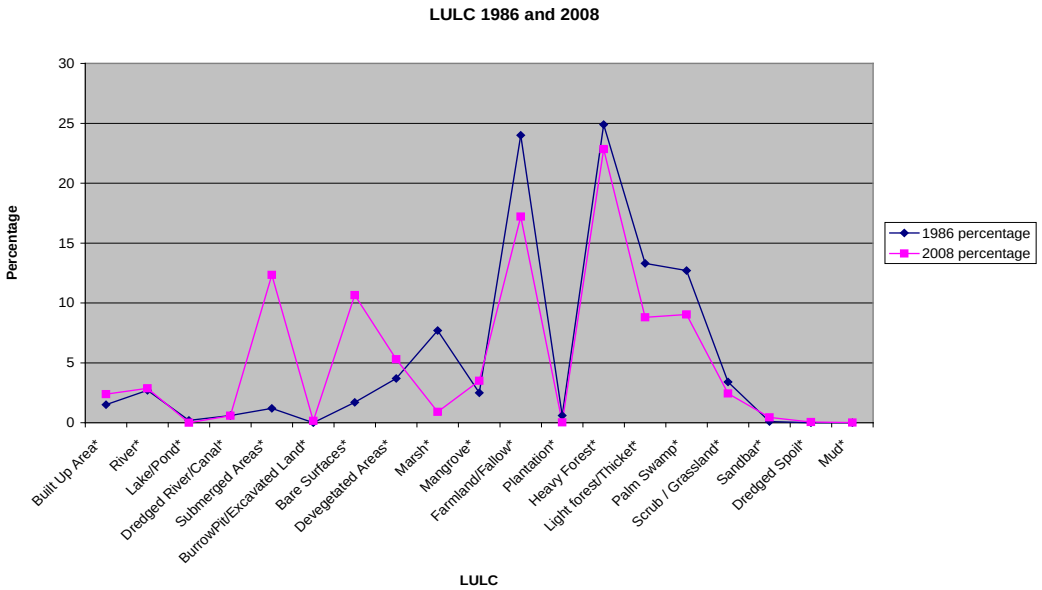

Figure 1. LULC for 1986 and 2008

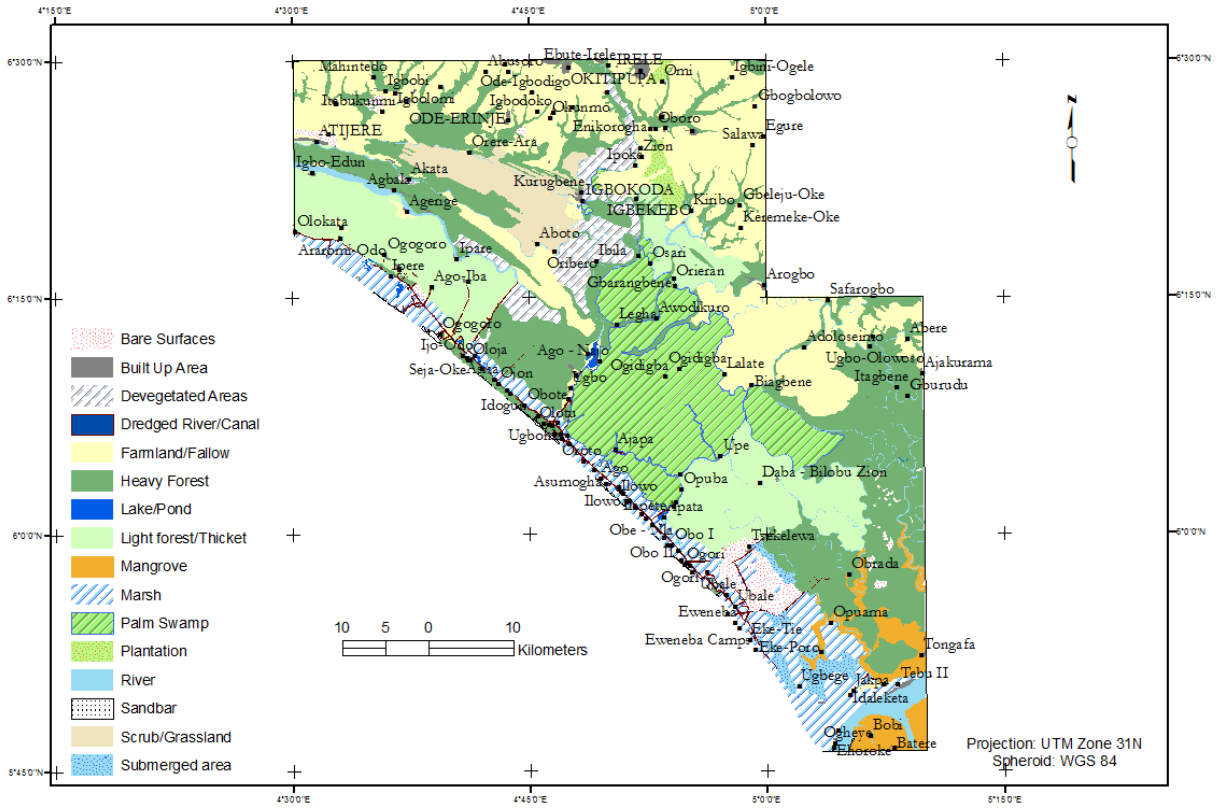

Figure 2. Land use-land cover map for 1986

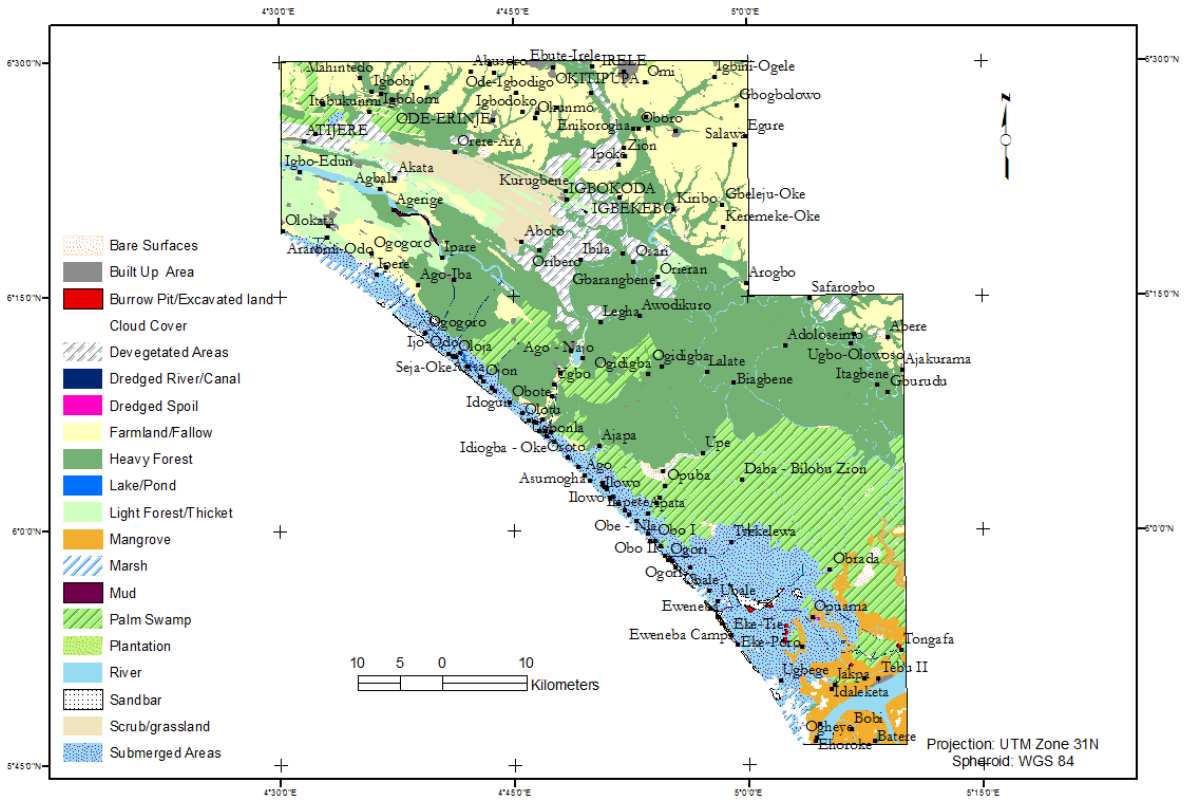

Figure 3. Land use-land cover map for 2008

Table 2. 1986-2008 change magnitude, trend and annual rate

Primary Class	Secondary Class	1986-2008 change		
		Magnitude (Ha)	Trend	Annual Change rate
Built-Up Areas	Built Up Area	2957.98	22.9	5.04
Waterbodies	River	607.63	3.31	0.73
	Lake/Pond	-595.25	-100	-22
	Dredged river/Canal	80.94	2.11	0.47
Degraded Lands	Submerged Areas	36982.66	82.63	18.18
	Burrow Pit/Excavated Land	534.60	100	22
	Bare Surfaces	29771-7	73.12	16.09
	Devegetated Areas	5280.12	17.70	3.89
Wetlands	Marsh	-22374.63	-78.80	-17.33
	Mangrove	3376.86	17.12	3.77
Agricultural Lands	Farmland/Fallow	-22274.78	-16.35	-3.60
	Plantation	-1997.69	-90.24	-19.85
Natural/ Semi Natural Vegetation	Heavy Forest	-6009.06	-3.78	-0.83
	Light forest/Thickest	-15812.03	-21.61	-4.75
	Palm Swamp	-11985.63	-16.70	-3.67
	Scrub / Grassland	2229.97	-11.15	-2.45
Open Area	Sandbar	979.52	50.27	11.06
	Dredged Spoil	201	100	22
	Mud	45	100	22

The agricultural lands also decreased to 57043.44ha (15.68%) with the level II classes of farmland/fallow being 56935.41ha (15.65%) and plantation being 108.03ha (0.03%). The natural/semi natural primary class experienced further decline in 2008. The total extent of the natural/semi natural primary class was 144249.91ha (48.72%) in 2008. The coverage of the primary classes are; heavy forest 76425.70ha (30.09%), light forest/thicket 29056.31ha (7.98%), palm swamp 29882.71ha (8.21%) and scrub/grasslands 8885.19ha (2.44%). The open area increased from 1 level II class to 3 level II class in 2008 with total area of 1710.66ha (0.47%) with specific coverage of sandbar being 1464.31ha (0.4%), dredged spoil being 201.27ha (0.06%) and mud being 45.08ha (0.01%). The cloud cover took 329.64ha (0.10%) of the area coverage thus increasing the total land mass of the study area to 330, 846.79ha higher than the previous 330, 517.15ha in 1960 and in 1986.

3.2. Magnitude, Trend (Percentage Change) and Annual Rate of Change (1960-2008)

The change magnitude, percentage (trend) and annual rate of change between 1986 and 2008 is presented in table 2.

The period 1986 – 2008 witnessed the emergence of degraded lands. The gains of existing classes reduced while their losses to the degraded lands increased. Correspondingly, the gain of the newer land cover classes increased substantially. Burrows pit/excavated land (100%), submerged areas (82.63%) and bare surfaces (73.12%) which are 2 of the newer classes recorded the highest gains between 1986 and 2008. Sand bar (50.27%) and built up areas (22.9%) also recorded high gains. Others classes that gained include river (3.31%), dredged river canal (2.11%), mangrove (3.77%) and devegetated areas (4.11%).

In summary, 8 of the 19 classes of 1986 recorded loss. These are lake/pond (22%), marsh (17.33%), plantation (19.85%), light forest/thicket (4.75%), palm swamp (3.67%), scrub/grassland (2.45%), farmland/fallow (3.6%) and heavy forest (0.83%).

3.3. Land Use- Land Cover Projection for the Year 2050

The land use land cover projection for the year 2050 was calculated based on the scenario of change between 1986 and 2008. The annual rate of change between 1986 and 2008 was used to multiply the difference in the years (2050-2008=42 years). This is done for all the classes and the resultant result is added to the present land use-land cover coverage for 2008. The projected figure is therefore presented in table 3.

From table 3, if the scenario between 1986 and 2008 is maintained, there is the possibility that by the year 2050, the percentage of built up area would have increased from 2.39% in 2008 to 2.5%, degraded ecologies from 31.47% in 2008 to 38.69% in 2050, natural/semi natural vegetation from 43.81% in 2008 to 42.99% in 2050, agricultural lands from 17.24% in 2008 to 16.98%, wetlands from 4.4% in 2008 to 4.09% by the year 2050, degraded lands from 28.38% in 2008 to 28.85% in 2050 and water bodies from 3.36% in 2008 to 3.43% in 2050. The built up area, water bodies, degraded lands and open area will increase giving the present land use land cover scenario while natural and semi natural vegetation, wetlands agricultural lands will decrease by the year 2050.

Table 3. Land use land cover projection for 2050

S/NO	Primary class	Secondary class	Area (Ha)	%
1.	Built up area	Built up area	8145.79	2.50
2	Water bodies	River	9508.67	2.84
		Lake/pond	0	0
		Dredged river/canal	1973.76	0.59
		Total	11482.43	3.43
3	Degraded lands	Submerged areas	41633.7	12.45
		Burrow pit/excavated land	1458.60	0.35
		Bare surfaces	35920.74	10.74
		Devegetated areas	17716.16	5.31
		Total	96729.20	28.85
4	Wetlands	Marsh	2282.31	0.68
		Mangrove	11710.33	3.41
		Total	13992.64	4.09
5	Agricultural lands	Farmland/fallow	56784.21	16.98
		Plantation	0	0
		Total	56784.21	16.98
6	Natural/semi-natural vegetation	Heavy forest	75544.24	32.73
		Light forest/thicket	28856.81	3.69
		Palm swamp	29728.57	3.95
		Scrub/grassland	8782.29	2.62
		Total	142911.91	42.99
7	Open area	Sandbar	1928.83	0.58
		Dredged spoil	1125.27	0.34
		Mud	969.08	0.29
		Total	4023	1.21
		Grand Total	334069.18	100.05

Source: GIS Analysis

Specifically, plantation agriculture would have disappeared by the year 2050 and the pose serious threat to food security and human survival. The degraded ecologies would have increased in size from 31.47% in 2008 to 38.69% by the year 2050. This calls for serious management of the ecosystem of the study area especially with the increase in the displacement of the people from their settlements and uproots of livelihoods such as agriculture especially fishing and crop production.

4. Conclusions

Findings in the study of an area of about 331,000 hectares have shown a significant spatio-temporal variation in the rate of gain and loss amongst the different land use-land cover categories. But of utmost relevance is the near complete loss of the region's ecological biodiversity.

The commencement of oil and gas exploration and exploitation, has brought environmental problems associated with canalization, oil spillage, gas flares, land subsidence, depletion of forest resources, riverbank and coastal erosion, and so on. There are indications that the extraction of large quantities of oil and gas from the region is continuing to cause subsidence and relocation of settlements.

This is most disturbing especially as sources of livelihoods in the form of farming and fishing which are the major occupations in the area are threatened. The survival of the inhabitants now hang in the balance and if drastic measures are not taken to check the high rate of land use- land cover change been witnessed the study area might witness restiveness as is currently going on in both the central and eastern Niger Delta.

On the basis of this study, it is highly recommended that all dredged canals and constructed water channels that opened directly from the land to the sea should be managed in such a way to prevent continued saline water inflow into the land areas

There is the need for urgent land resources restoration for areas that have suffered terrible degradation. In particular, the stretch of coastal land that runs along the ocean coast. Mangrove and marsh replant needs to be urgently considered.

Legislations compelling environmental protection, restoration and remediation should be enforced to stem externalities resulting from resource exploitation; oil companies' and other companies in the area should be environment-friendly in their activities and respect all laws on environmental protection and sustainability as expressed by[18].

The study area environment is no doubt under siege, and unless both short and long-term changes are instigated, sustainable development may remain an illusion. There is no doubt that there is need for balanced approach towards

sustainable development and environmental sustainability especially if the amnesty programme of the Federal Government of Nigeria is to be successful.

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