ISSN : 0974 - 7451 Volume 10 Issue 11

Environmental Science
An Indian Journal
Current Research Paper

ESAIJ, 10(11), 2015 [414-422]

Using satellite remotely sensed data and geographic information system to analyse mangrove forest distribution change in Akwa Ibom State from 1986-2003

Marcellinus Akaangee Hula[1]*, Dr I.J.Uwen[2]
[1]Department of Geography, Benue State University, P.M.B. 102119, Makurdi, (NIGERIA)
[2]Department of Geography and Natural Resource Management University of Uyo, Uyo, (NIGERIA)
E-mail: akamas3@yahoo.com

ABSTRACT

This paper utilised remotely sensed data and GIS to determining the change mangrove forests have undergone in Akwa Ibom from 1986 to 2003. The mangrove forest is known to be rich in both aquatic and terrestrial biodiversity as such a major source of rural life sustenance in the Akwa Ibom State as well as plays a vital role in ecosystems stabilization. Unfortunately, the Mangrove forest in recent times has been subjected to the effects of a growing population, economic and social pressures manifested in the form of rapid urbanization, agricultural land expansion and industrialization. At it stands, the mangrove forest is not under any known form of protection and or laws and strategies of biological resource conservation in Nigeria. Even in areas where they seem to exist, they have alienated the knowledge systems and practices of the local people. This paper therefore examines the change mangrove forests have undergone in the coastal line of Akwa Ibom State. Satellite images of Landsat TM 1986 and ETM 2003 of the study area were acquired from National Centre for Remote Sensing, Jos where change detection and analysis were done using Erdas Imagine 9.2 and ArcGis 9.2. The analysis of the images revealed that mangrove forests have change from 114103.8 ha representing 17.2% in 1986 to 107669.7ha (15.3%) in 2003. This change resulted in the loss of 96434.1 ha of mangrove forest due to the invasion of Nypa palm, activities of the oil companies, increasing rate of mangrove removal by timber logging, and local usage of mangroves. Thus, the study concludes by recommending that forest reserves should be established in Eastern Obolo where mangrove is still luxuriant with integrated sustainable forest management. Furthermore, policy makers and planners should enlighten the local people on the dangers of over exploitation and encourage them to strengthen these traditional resource management practices.

INTRODUCTION

The mangrove forests of Nigeria are the largest in Africa and are the third largest in the world after India and Indonesia (UNEP, 2007). According to Ukpong (2007), the term mangrove generally applies to an association of trees which live in wet, loose soils in tropical tide waters. Mangrove is normally restricted to those species of trees which possess either pneumtophores or viviparous fruits or both. The word mangrove is used when reference is made to individual kinds of trees, while the word mengal may be used with reference to the swamp forest community. The mangrove forest is known to be rich in both aquatic and terrestrial biodiversity as such a major source of rural life sustenance not only Akwa Ibom State but many other regions in Niger Delta and elsewhere.

Various sources have attributed conflicting quantities to the area coverage of mangrove in Nigeria. Figures quoted include 5,400 km² and 6000 km² (Mmom and Arokoyu, 2009); 9900 km², 9980 km², 7422 km² (Adegbehin and Nwaigbo, 1990) and the highest being 11,134 km². Estimates on extent of mangrove indicate a decline and has reduced by 26 per cent since 1980 (Bioresources Development and Conservation Programme, 2010). Some authors however, put the commencement of the decline at 1970 with the advent of the oil boom (UNEP, 2007), a development associated among others with petroleum and gas exploration and production especially from the seventies. The rate of decline due to various physical alteration and destruction of habitats have been estimated TABLE 1 but actual cover is at best estimated from aerial photographs, high resolution satellite imageries and thorough ground truthing based on surveys.

TABLE 1: Mangrove area estimates

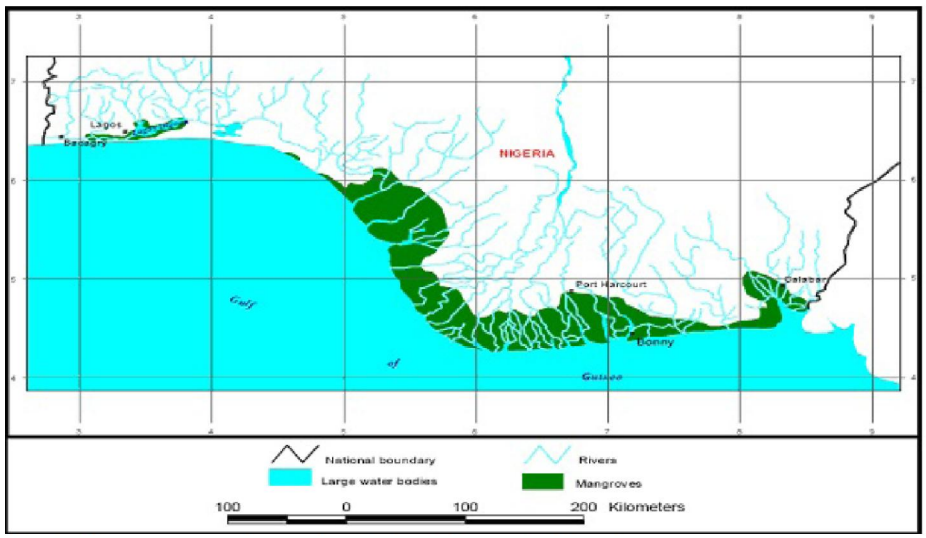
Year	Area (km²)
1980	9 990
1990	9 980
1997	11 134
2000	9 970
2005	9 970
2006	7 386

Source: UNEP (2007)

Mangroves are found to some extent in all the nine coastal States of Nigeria i.e. Lagos, Ogun, Ondo, Edo, Delta, Bayelsa, Rivers, Akwa Ibom and Cross River. The widest reach of mangrovies is in the edges of the arcuate Niger delta (Figure 1) and specifically Akwa Ibom, Delta, Bayelsa and Rivers States. The mangrove ecosystems are exposed to threats of destruction arising from urban development (e.g. dredging and sand filling for swamp reclamation, urban settlements, road construction, industrial development in coastal areas, coastal resorts, etc) coastal erosion, oil pollution, gas flaring, and subsidence of the coastal geosynclines aggravated by fluid withdrawal (oil and gas) from porous reservoirs in subsurface Niger Delta. However, the replacement of the mangroves by the exotic palm, *Nypa fruticans*, has been identified by various experts as a major threat to the mangrove ecosystem and an ecological disaster deserving urgent attention. However, in the study, the goal is to demonstrate how remotely sensed data can be used to explain the pattern of change mangrove forest has undergone recently in Akwa Ibom State.

Statement of problem

Nigeria is recorded to have the third largest mangrove forest in the world, and the largest in Africa, covering an area of approximately 105,000 hectares (Anon, 1995 and Ndukwu and Edwin-Nwosu, 2007). The Niger Delta area where Akwa Ibom State be-



Source: Mmom and Arokoyu (2010)

Figure 1: Mangroves and associated plants forest in Nigeria

longs has the largest proportion of Nigeria's mangrove forest, which is being reported to be the most exploited in the world (FAO, 1997). Unfortunately, the Mangrove forest in recent times has been subjected to the effects of a growing population, economic and social pressures manifested in the form of rapid urbanization, agricultural land expansion and industrialization. Thus, there is a steady deforestation of the mangrove forest and loss of biodiversity in the State. The mangrove forest is not under any known form of protection and or laws and strategies of biological resource conservation in Nigeria.

Consequent upon this, deforestation results to the rapid loss or decimation of biodiversity in the region. Elsewhere in the Nigeria, the growing awareness and concern about the rate of biodiversity loss generally has resulted to several biodiversity conservation strategies. This includes the designation of protected areas listing and protection of species among other legislations and regulations. Some examples of such protected areas according to Mmom (2007) are the Okwangwo Rainforest Reserve in Boki area of Cross River State; and Oban Group Rainforest Reserve Cross River State among others. However, most of these protected areas contain either agricultural land or sources of livelihood to the local people.

Thus formal protection does not guarantee protection of biodiversity. More so, not all biodiversity rich or sensitive areas are under any form of protection as in the case of the mangrove forest of Akwa Ibom State. In fact, most conservation efforts have ignored traditional knowledge system and practices that reflect many generations of experience in the conservation of their natural resources, thereby exposing the protected areas to external influences (poaching) as well as depriving the people access to their natural resources. The resultant effect of this is the failure of the conservation strategies and depletion of the forest resources. It is against this background that this paper aims at determining the rate of change mangrove forest has undergone over time in Akwa Ibom State.

Aim and objectives

The main aim of this study is to determine the changes mangrove forest has undergone in Akwa Ibom State from 1986 to 2003. To achieve this aim the following objectives were pursued vigorously;

To analyse the spatio-temporal change mangrove forest has undergone in Akwa Ibom State from 1986 to 2003.

To identify and examine the drivers of mangrove forest change in Akwa Ibom State from 1986 to 2003.

Scope and delimitation

The spatio-temporal scope of the study is restricted to Akwa Ibom State for a period of 17 years from 1986 to 2003 based on availability of cloud free satellite remotely sensed data. While the contextual scope is centred on mangrove forest vegetation found mostly along the coastal line of Akwa Ibom State especially in Oron, Udunguko, UrueEffiong/Oruko, Opobo, Uruan, Ikot Abasi, Essien Eket, Ibeno and Eastern Obollo.

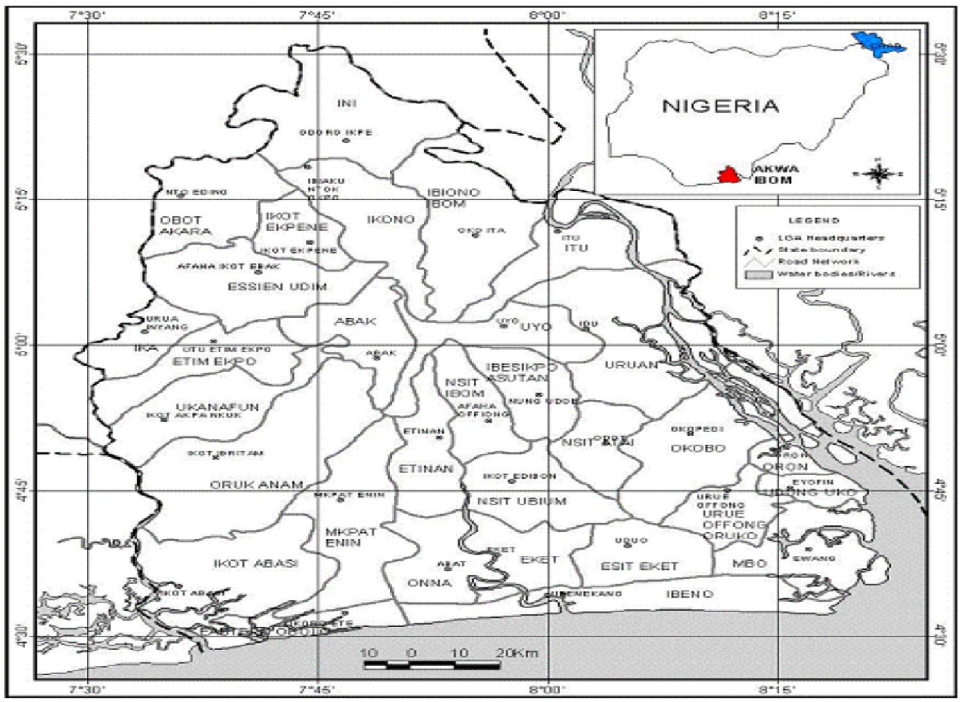
MATERIALS AND METHODS

The study area

Akwa Ibom State is located in South Eastern Nigeria and lies between latitude 4^{o} $30^{'}$ and 5^{o} $30^{'}$ N and longitude 7^{o} $30^{'}$ and $8^{o}15^{'}$ E (Figure 2). Mean annual rainfall over the area decreases gradually from about 4050mm near the coastal area (the southern part) to about 2100mm in the north. The State is noted for its wetlands, sandy coastal ridge barriers, brackish or saline mangroves, fresh and salt-water swamp forests as well as low land rain forest.

According to Ekpeyong (2008) as at 1982 when Akwa Ibom State was not created, much of the mangrove forests were found in the coastal areas of Uruan, Okobo, Oron, Udung Uko, Mbo, Ibeno and Eastern Obolo Local Government Areas. Overall, approximately 34379.966ha (4.74%) of Akwa Ibom State land was covered by mangrove (Ekpeyong, 2008). The State is traversed and criss-crossed by a large number of rivers, streams, canals and creeks. It has a long history of disasters such as oil spillage, flooding, gully and coastal erosions etc. The area is rich in crude oil, gas and many other natural resources.

Data and methodology



Source: Akwa Ibom State Surveys (1997).

Figure 2 : Location of Akwa Ibom State, Nigeria.

The first step employed to achieve the objectives of this study was acquisition satellite remotely sensed data of Akwa Ibom State for a period of 17 years. Hence Landsat TM image of 1986 and ETM image of 2003 were acquired from National Centre for Remote Sensing, Jos using Global Land Cover Facility (GLCF) resource of the United State Geological Survey (USGS). Additionally, site visit and literature was survey on mangrove forest distribution hotspots in Akwa Ibom as a guide to the analysis of the data on one hand and a form of ground truthing on another. Unfortunately, part of Mbo LGA was cut off by the satellite, however, for the purpose of uniformity; the Area of Interest (AOI) was also taken in line with the band that was cut off from the two images acquired. Personal interview was held with selected people around the hotspots areas of mangrove in order to elicit information about the drivers or causes of mangrove forest vegetation change in the State.

The second step was to analyse the change undergone by mangrove forest in Akwa Ibom State using remotely sensed data with the application of GIS. In carrying out this, both Landsat TM 1986 and ETM 2003 were processed using Erdas Imagine 9.2. Both 1986 and 2003 images were enhanced for proper visual interpretation using Principal Component Analysis algorithm. Six land cover and use classes were classified based on their spectral signatures on the images using unsupervised classification method of clustering algorithm in Erdas Imagine. Related to that, in mapping the land cover/use derived from image classification in Erdas Imagine, ArcGis 9.2 was used.

Figure 3 : Mangrove forest in Eastern Obolo, Akwa Ibom State (BDCP, 2010)

It should be noted here that quantification and delimitation of mangrove forest was made difficult especially from satellite imageries by unresolved differentiation of mangrove vegetation from Nypa palm. Visual comparison between raw satellite imagery and classification as well as looking at the mean spectral signatures of different classes was near impossible to ensure that the mangrove areas are distinguished from other vegetation types. Perhaps better resolution imagery could provide reliable quantification. However, efforts made to obtain a higher resolution of the satellite imagery did not yielded immediate results.

RESULTS AND DISCUSSION

Mangrove forest distribution in Akwa Ibom State

A detail survey of literature most especially the report submitted United Nations Industrial Development Organization (UNIDO) by Bioresources Development and Conservation Programme (BDCP, 2010), Ekpeyong (2008) and onsite assessment revealed that relics of some luxurious stands of mangroves are found in Oron, Udunguko, Mbo, Urue Effiong/Oruko, Opobo, Uruan, Ikot Abasi, Essien Eket, Ibeno, Eastern Obollo, and Parrot Island.

Mbo

BDCP (2010) finding reveal that mangroves in Akwa Ibom State have been reduced to just sparse stands and found mainly within the Stubbs Creek section of the Local Government Area (LGA). This LGA is characterized by large settlements/villages whose members are essentially fishermen engaged in high fish and shrimp production most of which require drying for a booming fish and shellfish market. There is no alternative energy source available to the people, making over-exploitation of mangroves inevitable.

Oron

This LGA shares much in common with Mbo even as they are neighbouring LGAs. The mangroves in this area have been greatly depleted. This was one of the earliest locations where Nypa palm was introduced in the early 1900s; the mangrove forests have been replaced by Nypa forests. Public awareness of mangrove degradation is high, especially among local artisanal fishermen occupationally in contact with mangrove vegetation on fishing trips. Dependence is high in terms of local usage and impact is high in terms of removal of vegetation.

Udunguko

Mangroves in this area have been seriously depleted. Even within the Stubbs Creek, Nypa palm is the dominant vegetation. Public awareness is high, dependence is high and human impact is high.

Eastern Obolo

This area is the richest in mangrove forests and thus is recommended for establishment of Forest Reserve and not as a site for reforestation. The abundance of mangroves here is only comparable to that in Bakassi area of Cross River State, with mangroves of about 40-60 m height. Awareness of mangrove as a resource is high, but dependence is medium and impact is also medium.

Analysis of mangrove forest change in Akwa Ibom State

An important aspect of change detection according to Zubair (2006) is to determine what is actually changing to what i.e. which land use or cover class is changing to the other. This process involves a pixel to pixel comparison of the study year images through overlay. Hence, mangrove forest change detection was carried out through area calculations and overlay for the nature and location of the changes as presented in Figure 4 and 5.

Spatio-temporal change in mangrove forest in Akwa Ibom

The mangrove forest spatio-temporal change was thus analysed in two perspectives. The first involved the changes in area covered by mangrove forest in 2003 from its area coverage in 1986, while the second aspect involves the conversion of mangrove forest to other land cover types between 1986 and 2003. By comparing the results of the statistics generated from the satellite images, the summary of the individual land cover is presented TABLE 2.

It is worthy of note here that the area of Akwa

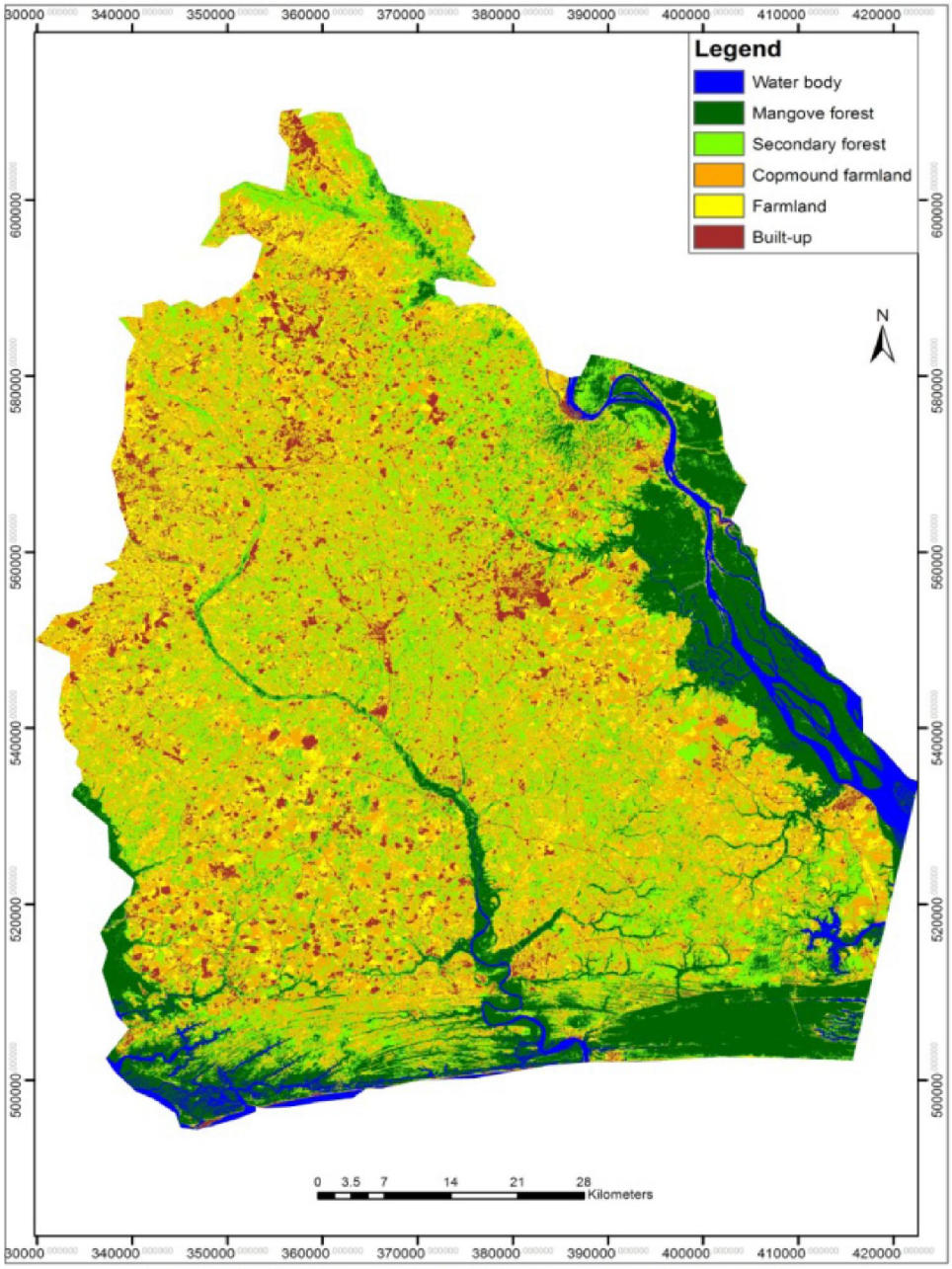


Figure 4 : Akwa Ibom State 1986 landcover map from landsat image

Ibom State has been measured to be 724, 593.5 ha as reported by Ekpeyong (2008). However, due the cutting off of the image in part of Mbo LGA by the satellite, the area has been reduced to 683, 242.9 ha giving a deficit of 41, 350.6 ha. It is this area of 683, 242.9 ha that has been used for the analysis of the change in mangrove forest in the study area. A critical examination of the result of analysis presented in TABLE 2 shows that in 1986 compound farmland occupied the largest area representing 26.3%. This was followed by secondary forest (24.6%), farmland (20.5%), mangrove forest (17.2%) while built up and water body occupied 8.2% and 3.2% respectively.

The result of the analysis also reveals that mangrove forest covered an area of 114103.8 ha representing 17.2% of the entire area of Akwa Ibom in 1986. However, in 2003, mangrove forest reduced from its initial area coverage to 107669.7ha (15.3%). This change observed from 1986 to 2003 (i.e. 17 year period) resulted in the loss of 96434.1 ha of mangrove forest to other land use/cover types

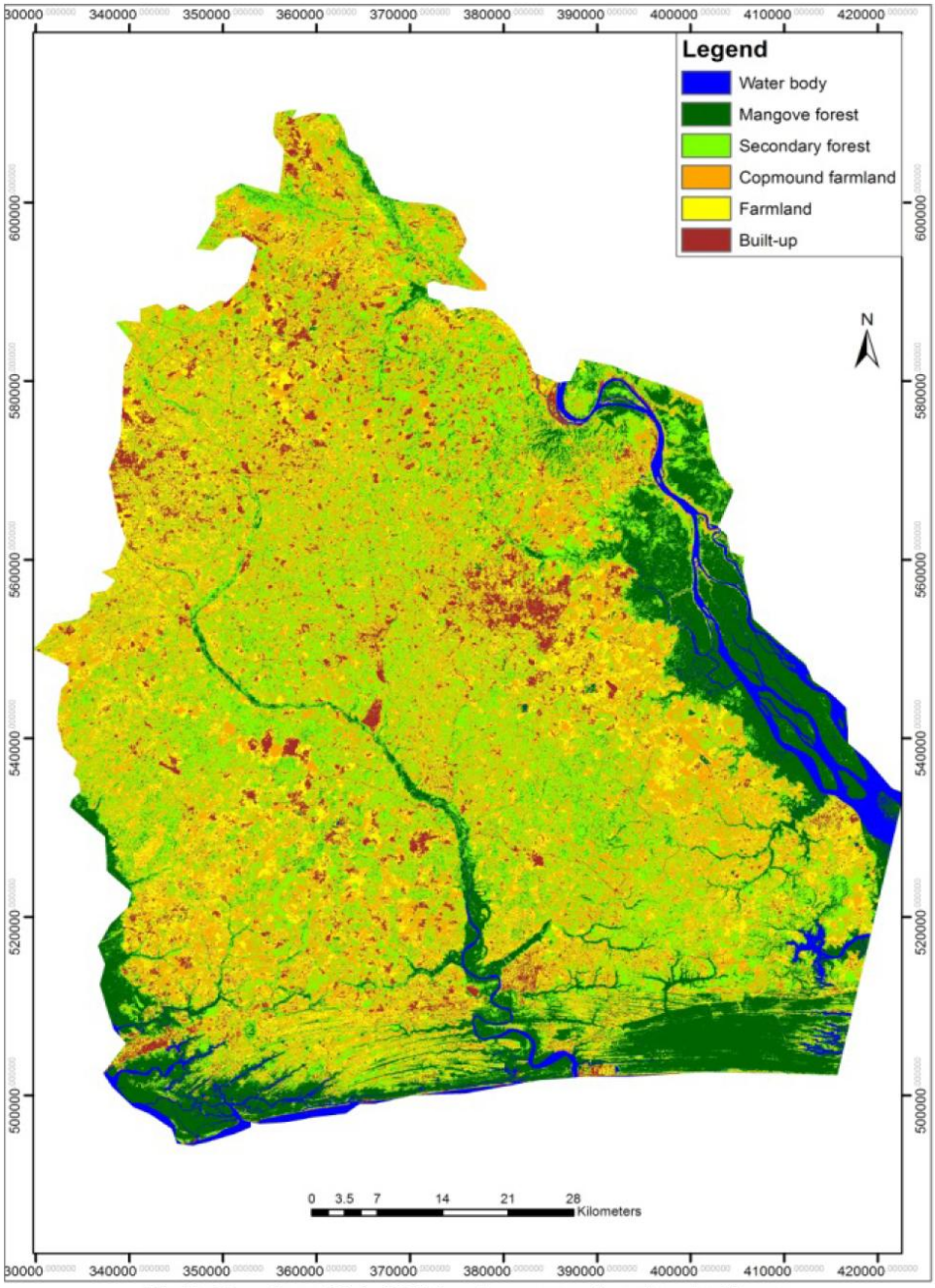


Figure 5 : Akwa Ibom State 2003 Landcover map from landsat5 image

TABLE 2 : Mangrove and other land cover/use change between 1986 and 2003

Class Name	Area 1986 (ha)	%	Area 2003 (ha)	%	Area Change km^2	% Change	Direction
Water body	21980.3	3.2	19655.2	2.9	2325.1	-0.3	Decreased
Mangrove forest	114103.8	17.2	107669.7	15.3	96434.1	-1.9	Decreased
Secondary forest	168079.5	24.6	189600.8	27.7	21521.3	3.1	Increased
Compound farmland	179840.3	26.3	170540.9	25.0	9299.4	-1.3	Decreased
Farmland	139658.1	20.5	139996.2	20.4	338.1	0.1	Increased
Built-up	55780.1	8.2	59580.9	8.7	3800.8	0.5	Increased
Total	683242.9	100	683242.9	100			

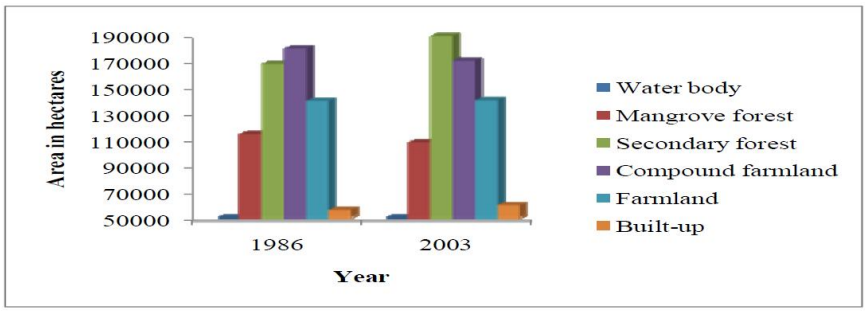


Figure 6 : Change in Mangrove Forest in Akwa Ibom State from 1986 to 2003

in Akwa Ibom State. Related to that, the result of the analysis of mangrove forest change as observed favoured other classes of land cover/use mostly secondary forest which changed from 168079.5 ha representing 24.6% in 1986 to 189600.8 ha (27.7%) in 2003 (see Figure 6).

Drivers of mangrove forest change in Akwa Ibom State

The decline of the mangrove resource is associated with the rapid population growth and expansion of settlements, high poverty, low development indices, poor governance in rural areas and open access of coastal resources. Generally, UNEP (2007) identified four drivers of mangrove change/loss in West African mangrove as population growth, socio-economic cum political trends, climate change, and changes in upstream habitats. The decline has generally been described as moderate for West African mangroves with 21-50 percent change in mangrove cover. In Nigeria, according to Mmom and Arokoyu (2010) the main drivers of change in mangrove status have been identified to include Petroleum and gas exploration and production; Deforestation-over harvesting/overexploitation near coastal settlements; Urban development-sand filling of swamps for construction purposes; Pollution arising from domestic and industrial wastes; Mangrove conversion activities-plantations of oil palm, rice fields and agriculture/aquaculture ponds; salt production, and Dredging activities-Drainage and canalization.

However, in Akwa Ibom State apart from invasion by Nypa palm, impacts on native mangroves are generally linked to three causative factors, which are activities of the oil companies (exploration and exploitation in mangrove swamps), increasing rate of mangrove removal by Timber logging, and local usage of mangroves. There are clear distinctions for the degradation/depletion due to socio-economic conditions and anthropogenic/developmental pressures in anyone location. By far, onshore exploration in mangrove swamps accounts for the highest rate of degradation, followed by logging activities and communal usage of mangroves. Other sources of mangrove forest loss in Akwa Ibom State include urban growth, industrial development and oil activities.

CONCLUSION

The use of remotely sensed data and application of Geographic Information System to determine the change in mangrove forest distribution was carried out using 1986 and 2003. Based on the finding of the study, it was concluded that mangrove forest vegetation in Akwa Ibom State has changed from 114103.8 ha (17.2%) in 1986 to 107669.7 ha (15.3%) in 2003 resulting to a loss of 96434.1 ha of mangrove forest to other land cover types such as secondary forest, compound farmland, farmland, built up areas and open water bodies. It was also revealed that the major drivers of the change in the area just as it is elsewhere in Nigeria apart from invasion of Nypa palm include activities of the oil companies, increasing rate of mangrove removal by timber logging, and local usage of mangroves. There were clear distinctions for the depletion due to socio-economic conditions and anthropogenic and developmental pressures in the area. Thus, the study concludes by recommending that forest reserve should be established in Eastern Obolo where mangrove is still luxuriant with integrated sustainable forest management. Additionally, policy makers and planners

should enlighten the local people on the dangers of over exploitation and encourage them to strengthen these traditional resource management practices.

REFERENCES

[1] J.O.Adegbehin, L.C.Nwaigbo: Mangrove resources in nigeria: use and management perspectives, Nature and Resources, **26**, 13-21 **(1990)**.

[2] Akwa Ibom State, Akwa Ibom State physical background, Soils and Land use and Ecological Problems (Technical Report of Task Force on Soils and Land use Survey) **(1989)**.

[3] S.T.Anon; Defining an environmental strategy for the niger delta, Industry and Energy Operation Division, West Central African Department **(1995)**.

[4] Bioresources development and conservation programme BDCP, Restoration and the Conjunctive Sustainable Management of Native Mangroves and Nypa palms in Cross River Estuary of Nigeria, Second Progress Report (Revised) Prepared for the United Nations Industrial Development Organization UNIDO, 37 **(2010)**.

[5] R.E.Ekpeyong; An assessment of the threats to food security in Akwa Ibom State, Nigeria, GSDI 10 Conference Proceedings,

[6] FAO, (1997), Management and Utilization of the Mangroves in Asia and the Pacific, FAO, Rome, 319 **(2008)**.

[7] P.C.M.mom; Impact of human density and economic activities on the mangrove forest of the niger delta, Nigeria, Paper presented at the Annual Conference of the International Association for Impact Assessment, held in Seoul South Korea, 1-9th June, **(2007)**.

[8] P.C.M.mom, S.B.Arokoyu, Mangrove forest depletion, biodiversity loss and traditional resources management practices in the niger delta, Nigeria, Research Journal of Applied Sciences, Engineering and Technology, ISSN: 2040-7467, **2(1)**, 28-34 **(2010)**.

[9] B.C.N.dukwu, N.L.Edwin-Wosu, Changes in specie diversity due to dredged spoils in the mangrove forest of the niger delta, Nigeria, **(2007)**.

[10] I.E.U.kpong; Mangrove forest under threat? An evaluation of the integrity of Mangrove Ecosystem Functioning, The 17th Inaugural Lecture delivered in the University of Uyo **(2007)**.

[11] Unep, Mangroves of western and central africa, UNEP-Regional Seas Programme /UNEP-WCMC, 88 **(2007)**.

[12] A.O.Zubair, Change detection in land use and land cover using remote sensing data and GIS: (A case study of Ilorin and its environs in Kwara State), **(2006)**.