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**Research Article**

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# Geographic Resource Monitoring and Assessment of Long-Term Land Cover Change in Oben Area, Onshore, Niger Delta, Nigeria

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**Abstract** Monitoring land use/cover changes is necessary for guiding decision making for resource management. This research demonstrated the ability and recent advancement in remote sensing techniques in capturing, retrieving and analyzing long-term spatio-temporal data.

A comprehensive land use land cover maps were developed for three distinct years 1987, 2002 and 2015 for a period of 28 years in Oben Area which showed both land use/cover conversion and modification.

The study has demonstrated that land use and land cover change can be delineated, quantified and compared across different timelines. Landsat data proved to be adequate data source for the analysis of long term land use land cover change due to its repeat cycle. The problems associated with the land use/land cover changes discussed are linked with the oil and gas development activities which have open up previously hitherto un-accessed areas, built-up/industrial development encroachment into the forest reserve areas, advance and crude agricultural methods/practices, socio economic status change of the local population as well as to a certain extent, with population growth/demographic factors. Settlement expansion and illegal logging are also the major drivers behind the land use/land cover changes observed in Oben Area.

**Keywords** Geographic Resource Monitoring, Landsat data

## Introduction

The land use/cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space. Land 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 is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. It was stated that identifying, delineating and mapping of land cover are important for global monitoring studies, resource management, and planning activities (Identification of land cover establishes the baseline from which monitoring activities (change detection) can be performed, and provides the ground cover information for baseline thematic maps [1-2]. Land use applications involve both baseline mapping and subsequent monitoring, since timely information is required to know which current quantity of land and which type of use and to identify the land use changes from year to year [3-5]. This knowledge helps to develop strategies to balance conservation, conflicting uses, and developmental pressures.

### Statement of the Problem

Oben Area, which covers over 45% of Urhonigbe Forest Reserve has witnessed an exponential growth in developmental activities associated with oil and gas exploration, exploitation and production over the last three decades leading to infrastructural development in the form of road construction and population growth thus, creating increase in demand for basic needs such as food and cash income, demand for more land for farming activities, access creation to forest reserve areas, surge in deforestation/logging activities, increased in other anthropogenic activities. It is therefore imperative to use satellite-image (Remote sensing techniques) based approach of detecting and delineating in this study to determine quantitatively land use/cover change that have occurred within Oben field over time, project land use/cover change that could take place over time and suggest ways that development could co-exist harmoniously with environment avoiding the associated problems in a sensitive ecosystem like Oben and other places around the world.

**Significance of the Study**

In recent times, increased in land cover alterations/modification in Oben Area due to anthropogenic disturbances requires powerful and sophisticated system to quantitatively detect and delineate this change. Remote Sensing techniques (in view of its temporal and repeat cycles) from which updated land cover information can be extracted in order to inventories, monitor and map changes in land use land cover becomes a viable tool, thus it provides an invaluable platform for monitoring land use land cover changes and provide a comprehensive overview and synoptic coverage of the extent of land cover disturbances that has taken place within Oben Area overtime, it is of note that Oben Area straddles Urhonigbe Forest Reserve which is a Federal Government Protected Reserve Forest.

**The Study Area**

Detailed information on the project area was extracted from previous studies conducted within the Oben Area. The coordinate for study locations are presented in the table 1.

**Table 1**: Coordinates of study location

| S/N | Co-ordinates | Description |
|---|---|---|
| 1 | N 06$^{O}$ 01′ 19.5″ E 005$^{O}$ 52′ 38.1″ | Bare soil- open field. |
| 2 | N 06$^{O}$ 00′ 43.5″ E 005$^{O}$ 51′ 54.8″ | Bare soil- open field |
| 3 | N 05$^{O}$ 59′ 47.8″ E 005$^{O}$ 53′ 41.2″ | Bare soil- open field |
| 4 | N 06$^{O}$ 00′ 19.6″ E 005$^{O}$ 55′ 28.2″ | Built up area - Ikobi Community |
| 5 | N06$^{0}$00.507$^{|}$ E005$^{0}$55.442$^{|}$ | Built up area - Ikobi Community |
| 6 | N 06$^{O}$ 02′ 10.5″ E 005$^{O}$ 57′ 19.3″ | Built up area - Obozogbe-Nugu community |
| 7 | N06$^{0}$02.230$^{|}$ E005$^{0}$57.320$^{|}$ | Built up area - Obozogbe-Nugu community |
| 8 | N 06$^{O}$ 00′ 28.9″ E 005$^{O}$ 55′ 30.3″ | Farm land/cultivated Area |
| 9 | N 06$^{O}$ 02′ 00.2″ E 005$^{O}$ 53′ 24.3″ | Farm land/Cultivated area |
| 10 | N 06$^{O}$ 02′ 29.0″ E 005$^{O}$ 00′ 53.3″ | Farm land/cultivated area |
| 11 | N 05$^{O}$ 59′ 04.4″ E 006$^{O}$ 01′ 52.3″ | Palm tree plantation. |
| 12 | N 060$^{0}$.997 E 005$^{0}$.51.403 | Lumbered - Lowland forest ecosystem |
| 13 | N05$^{0}$ 59.827” E005$^{0}$.53.639 | Farmland/cultivated areas |
| 14 | N06$^{0}$.00.511” E005$^{0}$.55.449” | Forest regrowth |
| 15 | N 06$^{0}$.02.199” E005$^{0}$.57.276 | Forest- mature, moist lowland secondary forest. |
| 16 | N06$^{0}$.01.241”, E005$^{0}$.51.570”, | Forest |
| 17 | N 0600503 E 00551831 | Lumbered area-open savanna-like grassland with highly grazed grasses, few scattered shrubs and isolated trees. |
| 18 | N06$^{0}$.04.621” E005$^{0}$.59.143” | Lumbered area-degraded, undifferentiated secondary forest with many lianas and vines. |
| 19 | N06$^{0}$.06.921” E005$^{0}$.57.276 | River. The vegetation towards the river is a gallery forest (riparian forest) |
| 20 | N06$^{0}$.06.921” E005$^{0}$.57.276 | River |

**Topography**

The area has an elevation varying between 0.9m to about 84m (north easterly part of the study area) (Figure 2). The ground water is relatively low and the surface water flow in a south-westerly direction.

**Vegetation/Forestry**

The study area is situated within the lowland rainforest belt of Nigeria. The natural vegetation has, however, been altered in most parts due to human activities.

Secondary lowland rainforests and bush fallows are the predominant types of vegetation cover. Various sizes of farmlands are located in the area.

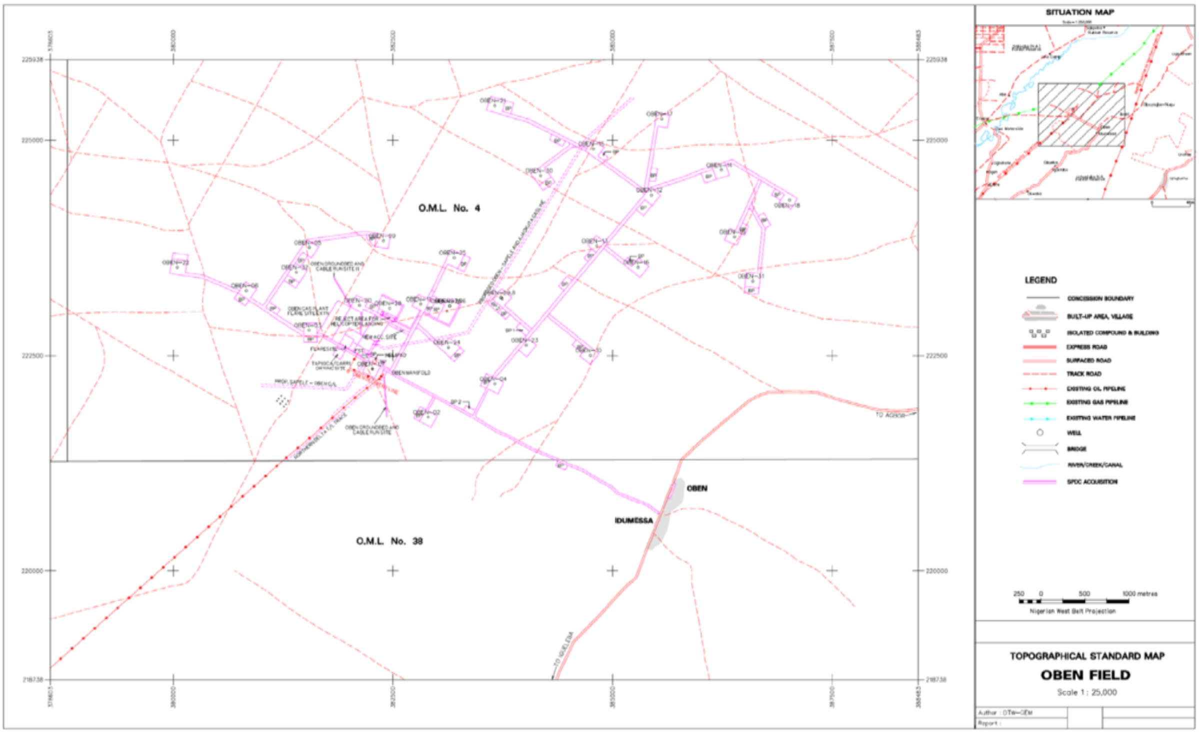


*Figure 1: Location Map of Oben Area*

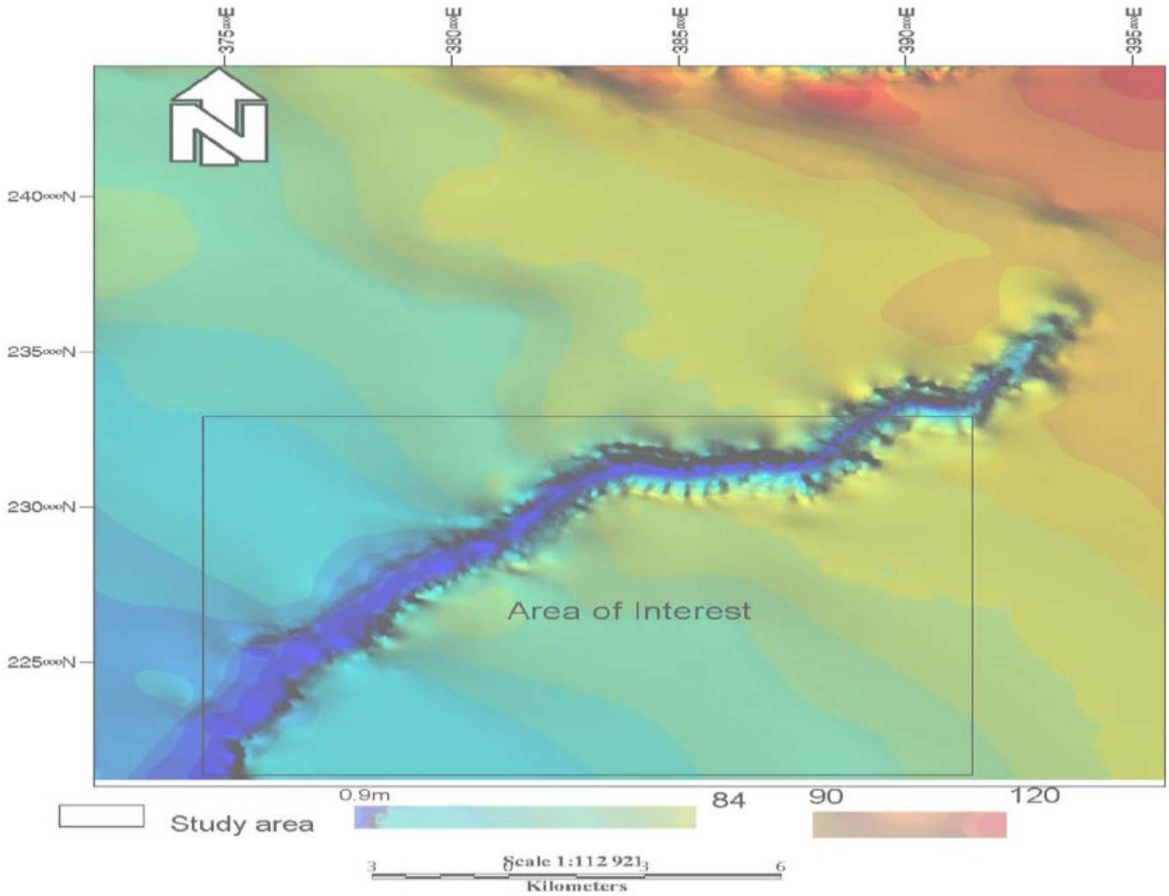


*Figure 2: Digital Elevation Model of Oben Area*

**Methodology**

**Introduction**

The research design for this work formed the basis for obtaining data for land use land cover trend and subsequent overall, the findings.

**Table 1:** Data Source

| S/N | Sattelite/ Data Type | Sensor | Path/Row | Date | Scale | Bands |
|---|---|---|---|---|---|---|
| 1. | Landsat 4 | Thematic Mapper (TM) | 189/056 | 21/12/1987 | 30m | 1, 2, 3, 4, 5, 6 & 7 |
| 2. | Landsat 7 | ETM+ | 189/056 | 30/12/2002 | 30m | 1, 2, 3, 4, 5, 6 & 7 |
| 3. | Landsat 8 | OLI/TIRS | 189/056 | 08/01/2015 | 30m | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 & 11 |

This datasets sensors has repeat cycles of 16 days, ground pixel dimension of 57m x 79m (TM), 16 bit pixel for values for OIL/TIRS and the spectral range includes seven spectral bands in the Visible/Near Infra-red (VNIR – Bands 1, 2, 3 & 4), Short Wave Infrared (SWIR – Bands 5 & 7) and Thermal Infra-Red (TIR – Band 6) parts of the electromagnetic (EM) spectrum. The spectral resolution of Landsat TM, ETM+ and OLI/TIRS (30M) data makes it very useful for land use/cover classification and general mapping.

**Software's Used**

Basically, the software's listed below were used in this research work:

- ERDAS 2014 version– this was used for displaying and subsequent processing and enhancement of the image. It was also used for the carving out of the study area imagery.
- Idrisi Selva – This was used for the development of land use land cover classes and subsequently for change detection analysis of the study area.
- ArcGIS 10.1 – This was used in developing, display and processing of the location maps
- Microsoft word version 2010 – was used basically for the presentation of the research work.
- Microsoft Excel was used in producing the bar chart and graph.

**(a) Image Processing**

In case of satellite sensing in the visible and near- infrared portion of the spectrum, it is often desirable to generate mosaics of images taken at different times or to study the changes in the reflectance of ground features at different times or locations. In such applications, it is usually necessary to apply a *sun elevation correction* and an *earth-sun distance correction*. Through this process, image data acquired under different solar illumination angles are normalized by calculating pixel brightness-values assuming the sun was at the zenith on each date of sensing. The irradiance from the sun decreases as the square of the earth-sun distance. Ignoring atmospheric effects, the combined influence of solar zenith angle and earth sun distance on the irradiance incident on the earth's surface can be expressed as:

$$E = \frac{E_0 Cos\, \theta_0}{d_2}$$

*Where*

$E$ = normalized solar irradiance

$E_0$ = solar irradiance at mean earth-sun distance

$\theta_0$ = sun's angle from the zenith

$d$ = earth-sun distance, in astronomical units

The atmosphere affects the radiance measured at any point in the scene in two contradictory ways. First, it attenuates (reduces) the energy illuminating a ground object. Second, it acts as a reflector itself, adding a scattered, extraneous "path radiance" to the signal detected by a sensor.

For convenience, haze correction routines are often applied uniformly throughout a scene. This may or may not valid, depending on the uniformity of the atmosphere over a scene. When extreme viewing angles are involved in image acquisition, it is often necessary to compensate for the influence of varying the atmospheric path length through which the scene is recording. In such cases off-nadir pixel values are usually normalized to their nadir equivalents.

Normally, detectors and data systems are designed to produce a linear response to incident spectral radiance. For example, the linear radiometric response functions typical of an individual TM channel. Each spectral band of the sensor has its own response function and its characteristics are monitored using onboard calibration lamps. The absolute spectral radiance output of the calibration sources is known from prelaunch calibration and is assumed to be stable over the life of the sensor. Thus, the onboard calibration sources form the basis for constructing the radiometric response function by relating known radiance values incident on the detectors to the resulting DNs.

It can be seen that a linear fit to the calibration data results in the following relationship between radiance and DN values for any given channel:

$$DN = GL + B$$

*Where*

DN = digital number value recorded

*G* = slope of response function (channel gain)

*L* = spectral radiance measured

*B* = intercept of response function (channel offset)

Note that the slope and intercept of the above function are referred to as the *gain* and *offset* of the response function, respectively. LMIN is the spectral radiance corresponding to a DN response of 0 and LMAX is the minimum radiance required to generate the maximum DN (here 255). That is, LMAX represents the radiance at which the channel saturates. The range from LMIN to LMAX is the dynamic range for the channel.

**(b) Image Enhancement**

Enhancement operations are normally applied to image data after the appropriate restoration procedures have been performed. Noise removal is an important precursor to most enhancements. Without it, the image interpreter is left with the prospect of analyzing enhanced noise.

Three techniques for digital enhancement can be categorized as *contrast manipulation, spatial feature manipulation* or *multi-image manipulation*.

**(c) Image Classification**

Image classification procedure is to automatically categorize all pixels in an image into land use/cover classes or themes. Normally, multispectral data are used to perform the classification and, the spectral pattern present within the data for each pixel is used as the numerical basis for categorization. That is, different feature types manifest different combinations of DNs based on their inherent spectral reflectance and remittance properties. *Spectral pattern recognition* refers to the family of classification procedures that utilizes this pixel-by-pixel spectral information as the basis for automated land cover classification.

*Temporal pattern recognition* uses time as an aid in feature identification. In agricultural crop surveys, for example, distinct spectral and spatial changes during a growing season can permit discrimination on multi-date imagery that would be impossible given any single date.

The other classification is *Unsupervised Classification*. This procedure is applied in two separate steps. The fundamental difference between these techniques is that supervised classification involves a training steps followed by a classification step. In the unsupervised approach the image data are first classified by aggregating them into the natural spectral groupings, or clusters, present in the scene. Then the image analyst determines the land cover identity of these spectral groups by comparing the classified image data to ground reference data.

**(d) Post Classification Smoothing**

Classified data often manifest a salt-and-pepper appearance due to the inherent spectral variability encountered by a classifier when applied on a pixel-by-pixel basis. For example, in an agricultural area, several pixels scattered throughout a corn field may be classified as soybeans, or vice versa. In such situation it is often desirable to “smooth” the classified output to show only the dominant classification.

One means of classification smoothing involves the application of a *statistical filter*. In such operations a moving window is passed through the classified data set and the majority class within the window is determined. If the center pixel in the window is not the majority class, its identity is changed to the majority class. If there is no majority class in the window, the identity of the center pixel is not changed. As the window progresses through the data set, the original class codes are continually used, not the labels as modified from the previous window positions. The classified map was prepared in this manner, applying a 3 x 3 pixel medium filter to the data.

## Results and Discussion

### Presentation and Analysis of Data

### Land Use/Cover Classification

Three successive supervised and unsupervised land use/cover classifications were discriminated into four classes: water, forest, woodland/rangeland and built up area. Result of the accuracy assessment of the classification is as provided in Tables 2.

**Table 2**: Accuracy Total Report (2015) of Oben Area

| Class Name | Reference Totals | Classified Totals | Number Correct | Producer's Accuracy (%) | User's Accuracy (%) |
|---|---|---|---|---|---|
| Woodland / Rangeland | 5 | 4 | 4 | 80.00 | 100.00 |
| Forest | 11 | 12 | 11 | 100.00 | 91.67 |
| Water | 0 | 0 | 0 | - | - |
| Built up Area | 14 | 14 | 13 | 92.86 | 92.86 |
| Total | 30 | 30 | 28 | | |

Over all Classification Accuracy: = 93.3%

Kappa (k) Statistics

| Class Name | Kappa |
|---|---|
| Woodland / Rangeland | 1.000 |
| Forest | 0.8684 |
| Water | 0.000 |
| Built up Area | 1.8661 |

Overall Kappa Statistics: = 0.8913

### Land Use/Cover Distribution

In this section land use/ cover maps of different years were delineated and compared. The land use/cover of Oben field had changed dramatically during the period of 28 years. The data interpretation, analysis/discussion is based on comparison of land use land cover for different timelines in a 28 year period. The spatial static land use land cover distribution for 1987, 2002 and 2015 as derived from the image maps are presented in Table 3.

A review of Table 3 shows that in 1987, built-up area occupied the least in class with just 4.80% (11.407km$^2$) of the total classes. This may not be unconnected to low demographic structure of the area, sparse settlements, inaccessibility due to thick forest cover as well as seasonal inundation of the area, woodland and rangeland occupied 10.19% (24.244km$^2$) of the total classes, this may be due to the fact that farming was practice moderately, E&P activities were at exploratory level with drilling of appraisal wells. Water occupied 17.29% (41.139km$^2$) this is related to thick forest occupying over 161.103km$^2$ (67.72%), the thick forest area is a Government Reserve Forest called Urhonigbe Forest Reserve.

**Table 3:** Percentage Change in Land Use Land Cover between 1987-2015 in Oben Area

| Land use / Cover Category | 1987 (km$^2$) | 2002 (km$^2$) | Change (km$^2$) | (%) Change | Annual Rate of Change | 2002 (km$^2$) | 2015 (km$^2$) | Change (km$^2$) | (%) Change | Annual Rate of Change | Total Change | Total % Change | Total Rate of Change |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water | 41.139 | 7.194 | -33.942 | -82.51 | -12.38 | 7.194 | 4.532 | -2.662 | -37.00 | -4.81 | -36.604 | -119.51 | -17.19 |
| Forest | 161.103 | 165.663 | 4.560 | 2.75 | 0.41 | 165.663 | 107.275 | -58.388 | -54.43 | -7.08 | -53.828 | -50.18 | -9.83 |
| Woodland/ Rangeland | 24.244 | 25.026 | 0.882 | 3.52 | 0.53 | 25.026 | 27.210 | 2.189 | 8.03 | 1.04 | 2.966 | 41.14 | 1.57 |
| Built up Area | 11.407 | 40.100 | 28.693 | 71.55 | 10.73 | 40.100 | 98.876 | 58.776 | 59.44 | 7.73 | 87.469 | 88.46 | 18.46 |

*Figure 3: Open area dominated by grasses, shrubs and trees*

*Figure 4: Open area dominated by grasses and shrubs with isolated small trees and shrubs*

In 2002, built up area rose to 16.85% (40.10km$^2$) and maintained a double digit in growth to 41.56% (98.876km$^2$) in 2015. This period coincided with an increase in E&P activities in Oben Area with the opening up the hitherto un-accessed areas to the population to build houses, the population was also economically empowered through white collar jobs in the E&P sector, payment for acquired land and hence could afford to build houses, road networks were constructed by the oil and gas operating companies linking oil and gas infrastructures, oil wellheads, pipelines, flowstation, flowlines NGC gas station were also constructed thereby taking appreciable land area hence contributing to increased built up area, markets, schools and hospitals sprout up within Oben. Forest area rose up marginally by 69.63% (165.663km$^2$) due to the reduction in water cover with such areas being reclassified as forest thus leading increase forest in 2002. Increase in woodland/rangeland is due to increase in farming activities within Oben field. There is apparent changes in waters of Oben by 2002 occupying 3.02% (7.194km$^2$). This may be due to siltation and runoffs/soil washed off from deforested areas into the Jamieson river and inability of the deforested areas to hold unto flooded water resulting to increased surface water runoffs and evaporation.

The pattern of land cover distribution in 2015 indicated that forest occupied 45.09% of the total class, woodland/rangeland occupied 11.44% of the total class, built up area occupied 41.56% of the total class, water bodies maintain the least position in the classes with 1.91%.

**Land Use/Cover Change: Trend, Rate and Drivers**

Forest experienced a positive change of 4.560km$^2$ with a percentage change of 2.75% at the annual rate of change totalling 0.41 from 1987 to 2002. This positive trend in forest within this period is attributed to cultivation of cash crops such as palms and rubber within the period.

Open grazing of animal (see figure 3 and 4**)** within the study area has also contributed to growth in rangeland in the area. The growth in demography of the area, increasing deforestation due to over logging, lumbering, cultivation (through cut and burn), overgrazing and change in socio-economic status of the people as well as oil and gas activities has contributed extensively to the positive change in woodland/rangeland land cover of Oben Area.

Forest experienced a negative change within the period covering 2002-2015 with a percent change of -54.43% (-58.388km$^2$) and an annual change rate of -4.81. The decrease in forest within the period could be related to the positive increase in woodland/rangeland where forest areas were being converted to croplands. Opening up of the forest area for expansion in E&P activities further gave additional access to the forest area for farming, logging/lumbering (timber harvest), extraction of fuelwood removals by the community members. The low to moderate nutrients (e.g. total organic carbon, total nitrogen, chloride, nitrate, sulphate and nitrite) status in soils of the area renders the soil infertile as reported in the SPDC EER, 2010.).

The oil boom between 1987-2015 in Oben Area seeded the area with the chemistry needed to alter land use land cover change in the form of urban growth, industrial and open bare soils, woodland/rangeland as well as and forest and reduction in waters of the area.

**Land Use/Cover Change: Nature and Location**

An important aspect of change detection is to determine what is changing to what. This information is a vital tool in policy and management decision taking. This process involves a pixel to pixel and direct comparison of raster image maps of the study years.

Looking at changes in terms of location of change, urban/industrial area (built up area) change between 1987, 2002 and 2015 seemed to exists as the growth of the settlements is observed in the south around clusters of infrastructural development areas, road network away from the settlement centres following the concentric theory of urban growth postulated by Christaller (1933). Although the pattern seems to be uniform across the four communities in the study area. Built up areas are predominantly located in open bare soil away from forested areas.

Woodland/rangeland are predominately located in the northwest northeast and south in 1987, while in 2002 it was sparsely equally distributed around Oben Area but predominantly located in the northwest and Northern part of Oben in 2015 away from population centres and thick forested areas.

Water is identifiable by the presence of Jemison river straddling from North East to South West with part of the entire North West to South West under water in 1987, by 2002 the water was reduced to a well-recognised stream flowing from North East to South West with visible pools also existing in the North Eastern axis of Oben Area. By 2015, Jemieson river is observed stretching midway from Northeast to South West.

Forested areas is observed spread across Oben Area as at 1987 and 2002, by 2015 forest areas are observed shrinking from the Southern part of Oben, this part is taken over by built up/industrial, bare soil and rangeland/woodland areas. Hence, forest area is observed being restricted to the fringes in North East corner of Oben Area.

**Land Use/Cover Projection**

The transition probability matrix records the probability that each land cover category will change to the other category. This matrix is produced by the multiplication of each column in the transition probability matrix be the number of cells of corresponding land use land cover in the later image.

**Table 4**: Land Use/Cover Projection in Oben Area for 2025 (10yrs)

| Class Name | Water | Forest | Woodland / Rangeland | Built up Area |
|---|---|---|---|---|
| Water | 0.0194 | 0.5663 | 0.1942 | 0.1949 |
| Forest | 0.0110 | 0.4708 | 0.1139 | 0.3396 |
| Woodland / Rangeland | 0.0014 | 0.4636 | 0.1563 | 0.3507 |
| Built up Area | 0.000 | 0.3305 | 0.0790 | 0.5881 |

**Table 5**: Land Use/Cover Projection in Oben Area for 2035 (20yrs)

| Class Name | Water | Forest | Woodland / Rangeland | Built up Area |
|---|---|---|---|---|
| Water | 0.0152 | 0.5279 | 0.1670 | 0.2688 |
| Forest | 0.0091 | 0.4566 | 0.1099 | 0.4116 |
| Woodland / Rangeland | 0.0023 | 0.4536 | 0.1396 | 0.3816 |
| Built up Area | 0.0006 | 0.3540 | 0.0849 | 0.5560 |

**Table 6**: Land Use/Cover Projection in Oben Area for 2045 (30yrs)

| Class Name | Water | Forest | Woodland / Rangeland | Built up Area |
|---|---|---|---|---|
| Water | 0.0115 | 0.4952 | 0.1443 | 0.3314 |
| Forest | 0.0075 | 0.4445 | 0.1066 | 0.4291 |
| Woodland / Rangeland | 0.0031 | 0.4449 | 0.1256 | 0.4079 |
| Built up Area | 0.0018 | 0.3734 | 0.0897 | 0.5288 |

As observed from the tables, as we progressed through year 2035, water has a 0.0152 probability of remaining water and a 0.5279 of drying up within the forest areas in 2035. This is also an indication of an undesirable change (reduction), with a probability of change which is much higher than stability. Forest area during this period has 0.1099 probability of being converted to woodland/rangeland and a probability of 0.4116 of changing to built-up area in 2035. On the other hand, the woodland/rangeland has a probability of 0.3816 of changing to built-up area. Built-up land area has a probability as high as 0.5560 in 2035 which signifies stable growth in urban/industrial/bare soil area of Oben Area.

As indicated in table 6, in year 2045, water has a low 0.0115 probability of remaining water and a 0.4952 of drying up within the forest area, 0.3314 probability of it changing within the built up areas in 2045. This is a clear indication of an undesirable change (reduction), with a probability of change which is much higher than stability. Forest area during this period has a probability 0.1066 to change to woodland/rangeland area and 0.4291 of being converted to built-up areas. Woodland/rangeland has a probability as high as 0.4079 to be converted to built-up area indicating a high level of instability in woodland/rangeland during this period. Built-up land maintained a probability as high as 0.5288 of growth in 2045 which signifies growth in urban/industrial/bare soil area of Oben field.

The findings of the research are:

- Water experienced negative change between 1987-2002 and 2002-2015, forest experience positive change between 1987-2002 and negative change between 2002-2015, woodland/rangeland exhibited positive change from 1987-2002 and 2002-2015, while built up area exhibited positive change between 1987-2002 and 2002-2015.
- Drivers of the land use land cover change in Oben Area include E&P development activities, demographic factors, infrastructural development, agricultural practices and economic factors.
- The projections of future land use/cover changes on the basis of a Markov model showed a trend of increase in built up and woodland/rangeland and a continued decline in forests and water covers within Oben Area.

## References

[1]. Foody. G. M. and Atkinson, P. M. 2002. Uncertainty in remote sensing and GIS, John Wiley and Sons, London.

[2]. Aspinalls, R. J. and Hill, M. j. 2008. Land use change, science policy and management. New York CRC Press, Taylor and Francis Group.

[3]. Read, J. M. and. Lam, N. S. N. 2002. Spatial methods for characterizing land cover and detecting land cover changes for the tropics. *International Journal of Remote Sensing,* 23 (12): 2457-2474.

[4]. Sabins, F. F. 1997. Remote sensing, principles and interpretation. (3rd ed). W. H. Freeman and Company, New York.
[5]. Campbell, J. B. 2002. Introduction to remote sensing. (3rd ed.), Taylor and Francis.