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TREND IN LAND USE/COVER CHANGES IN STUBBS CREEK FOREST, AKWA IBOM STATE, NIGERIA

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ABSTRACT
This study examined the land cover changes in Stubbs Creek, Nigeria using a combination of satellite remote sensing and ground data with the aim of determining the spatial extent and trend of changes of forest landscape in the area using three epochs of satellite imagery (1986, 2000 and 2014) The results indicated that the spatial extent and trend of forest landscape changes within the 28 years period under study (1986 – 2014) showed a decrease of -292.73ha (0.66%) of water bodies with an annual trend of 10.45ha, 11,519.29ha (25.84%) for primary forest with annual trend of 411.40ha and -10,478 (23.50%) hectares for secondary forest with annual trend of 374.21ha, while cultivated lands and Built-up/Bare lands increased by 18,211.79ha (40.86%) and 4,078.23 (9.11%) with an annual trend of 650.48ha and 145.65ha respectively. All land cover changes followed a positive coefficient of correlation. An urgent review of the management of the forest structure in the state, especially around the coastal region is recommended to curtain flooding and erosion.

Keyword: Stubbs Creek, Remote sensing, Landuse change, Tropical forest, Biodiversity

INTRODUCTION

Land is one of the most important natural resources, as life and developmental activities are based on it (Ezeomedo and Igbokwe, 2013). It is becoming a scarce resource due to immense agricultural and demographic pressure. Hence, information on land use/land cover and possibilities for their optimal use becomes pertinent for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare (Ezeomedo and Igbokwe, 2013).
Land-use change and land-cover change (LULCC) are terms often used interchangeably but the two have different meanings. Land cover describes the natural and anthropogenic features that can be observed on the Earth's surface (deciduous forests, wetland, developed/built areas, grasslands, water, etc.) and Land use, by contrast, describes activities that take place on the land and represent the current use of property such as residential homes, shopping centers, tree nurseries, state parks, reservoirs, etc. (Jensen, 2005). LULCC, especially those caused by human activities, is one of the most important components of global environmental change (Jensen, 2005). Land use/land cover and human/natural modifications have largely resulted in deforestation, biodiversity loss, global warming and increase of natural disaster-flooding (Reis, 2008). Therefore, available data on LULC changes can provide critical input to decision-making of environmental management and planning the future (Jacob and Olajide, 2011). The growing population and increasing socio-economic necessities creates a pressure on land use/land cover. This pressure results in unplanned and uncontrolled LULC changes. The LULC changes are generally caused by mismanagement of agricultural, urban, range and forest lands which lead to severe environmental problems such as landslides, floods etc. (Reis, 2008).

Coastal regions are the most important biodiversity spot and intensely used areas settled by humans in the world (Sesil and Aydinoglu, 2005). In Nigeria, the Niger delta region is an ecological fragile region with high levels of biodiversity and is known to be a repository of biologically diverse plants that offers opportunities for food and pharmaceuticals (NDES, 1997). In addition to providing plants for medicinal purpose, the forest ecosystem also offers products such as fuel wood for cooking, heating, drying/smoking of fish, timber for construction, building industry or boat construction and edible wildlife plants in forms of leafy vegetables, fruits and seeds, spices, food wrappers and starchy tubers (Onojeghuo and Onojeghuo, 2015). Stubbs Creek Forest Reserve located in the Niger delta is believed to contain the largest intact block of forest remaining in Akwa Ibom State (Udo *et al.*, 1997). The reserve is unique because of its composite nature - it includes mangrove forest, swamp forest, and lowland rainforest. As a result of population increase, unemployment, oil exploration, etc. and its resulting negative consequences in the area, the unstable and unbalanced development is bringing about destruction to the flora and fauna biodiversity loss.

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Several studies have demonstrated the potential of combining satellite remote sensing and ground data (Murdiyarso and Skutsch, 2006) to effectively determine the spatial extent of deforestation across tropical forest regions of the world (DeFries *et al*., 2005; Ellis and Porter-Bolland, 2008; Onojeghuo and Onojeghuo, 2015). In a study conducted by Ekpeyoung (2015) and Onojeghuo and Onojeghuo (2015), multiple satellite imagery was used to examine the extent of forest cover loss over a period of more two decades in the tropical forests landscape of Akwa Ibom and Cross River States. In order to fill in the existing gap in literature on spatial information of landscape dynamics in the Akwa Ibom State, this paper presents results on the current status of forests in Stubbs Creek with the overall aim to conduct a spatially explicit study of forest cover changes in the area using satellite remote sensing and ground data.

MATERIALS AND METHODS

Study Area

The Stubbs Creek Forest Reserve (SCFR) covers 310km^2 in southeastern Akwa Ibom State, Nigeria (Ndoho *et. al.*, 2009). It was first created in 1930 under Order 45. This original order has subsequently been amended by Order 16 of 1941, order 17 of 1941, Order 28 of 1941, E.R.L.N 236 of 1955 and E.R.L.N 56 of 1962. Gazetted in 1955 as a forest Reserve, it is probably the only significant forest Reserve in Akwa Ibom State (Ndoho *et. al.*, 2009). Legally, the reserve belongs to the Nigerian Federal Government, but it is managed by Akwa Ibom State.

The SCFR lies approximately between latitudes 4°32’ N and 4°38’N and longitudes 7°54’E and 8°18’E. It is bounded by Mobil Producing Nigeria Unlimited (MPNU) installations and Ntak to the West and Unyenge and Okposso communities in the East (Ndoho *et. al.*, 2009). The SCFR is bordered by water on three sides: the Atlantic Ocean on the South, the Kwa Ibo River on the West, and the Cross River estuary on the East (Baker, 2003). The two major creeks, Stubbs and Widenham, run west-east (at about 4°36') in the northern half of the reserve (Gadsby, 1989). Mean annual rainfall for this coastal region is high – from 2,000mm to 2,500mm. The mean minimum and maximum temperature are 26°C and 30.5°C respectively while the mean relative humidity of the area is about 83% (Werre, 2001).

Stubbs Creek is predominantly a freshwater swamp forest that seasonally floods in some zones. It also comprises brackish-water swamp forest, mangrove forest in the eastern end of the reserve, secondary forest, farmland, palm bush, and abandoned farms (Gadsby 1989). In AkwaIbom State, Stubbs Creek represents the only remaining natural coastal swamp forest of any significant size (Tooze *et al*. 1998a; Tooze *et al*. 1998b).

Remotely Sensed Data

The satellite imagery used for the landuse classification and change detection analysis was Landsat Thematic Mapper imageries for three epochs (1986, 2000 and 2014) obtained from the United State Geological Surveys (USGS) with a resolution of 28.5m. These datasets were all acquired in the dry season in order to minimize seasonality variations (Malingreau *et al*., 1995) and were radiometrically and geometrically corrected to allow for direct image-to-image comparison.

Image Classification and Change Detection Analysis

The satellite images were classified using the unsupervised ISODATA (Iterative Self Organising Data Analysis) classification technique as described by Ball and Hall (1965) and Onojeghuo and Onojeghuo (2015). This procedure was performed using the ISODATA classifier algorithm in ERDAS Imagine software (ERDAS, 2014). Using independent training and testing data, a total of five broad classes were delineated to show primary forest, secondary forest, cultivated land, built-up/bare land and water bodies. The classified images were also confirmed that they were within tolerance level. The training and validation ground truth data were obtained from Google Earth, high resolution satellite imageries, historic aerial photographs, global positioning system (GPS) ground data and manual interpretation of the satellite imageries used in the study. The process of change detection analysis was performed using the Land Cover Modeler of IDRISI 17.0 Selva Edition. The three time intervals investigated in this study were 1986 to 2000, 2000 to 2014 and 1986 to 2014 respectively. The resulting Areas (in hectares) of land cover types were calculated for each of the study year. The comparison of the land cover statistics assisted in identifying the change in hectares/percentage, trend and rate of change. The percentage change to determine the trend of change was calculated by dividing observed change by sum of changes and multiplied by 100.

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$$(\textbf{\textit{Trend}})\ \text{percentage change} = \frac{\text{Observed change}}{\text{Sum of change}} * 100 \qquad - \qquad - \qquad (1)$$

RESULTS AND DISCUSSIONS

Land Cover Inventory

The result in Table 1 and Figure 1, 2 and 3 below indicates that in 1986, water bodies occupied 30,254.40 hectares, primary forest 23,178.33 hectares, secondary forest 22,918.76 hectares, cultivated lands 17,048.03 hectares and built-up/bare lands 5,946.22 hectares. In 2000, water bodies was reduced to 30,122.26 hectares, primary forest area reduced to 22,077.90 hectares, secondary forest reduced to 20463.22 hectares while cultivated lands and built-up lands increased to 19,875.08 hectares and 6807.27 hectares respectively (Figure 2). In 2014, water bodies and primary forest were reduced to 29,961.67 hectares and 11,659.04 hectares respectively while secondary forest, cultivated lands and built-up/bare lands were also reduced to 12,440.76 hectares, 35,259.82 hectares and 10,024.45 hectares respectively.

Table 1: Land Cover Inventory of Stubbs creek forest

Class Name	1986 Area (ha)	2000 Area (ha)	2014 Area (ha)
High Forest	23178.33	22077.90	11659.04
Secondary Forest	22918.76	20463.22	12440.76
Cultivated Lands	17048.03	19875.08	35259.82
Built-up/ Bare Lands	5946.22	6807.28	10024.45
Water	30254.40	30122.26	29961.67

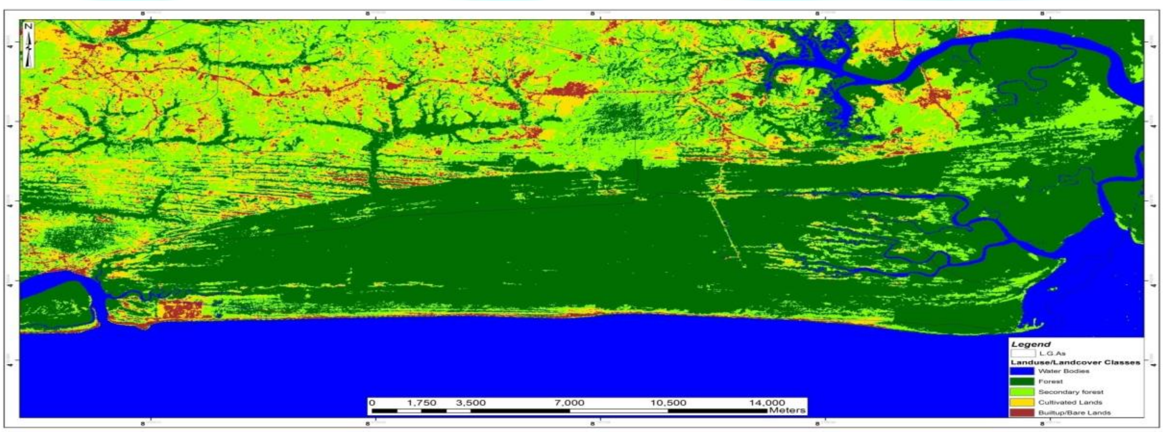

Fig. 1: Coastal Area of Akwa Ibom State showing the Extend of Stubbs Creek at 1986

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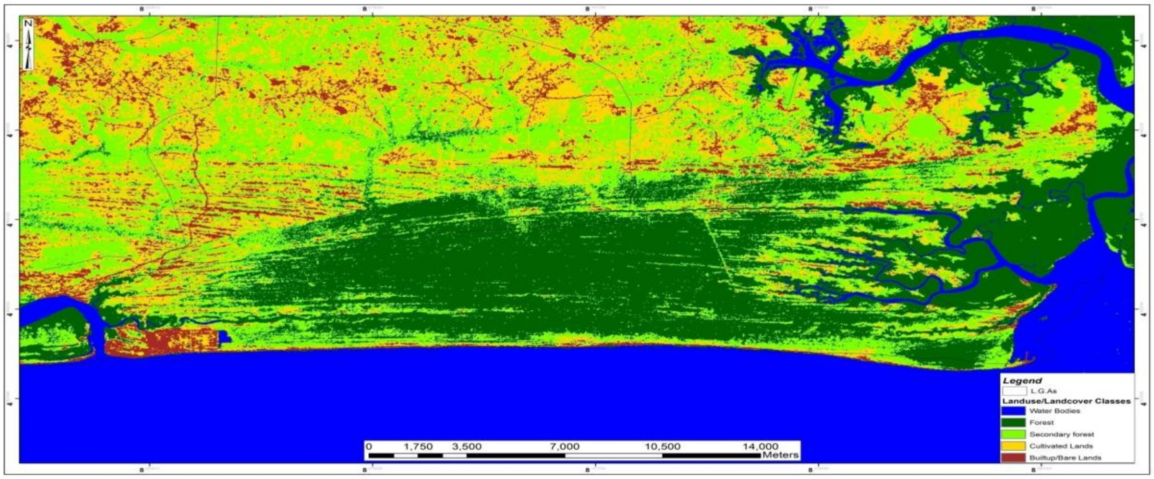

Fig. 2: Coastal Area of Akwa Ibom State showing the Extend of Stubbs Creek at 2000

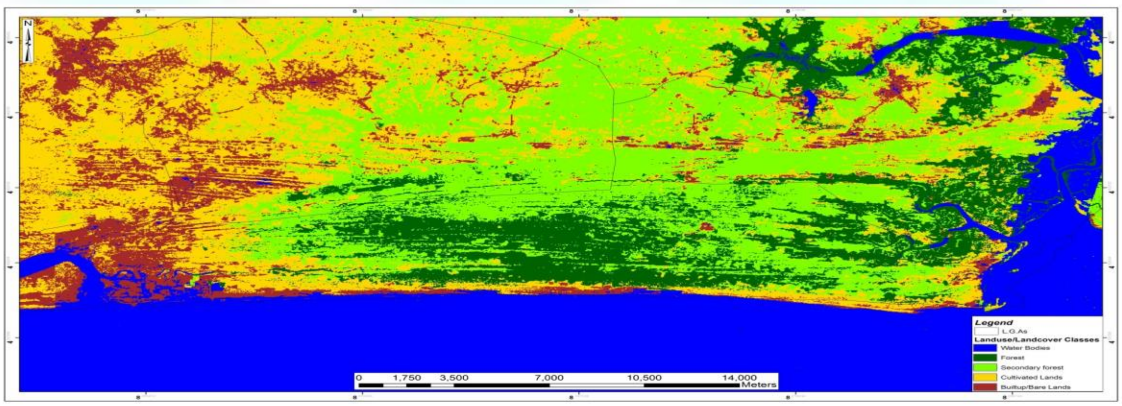

Fig. 3: Coastal Area of Akwa Ibom State showing the Extend of Stubbs Creek at 2014

AREA ANALYSIS OF LAND USE/COVER CHANGE

It is obvious in Table 2 that between 1986 and 2000 (14 years period), primary forest showed a negative increase of -1,100.43, representing 14.92% decrease in area, Secondary forest also had an increase of -2,455.54 implying a decrease in 33.28% area. Cultivated lands and Built up / Bare lands increases positively by 2,827.05 (38.33%) and 861.06 11.68%) respectively, while water bodies indicated a negative changed of -132.14 hectares representing 1.79% decrease in size. In the last 14 years (2000-2014), the primary forest, secondary forest and water increased negatively by -10,418.86 (28%), -8,022.46 (21.56%) and -160.59 (0.43%) hectares respectively. However, Cultivated lands and Built up/Bare lands increased positively with 15,384.74 (41.34%), 3,217.17 (28%) and 3,217.17 (8.67%) hectares respectively.

Generally, trend of changes within the 28 years period under study (1986 – 2014) showed that there was a decrease of -292.73 (0.66%) hectares for water bodies, 11,519.29 (25.84%) hectares for primary forest and -10,478 (23.50%) hectares for secondary forest, while there was an increase of 18,211.79 (40.86%) hectares for cultivated lands and 4,078.23 (9.11%) hectares for Built-up/Bare lands respectively (Figure 4). This implies that the land cover changes between 1986 - 2014 for the primary forest decreased by 49.70% with a R^2 of 82.08%, secondary forest decreased by 45.71% with a R^2 of 91.40% and water bodies also decreased by 0.97% with a R^2 of 99.69%, cultivated land and built-up/bare land area increased by 106.83% with R^2 of 86.32% and 68.58% with R^2 of 89.99% respectively (Fig. 4).

Table 2: Trend of Land covers change in the study area

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Class Name	Area Change 1896-2000	% Change 1986-2000	Area Change 2000-2014	% Change 2000-2014	Area Change 1896-2014	% Change 1986 -2014	% Class change 1986-2014	Annual rate of change (ha)
High Forest	-1,100.43	14.92	-10,418.86	28.00	-11,519.29	25.84	49.70	411.40
Secondary Forest	-2,455.54	33.28	-8,022.46	21.56	-10,478	23.50	45.71	374.21
Cultivated Lands	2,827.05	38.33	15,384.74	41.34	18,211.79	40.86	106.83	650.42
Built-up/ Bare Lands	861.06	11.68	3,217.17	8.67	4,078.23	9.14	68.58	145.65
Water	-132.14	1.79	-160.59	0.43	-292.73	0.66	0.97	10.45
Total	**7,376.22**	**100**	**37,203.82**	**100**	**44,580.04**	**100**		**1592.13**

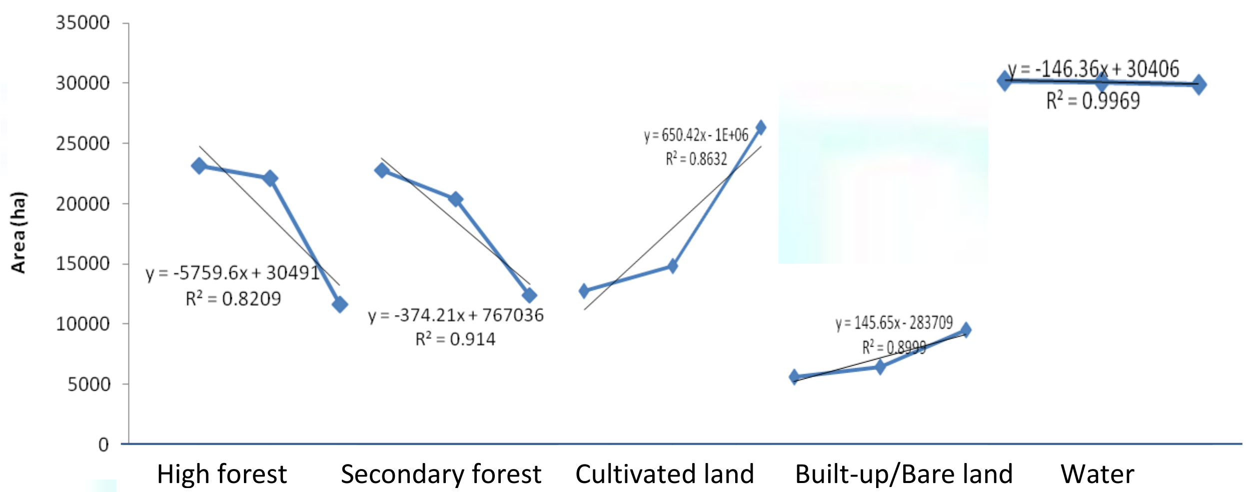

Figure 4: Landuse change trend and coefficient of change

DICUSSION

As indicated in the result (Table 2), there was a decrease of -292.73 (0.66%) hectares for water bodies, 11,519.29 (25.84%) hectares for primary forest area and -10,478 (23.50%) hectares for Secondary forest, while there was an increase of 18,211.79 (40.86%) hectares for Cultivated lands and 4,078.23 (9.11%) hectares for Built-up/Bare lands respectively. These changes could be as a result of natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics which may initiate modifications upon land cover (Zubair, 2006). However, globally, land cover today is altered principally by direct human use such as agriculture and livestock raising, forest harvesting and management, urban and suburban construction and development. Incidental impacts on land cover from other human activities on the forest and lakes could also be by acid rain from fossil fuel combustion, and oil exploration (Meyer, 1995; Zubair, 2006).

In the study area, a study by Ndoho *et al.* (2009) and Baker (2003) showed that majority of the people are self employed and their major occupation are farming, fishing and logging with an annual income per household of less than N300,000.00 annually (N25,000.00 per month). The spatial distribution of the dependency of the households on SCFR by the different villages in the study area showed that in all the communities, the people utilize the forest products for livelihood activities (Ndoho *et al*., 2009). However, the dependency rate is not the same for all SCFR resources. The dependency on SCFR according to Ndoho *et al.* (2009) for fishing, palm fruits collection, farming ranked first, second and third respectively. These were followed by dependency on firewood and periwinkles which ranked. The frequencies of extracting resources from SCFR showed that distance was the principal factor. Distances from the villages to the forest periphery and the core parts varied from one location to another as such the

frequencies of extracting resources from SCFR and the rate of deforestation or
increase in the trend of forest area lost over the period under study as a result of increase in population.

Changes in the land use/land cover in the study area can be attributed to farming activities. According to Baker (2003), commercial farming is an economic activity for most of the communities. However, in fewer smaller villages, farming was mainly for subsistence. Major crops cultivated by the people include cassava, cocoyam, melon, maize, oil palm, and cucumber (Baker, 2003).

Also, an assessment of the threats to the conservation of the Stubbs Creek reserve by Baker (2003) indicated an increase in timber-extraction clearings and further degradation in the west end of the reserve, particularly around Douglas Creek and close to the main oil terminal. Also noted was the continued extirpation of the mangroves that dominate the eastern portion of Stubbs Creek, due more to the exotic invasive Nipa palm (*Nypa fruiticans*) than to anthropogenic vegetation clearance. In contrast, as also noted by Coad (undated) in Baker (2003), the degradation of the western portion of the reserve has been primarily due to clearing of land for agriculture. The proximity of a major road leading to the ExxonMobil terminal from the town of Eket is believed to have also facilitated use of the reserve for both farming and logging activities.

The intensity of logging in the study area varies from community to community. In many cases, logging activities are conducted by outsiders, often people from the main village, and usually just a few locals are hired for extraction activities, such as cutting and hauling timber (Baker, 2003). Timber extraction occurs year-round. Stubbs and Widenham Creeks are used primarily in the rainy season and boats transport is used to convey the wood to the main road. Along the coast timber is usually extracted by lorries on the beach during low tide.

Oil-related development activities seem to have little direct impact on the reserve. ExxonMobil's oil-drilling operations are off-shore. However, the major road built by ExxonMobil has indirectly facilitated human use of the reserve and exploitation of its natural resources (via hunting, farming, and logging) (Baker, 2003). Burying of oil and gas pipelines fragments or destroys the rich biodiversity ecosystems. Apart from the reduction in habitat area (forest area), clearing of pipeline track delineates natural populations, which might in turn distort breeding (Nenibarini, 2004). Oil spillages also occur in the area. Sources of oil in the environment are variable, including, pipeline leakage and rupturing, accidental discharges (tank accident) discharges from refineries, urban centers etc. There are also biogenic sources of hydrocarbons. The overall effects of oil on ecosystem health and biota are very many including the interference with the functioning of various organs systems of plants and animals, creating environmental conditions unfavourable for life e.g oil on the water surface forms a layer which prevents oxygen from dissolving in water. Crude oil contains toxic components, which caused out right mortality of plants and animals as well as other sub lethal impacts. Generally, toxicity is dependent on the nature and type of crude oil, the level of oil contamination, type of environment and the selective degree of sensitivity of the individual organism.

Gas flaring associated with oil production in the study area is very unfriendly to natural ecosystems and biodiversity. Gas flares contain over 250 toxins (Nenibarini, 2004). A study of the impact of gas flaring on the environment revealed that there was about 100% loss in yield in all crops cultivated about 200 metres away and from the gas flaring plant, 45% loss of those about 600 metres away and about 10% loss in yield for crops about one kilometer away from the flare (Okezie and Okeke, 1987). The poor yield of agricultural crops will translate into increased clearance of more virgin land for farming activities and a decrease in the amount of available forest area. Leakages and fire incidents are also associated with gas production and transportation. Local plants and animals inhabiting the affected area were killed, thus corroborating the observation of Phil-Eze and Okoro (2009) that there has been a substantial decline in biodiversity around the Niger Delta due to immense loss in forest cover. It must be stressed that incidents such as mentioned above can result in elimination of whole population of endangered species with restricted distribution.

CONCLUSION

The study demonstrated the effectiveness of satellite remote sensing and ground based measurements in determining the spatial extent and forest landscape changes in the Stubbs Creek. The results indicates that spatial extent of landscape for the study area decreased by 11519.29ha (49.70%), 10478ha (45.71%) and 292.73ha (0.97%) for the primary forest, secondary forest and water bodies with an annual trend of 411.40ha, 374.21 and 10.45ha respectively over the period of study (1986 – 2014). Cultivated and built-up/bare landscapes were observed to increase by 18211.79ha (106.83%) and 4078.23ha (68.58%) with annual trend of 650.42ha and 145.65ha respectively. From the results, it is obvious the Stubbs Creek has lost a total of 95.41% of its forest area; hence there is an urgent need to review the management of the forest structure in the state, especially around the coastal areas as these forest help to cushion the tidal effects on the riverine communities.

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