 

# Analysis of the Locations of Land Cover Change in Akwa Ibom State, Nigeria

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**Abstract**
The aim of this study was to examine the locations of land cover change in Akwa Ibom State, Nigeria from 1987 when the State was created. Land cover mapping and change analysis was carried out using remote sensing techniques. The study revealed that between 1986 and 2007, land cover significantly changed in nature, rate, direction, location and area. In particular, farm/fallow land and built up area/baresoil increased in area at the expense of swamp and secondary forest. Also, the change from swamp forest to farm/fallow land and secondary forest to farm/fallow land were more significant. The locations of these changes were also determined and mapped. The paper concluded that with the maps showing the locations of land cover change, policy/decision makers and the public can be properly guided

**Keywords**: Land cover, Land cover change, Remote sensing, deforestation, Geographic information systems

## 1 Introduction

Land cover is the observed (bio) physical cover on the earth's surface (Lillesand, et al. 2004). Studies have shown that information on land use/land cover is the basis on which the past and present human interactions with the natural resources and the environment can be understood. Such knowledge is also required for rational and sustainable allocation of land resources for future development. This implies that, an essential prerequisite to any development effort is the appraisal of existing land cover and the changes it is undergoing.

Changes in land cover have been taking place in different parts of the world including Nigeria. These changes vary in nature, rate and magnitude/dimension from one location to the other. Furthermore, changes in land cover have resulted in numerous environmental problems including soil erosion/degradation, loss of biodiversity, air/water/land pollution, increased atmospheric concentration of greenhouse gases/global warming, stratospheric ozone depletion to mention just a few (Uboldi et al. 1997, Adeniyi et al. 1999, Fenglei et al. 2007). It is obvious from the foregoing that, data on land use/land cover change are of great importance to planning and development.

Given the increasing threat to land resources, and especially the growing problem of deforestation and soil erosion, an urgent need thus exists to provide information which can help to target policy actions to the areas of greatest need. Accordingly, the aim of this research is to analyze the locations of land cover change in Akwa Ibom State, Nigeria between 1986 and 2007 [i.e. the period just before the State was created twenty one years after. This is because, unless we know exactly where changes have taken place, we cannot really and accurately determine the causes and effect/impact of such changes as well as find cost-effective and sustainable solutions.

## 2 Materials and Methods

### 2.1 Location of the Study Area

Akwa Ibom State is situated in South Eastern Nigeria. It lies between latitude $4^0$30" and $5^0$30"N and longitudes $7^0$30" and $8^0$ 30"E (Figure1). This location is within the tropical rainforest belt where deforestation destroys globally important carbon sinks that currently sequester carbon dioxide [$CO_2$] from the atmosphere and are critical to future climate stabilization (Ayoade 2003).

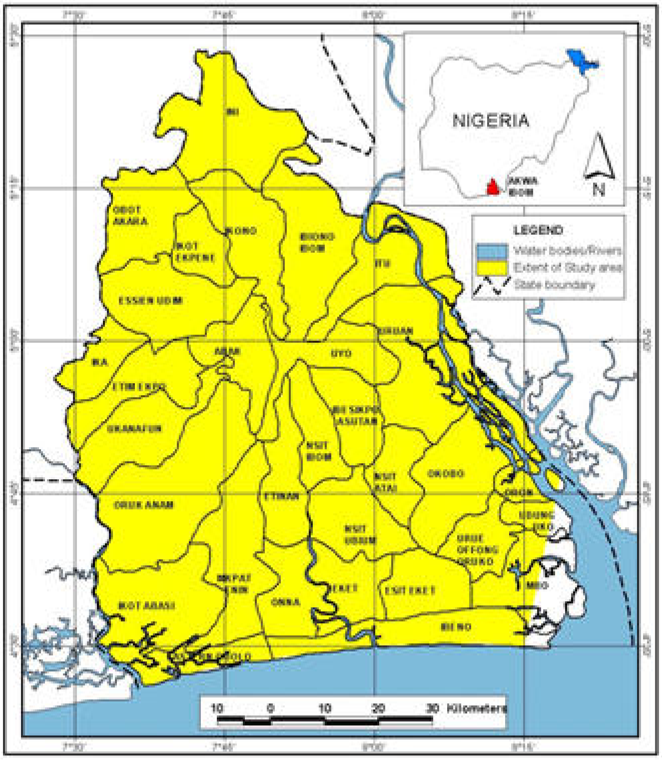


Fig.1: Location of Akwa Ibom State, Nigeria

One of the constraints to this study was the lack of current cloud free satellite imagery covering the entire State. The coverage area of the satellite imageries that were used is shown in yellow color on the map [fig. 1]

**2.2 Data acquisition**

**2.2.1 Remote sensing Data**

Land cover change analysis and mapping requires high spatial and temporal resolution satellite data. The 28.5m resolution landsat TM satellite imagery has become the standard. Consequently, the orthorectified Landsat TM satellite data for 1986 and NIGERSAT-1 imagery for 2007 were acquired and used for land cover mapping and change detection/analysis. These imageries were photographs of the condition of the environment before and after Akwa Ibom State was created in 1987.

**2.2.2 Field data**

Prior to image classification, cluster analysis [unsupervised classification] was carried out using satellite imageries of the different time periods. This allowed natural spectral clusters to be defined with high level of objectivity and reliability. This exercise helped in the pre-determination of training/test sites. Field verification was then carried out to determine coordinates of the sites with GPS as well as the nature of land cover at such sites. Also, to obtain historical land cover data, the local people were interviewed at different locations to determine whether or not a particular land cover category existed at the different time periods under consideration. This information was used in image classification and accuracy assessment.

**2.2.3 Classification scheme**

Definition of a classification scheme is an initial step in any classification project. In this research, the FAO Land Cover Classification System [LCCS] was used. Based on the ancillary data and information gathered from the field, the land cover types in the study area were generated using the LCCS software package (FAO, 2005).

**2.3 Image Classification**

**2.3.1 Supervised classification**

To produce the Land cover maps, supervised classification algorithm was used. First**,** a color composite of the 1986 landsat TM imagery was created using non-correlated bands [i.e bands 3, 4, and 5] identified as a result of PCA. To perform supervised classification, the color composite image was displayed using IDRISI software. Thereafter, 30 training/test sites were identified and demarcated based on the coordinates gathered during field verification to create signature files for image classification. Supervised classification was then carried out using the signature files.

**2.3.2 Assessment of the Accuracy of Land Cover Maps**

 

Total of 30 points was used for the assessment. The error matrix showing producer's and user's, and overall classification accuracy including the Kappa coefficients for land cover maps of the two time periods are shown in Tables 1 and 2.

Table 1: Confusion/Error Matrix For 1986 land cover map

| **CLASSIFICATION RESULTS** | **FIELD TEST POINTS** | | | | | | **User's** |
|---|---|---|---|---|---|---|---|
| | **BB** | **FF** | **SWF** | **SF** | **RV** | **Row Total** | **accuracy** |
| **BB** | 6 | 0 | 0 | 0 | 0 | **6** | 100.00% |
| **FF** | 0 | 5 | 0 | 1 | 0 | **6** | 83.33% |
| **SWF** | 1 | 0 | 5 | 0 | 0 | **6** | 83.33% |
| **SF** | 0 | 0 | 1 | 5 | 0 | **6** | 83.33% |
| **RV** | 0 | 0 | 1 | 0 | 5 | **6** | 83.33% |
| **Column Total** | **7** | **5** | **7** | **6** | **5** | **30** | |
| **Producer accuracy** | **85.71%** | **100.00%** | **71.43%** | **83.33%** | **100.00%** | | |
| **Confusion %** | **14.30%** | **0** | **28.6** | **16.7** | **0** | | |
| **Overall Classification Accuracy = 86.67%** | | | | | | | |
| **Overall Kappa Statistics = 0.8333[83.33%]** | | | | | | | |
| **Conditional Kappa for each Category.** | | | | | | | |

| **Class Name** | **Kappa** |
|---|---|
| Built-up Area/Baresoil | 1 |
| Farm/Fallow Land | 0.8 |
| Swamp forest | 0.7826 |
| Secondary Forest | 0.7917 |
| Rivers | 0.8 |

*BB: built-up area/baresoil; FF: Farm/Fallow land; SWF: Swamp forest; SF: secondary forest; RV: Rivers*

The error matrix [table 1], revealed that farm/fallow land and rivers scored the lowest confusion index of 0% because they were easy to delineate. Secondary forest and swamp forest had higher confusion index of 16.7% and 28.6% respectively. Overall accuracies obtained for 1986 image was 86.67%. The overall Kappa coefficient was 0.8333 [83.33%]. Also, the user's and producer's accuracies of individual classes were extremely high, ranging between 70% and 100%. High values of user's and producer's accuracies indicate that the classes were produced without much confusion. On the whole, these values are considered above the minimum value (85%) stipulated for interpretation accuracy in the identification of land use/land cover categories from remotely sensed data (Anderson et al. 1976).

The situation regarding the 2007 land cover map was different. Table 2, revealed that secondary forest and swamp forest had very high confusion index of 66.7% and 57.1% respectively. This indicates a poor discrimination of these two areas from other classes. An overall accuracy of about 73.33% was obtained. Overall Kappa coefficient was 0.6667 [66.67%]. Although the producer's accuracy for the farm/fallow land and rivers classes was 100%, the user's accuracy was only 66.67% and 50%, respectively. This means that, only 66.67% of all pixels labeled farm/fallow land in the 2007 land cover map turned out to be farm/fallow land while 50% of map pixels labelled rivers turned out to be rivers. Considering the relatively low spatial resolution [32m] and the availability of only 3 bands from NIGERSAT 1, the land cover classification result may be regarded as satisfactory based on frequently reported accuracy's of land cover maps derived from satellite data (Dimyati *et al.* 1996, Miguel-Ayanz & Biging 1997, Ramsey *et al.* 1997, Mas 1999, Yuan *et al*. 2005, Zhang *et al*. 2002).

Table 2: Confusion/Error Matrix For 2007 land cover map

| **CLASSIFICATION RESULTS** | **FIELD TEST POINTS** | | | | | | **User's** |
|---|---|---|---|---|---|---|---|
| | **BB** | **FF** | **SWF** | **SF** | **RV** | **Row Total** | **accuracy** |
| **BB** | 6 | 0 | 0 | 0 | 0 | 6 | 100.00% |
| **FF** | 0 | 4 | 2 | 0 | 0 | 6 | 66.67% |
| **SWF** | 0 | 0 | 3 | 3 | 0 | 6 | 50.00% |
| **SF** | 0 | 0 | 0 | 6 | 0 | 6 | 100.00% |
| **RV** | 0 | 0 | 2 | 1 | 3 | 6 | 50.00% |
| **Column Total** | **6** | **4** | **7** | **10** | **3** | **30** | |
| **Producer accuracy** | **100.00%** | **100.00%** | **42.86%** | **60.00%** | **100.00%** | | |
| **Confusion %** | **0** | **0** | **57.1** | **66.7** | **0** | | |

| **Overall Classification Accuracy = 73.33%** | |
|---|---|
| **Overall Kappa Statistics = 0.6667[66.67%]** | |
| **Conditional Kappa for each Category.** | |
| **Class Name** | **Kappa** |
| Built-up Area/Baresoil | 1 |
| Farm/Fallow Land | 0.6154 |
| Swamp forest | 0.3478 |
| Secondary Forest | 1 |
| Rivers | 0.4444 |

*BB: built-up area/baresoil; FF: Farm/Fallow land; SWF: Swamp forest; SF: secondary forest; RV: Rivers*

### 2.4 Post Classification Change Detection

The post classification change detection approach was adopted in this study. This method involved two independently produced classified land cover maps at a time. The principal advantage of this approach lies in the fact that the two datasets involved were separately classified thereby minimizing the problem of radiometric calibration between dates (Jensen 2005, Yuan *et al*. 2005, Wen, et al. 2009).

To determine the changes, the land cover maps for the different time periods were loaded into the land cover change modeller in IDRISI Taiga software. This made it possible for the land cover maps to be compared point [pixel] by point (Jensen 2005). Using this method, the nature, area, location and direction of change were identified and mapped.

### 2.5 Determination of the locations of land cover change

Satellite imageries does not come with place names and/or names of countries, administrative units etc. Such information has to be superimposed on it if required after classification/necessary processing. In this study, the locations of land cover change were given at the local Government Area level. This was done by overlaying the map showing local Government Areas on the change maps [fig. 5 to 11]. However, if it becomes necessary, the locations can be determined and given at the community level by simply overlaying a map showing villages/communities in the area on the change maps using the Geographic information systems [GIS] technology. In addition, the geographic coordinates [latitude and longitude] of such locations can be determined by simply placing the mouse pointer on any of the change locations and reading its latitude and longitude on the status bar of the viewer. With this kind of information, policy/decision makers, agricultural extension officers, planners etc. can visit such locations to carry out further investigations, enforce the law etc.

 

## 3. Results

### 3.1 Distribution of land cover types

The types and coverage areas of land cover for each study year [i.e. 1986 and 2007] as derived from the land cover maps [Fig. 2 and 3] are presented in the tables 3 and 4.

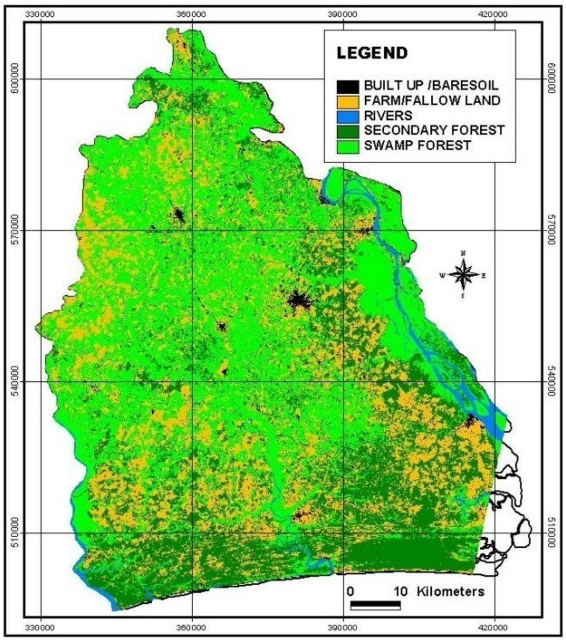


Figure 2: Akwa Ibom State: Land Cover - 1986

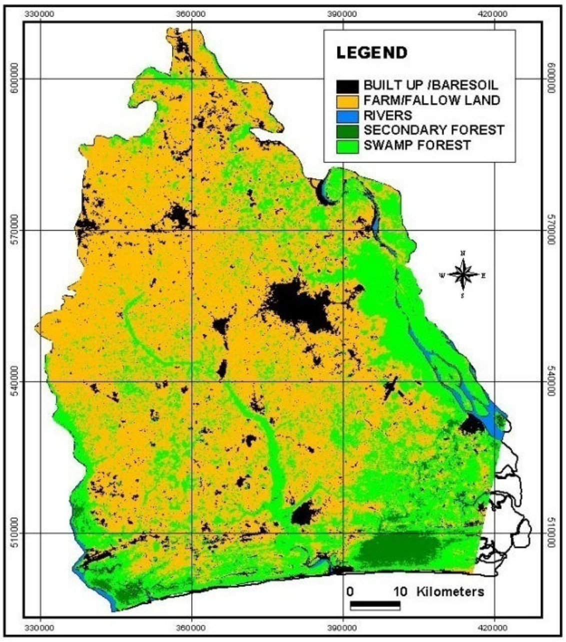


Figure 3: Akwa Ibom State: Land Cover - 2007

Table 3: Akwa Ibom State: Coverage area of Land Cover as at 1986

| Land_Cover Types | Area_Covered [Ha] | Percentage |
|---|---|---|
| Built Up Area/Baresoil | 10651 | 2 |
| Farm/Fallow Land | 186110 | 27 |
| Swamp Forest | 290540 | 42 |
| Secondary Forest | 185138 | 27 |
| Rivers | 14704 | 2 |
| **Total** | **687143** | **100** |

SOURCE: Land cover map [fig. 2]

Table 4: Akwa Ibom State: Coverage area of Land Cover as at 2007

| Land_Cover Types | Area_Covered [Ha] | Percentage |
|---|---|---|
| Built Up Area/Baresoil | 48525 | 7 |
| Farm/Fallowland | 418245 | 61 |
| Swamp Forest | 191750 | 28 |
| Secondary Forest | 18853 | 3 |
| Rivers | 9770 | 1 |
| **Total** | **687143** | **100** |

SOURCE: Land cover map [fig. 3]

It is obvious from table 3 that, before Akwa Ibom was created in 1987, the dominant land cover type was swamp forest [42%], followed by farm/fallow land [27%] and secondary forest [27%]. Rivers occupied the least [2%]. The situation as at 2007 [i.e. twenty one years after Akwa Ibom was created] is shown in table 4. The area occupied by farm/fallow land increased to 61% while that of the swamp and secondary forest decreased to 28% and 3% respectively. Also, built up area/bare soil increased from 2% in 1986 to 7% in 2007 while rivers reduced to 1%.

### 3.2 land cover change

The result of change analysis is presented in the land cover change matrix [table 5]. It is obvious from the change matrix that, between 1986 and 2007, the land cover classes with the highest change were swamp forest [66.23%] and secondary forest [91.87%]. All others recorded below 50% change to other land cover types. During the period, swamp and secondary forest decreased from 42% and 27% in 1986 to 28% and 3% respectively in 2007. This decrease was at the rate of 9163ha and 8099ha per year respectively. These changes are indications of high rate of deforestation in the area. This rate of deforestation is contrary to the principles of sustainable development. An unsustainable situation occurs when the sum total of nature's resources is used up faster than it can be replenished. Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. This is not the case with secondary forest in the study area. At the present rates, it means that by 2017 much of our forest cover would disappear leaving our future generation with almost nothing.

Furthermore, the direction of change [positive or negative] in each land cover type was also determined. Table 3 shows that built-up area/baresoil and farm/fallow land changed in the positive direction by gaining 37874ha and 232135ha respectively while swamp forest, secondary forest and rivers changed in the negative direction by loosing 98790ha, 166285ha and 4934ha respectively.

Table 5: Land cover change detection statistics report 1986-2007

| | Built-up/ Baresoil_86 | Farm/ Fallow Land_86 | Swamp Forest_86 | Secondary Forest_86 | Rivers _86 | Class Total |
|---|---|---|---|---|---|---|
| **Built-up/ Baresoil_07** | 6948 [65.23%] | 26169 [14.06%] | 7302 [2.52%] | 7220 [3.90%] | 871 [5.93%] | 48510 |
| **Farm/ Fallow Land_07** | 3339 [31.35%] | 138511 [74.42%] | 181829 [62.58%] | 94283 [50.93%] | 242 [1.64%] | 418204 |
| **Swamp Forest_07** | 248 [2.33%] | 20686 [11.12%] | 98114 [33.77%] | 68520 [37.01%] | 4239 [28.83%] | 191807 |
| **Secondary Forest_07** | 1 [0.01%] | 721 [0.39%] | 3021 [1.04%] | 15062 [8.13%] | 50 [0.34%] | 18855 |
| **Rivers_07** | 115 [1.08%] | 23 [0.01%] | 274 [0.09%] | 53 [0.03%] | 9302 [63.21%] | 9767 |
| **Class Total** | 10651 | 186110 | 290540 | 185138 | 14704 | |
| **Class Changes** | 3703 [34.77%] | 47599 [25.58%] | 192426 [66.23%] | 170076 [91.87%] | 5402 [36.80%] | |
| **Image Difference** | 37859 | 232094 | -98733 | -166283 | -4937 | |

N.B: Values in the diagonal cells (in red color) represent area of land cover that did not change
Source: Result of change analysis with IDRISI land change modeler by author 2011

### 3.3 Locations of changes in land cover

An important aspect of change detection is to determine what has changed to what and where the change took place. This information will reveal both the desirable and undesirable changes and classes that are “relatively” stable overtime. This information will also serve as a vital tool in management decisions. This process involves a pixel to pixel comparison of the study year images through overlay [fig.4].

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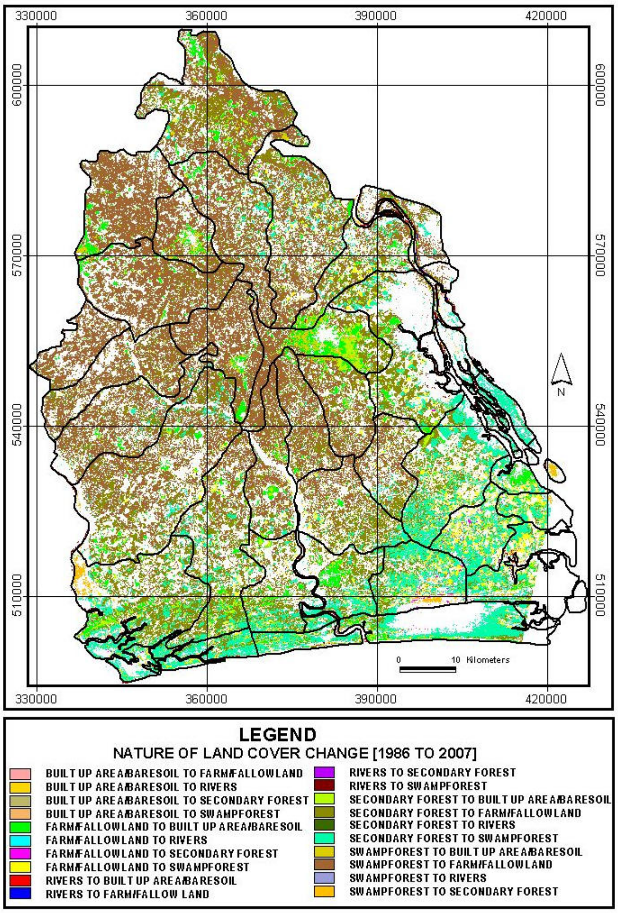


Figure 4: Akwa Ibom State: Net Change in Land Cover between 1986 and 2007

The attribute database of change map [fig 4] was queried to separate the various land cover changes. To enhance the clarity of the locations of change, map layer showing Local Government Area [LGA] boundaries was overlaid on the map showing changes in land cover. The results of this manipulation are displayed in fig. 5 to fig. 10.

*3.3.1 Change from farm/fallow land to built-up/baresoil*

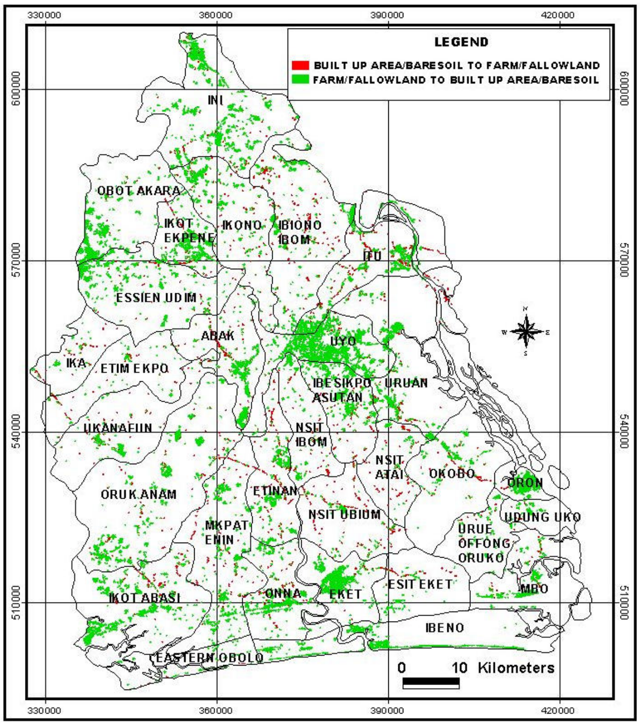


Figure 5: Locations of changes from farm/fallow land to built up area/baresoil and vis-versa

Locations of this change are shown in fig. 5. This map shows that most of the changes from farm/fallow land to built-up/baresoil took place within Uyo, Oron, Eket and Ini Local Government Areas.

*3.3.2 Change from secondary forest to built up area/baresoil*

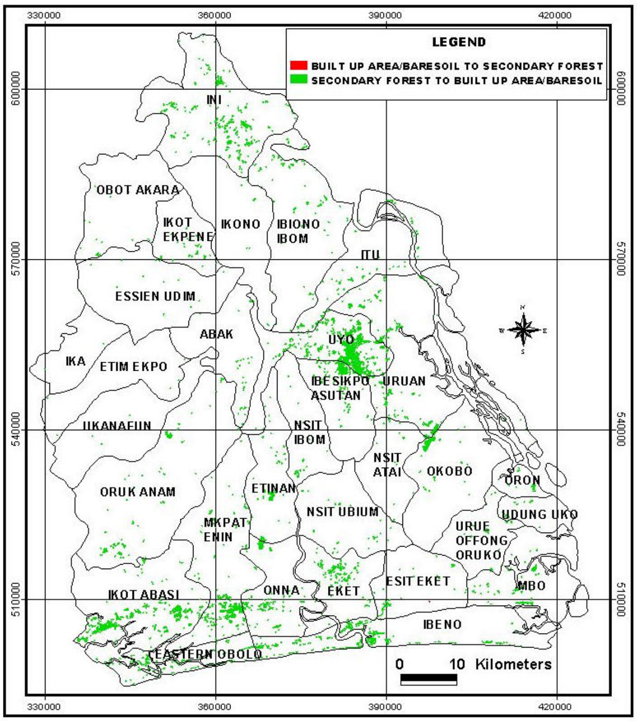


Figure 6: Locations of changes from secondary forest to built up area/baresoil and vis-versa

 

Locations of this change are shown in Fig. 6. Here most of the changes from secondary forest to built up area/baresoil took place in Uyo LGA.

*3.3.3 Change from swamp forest to built up area/baresoil*

The locations of this change are shown in Fig. 7. It is obvious from fig. 7 that, most of the changes from swamp forest to built up area/baresoil took place in Uyo, Ini and Ikot Ekpene LGAs.

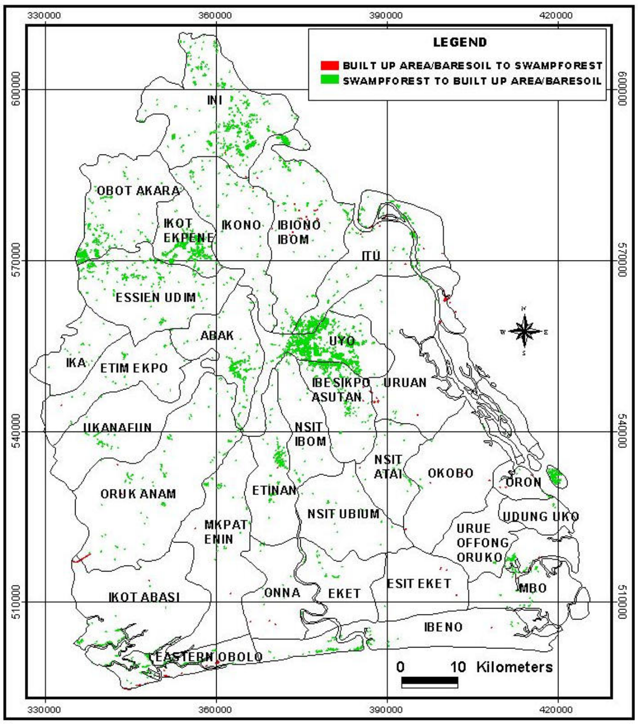

Figure 7: Locations of changes from swamp forest to built up area/baresoil and vis-versa

 

### *3.3.4 Change from secondary forest to farm/fallow land*

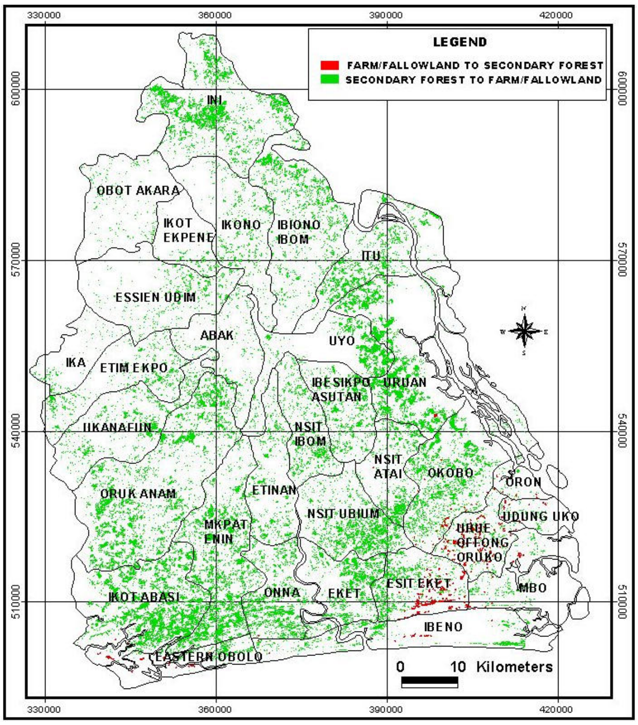


Figure 8: Locations of changes from secondary to farm/fallowland and vis-versa

Changes from secondary forest to farm/fallow land took place in almost all the Local Government Areas as shown in fig. 8.

### *3.3.5 Change from swamp forest to farm/fallow land:*

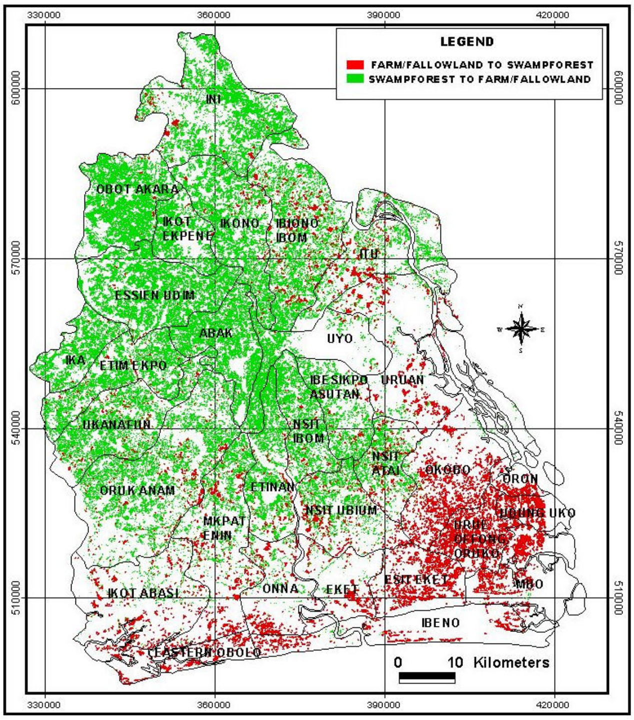


Figure9: Locations of changes from swamp forest to farm/fallowland and vis-versa

Swamp forest changed to farm/fallow land in nineteen Local Government Areas as shown in Fig. 9. The Local Government Areas included Ini, Ikono, Ibiono Ibom, Ikot Ekpene, Obot Akara, Essien Udim, Ika, Ukanafun, Oruk Anam, Abak, Uyo, Nsit Atai, Ibesikpo Asutan, Etinan, Nsit Ibom, Nsit Ubium and Mkpat Enin. Also, farm/fallow land changed to swamp forest in Okobo, Urue Ofong Uruko, Udung Uko, Uquo and Mbo LGAs.

*3.3.6 Change form secondary forest to swamp forest:*

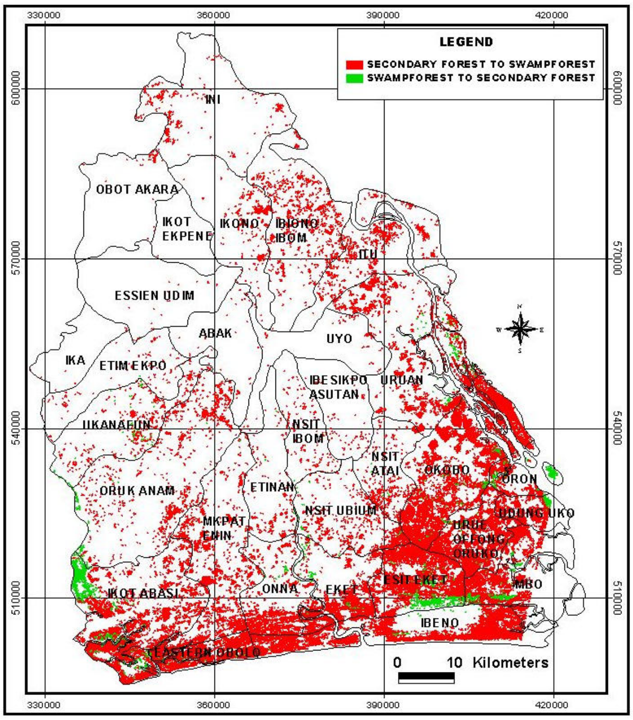


Figure 10: Locations of changes from secondary forest to swamp forest and vis-versa

Locations of this change are shown in Fig. 10. The change from secondary forest to swamp forest was predominant in Okobo, Uquo, Urue Ofong, Udung Uko, Mbo, Ibeno, Onna, Eket, Eastern Obolo and Ikot Abasi LGAs.

*3.3.7 Locations without change*

Areas where land cover persisted [remained stable/unchanged] over the years are shown in fig. 11. Table 6 revealed that 51.7% of the areas under farm/fallow land did not change during the period under study. Only 36% of the area under swamp forest persisted till 2007.

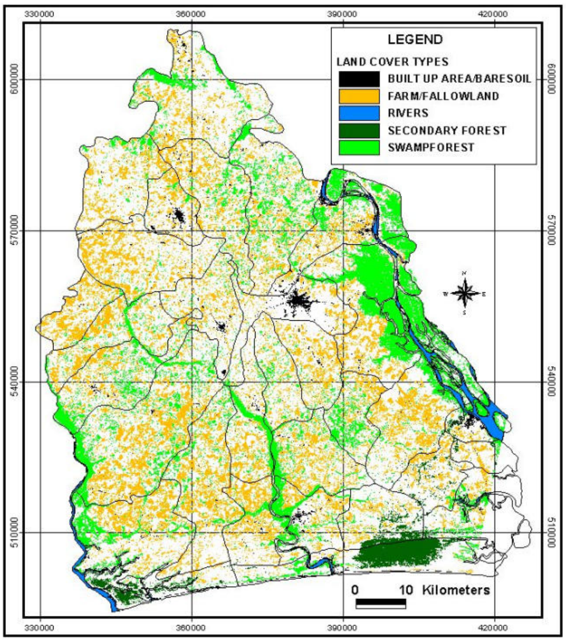


Figure 11: Akwa Ibom State: Locations without change

Table 6: Coverage Area of Unchanged Land Cover

| Land Cover | Area[Ha] | Percentage |
|---|---|---|
| Built Up Area/Baresoil | 6948 | 2.6 |
| Farm/Fallow land | 138511 | 51.7 |
| Swamp forest | 98114 | 36.6 |
| Secondary Forest | 15062 | 5.6 |
| Rivers | 9302 | 3.5 |
| | 267937 | 100.0 |

## 4. Discussion

From the results of data analysis, the period 1986 to 2007 witnessed a lot of changes in the nature, rate, location and coverage areas of land cover in Akwa Ibom State. During the period, swamp and secondary forest decreased from 42% and 27% in 1986 to 28% and 3% respectively in 2007. This decrease was at the rate of 9163ha and 8099ha per year respectively. These changes are indications of high rate of deforestation in the area. This rate of deforestation is contrary to the principles of sustainable development. We need to plant trees to check this trend and this study has revealed exactly where trees should be planted. Maps showing areas where land cover changed from swamp forest and secondary forest to other cover types are the locations with favourable conditions for the particular tree[s].

Other negative trends include were forest and farm/fallow land changed to built-up areas. This is a trend that should be curtailed to boost market gardening [in particular food security] and safe guide the climate through the development of green belts to serve as carbon sinks. If policies are made to counter this trend, the relevant maps show the locations of forest and farm/fallow lands that should be monitored.

Also, where rivers changed to swamp forest is because of the tree canopy covering the river channel especially where the channel is narrow. We need to navigate our water ways regularly to free them from entanglements that may hamper water transportation and the degradation of water quality.

Furthermore, where secondary forest changed to swamp forest is suggestive of flooding arising from sea level rise and/or increase in the amount of rainfall. From met data that is available, rainfall in this area has been increasing in the last decade apparently because of climate change.

Moreover, the change from farmland to swamp forest is suggestive of the fact that most people in the area have taken to fishing and other socio-economic activities leaving the land to fallow for too long. This was found mostly in the areas located near the coast. This trend is not negative. It may help in developing/conserving forest cover especially mangrove which provides a lot of ecosystem goods and services. On the whole, there is the need to continue to monitor and manage land cover types in locations that did not experience change. This is where figure 11 becomes useful.

## 5. Conclusion

This study has revealed that, land cover significantly changed in nature, rate, direction, location and area between 1986 and 2007 in Akwa Ibom State. The locations of these changes have been mapped and analyzed so that policy/decision makers and the public can be properly guided. This is because land cover change is increasingly recognized as an important driver of environmental change on all spatial and temporal scales. It contributes significantly to earth atmosphere interactions, forest fragmentation, and biodiversity loss. It has become one of the major issues for environmental change monitoring and natural resource management

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