Global Journal of HUMAN-SOCIAL SCIENCE: B
Geography, Geo-Sciences, Environmental Disaster Management
Volume 14 Issue 6 Version 1.0 Year 2014
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-460X & Print ISSN: 0975-587X

# Assessment of Land use and Land Cover Change in Kwale, Ndokwa-East Local Government Area, Delta State, Nigeria

By A. Dami., J. O. Odihi & H. K. Ayuba
*University of Maiduguri, Nigeria*

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*GJHSS-B Classification :* *FOR Code: 960305*

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A. Dami. α, J. O. Odihi σ & H. K. Ayuba ρ

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## I. Introduction

Kwale falls within the Niger Delta region of Nigeria. The area is located within latitudes 5°40'N and 5°50'N and longitudes 6°15'E and 6°30'E (Figure 1a, b) (Anonymous, 2011 and Avbovbo and Ogbe, 1978). The Niger Delta is located within the southern part of Nigeria. It is home to numerous creeks, rivers and possesses the world's largest wetland with significant biological diversity (Twumasi and Merm, 2006). Okpai/Aboh region is within Ndokwa East Local Government Area and is situated within the Sombriero Warri deltaic plain deposit invaded by mangroves. The geographical Niger Delta has been said to cover an estimated area of between 19,100 $km^2$ to 30,000 $km^2$ based on hydrological, ecological as well as political boundaries (Keddy, 2010; Ibe, 1988; Merki, 1972 and Murat, 1972). Okpai/Aboh region is a low-lying area with elevation of not more than 3.0 metres above sea level and generally covered by fresh water, swamps, mangrove swamp, lagoonal marshes, tidal channels, beach ridges and sand bars along its aquatic fronts (Dublin-Green *et al*, 1997). The area has a characteristic tropical monsoon climate at the coast with rainfall peaks in June and September/October with prevailing tropical maritime air mass almost all year round with little seasonal changes in wind directions (Olaniran, 1986). Annual mean total rainfall is about 2,500mm. The mean monthly temperature range from 24-25°C during the rainy season in August to 27-29°C during the end of dry season in March/April. Leroux (2001) reported that maximum temperatures are recorded between January and March (33°C) while minimum temperature are recorded in July and December (21° C), respectively. Temperatures are moderated by cloud cover and damp air. It experiences a humid tropical equatorial climate consisting of rainy season (April to November) and dry season (December to march). The average annual rainfall is about 2,500mm while the wind speed ranges between 2-5m/s in the dry season to up to 10m/s in the rainy season especially during heavy rainfall and thunderstorms. The region is criss-crossed with distributaries and creeks. This area has been classified geomorphologically as tidal flat and large flood plains lying between mean, low and high tides. Three different highs exist within the Kwale, in Ndokwa-East Local Government block, namely a central high where most of the wells have been drilled, an eastern high housing one well and a north western high whose extent has not been clearly defined. The area lies within the freshwater forested region of the Niger Delta.

*Author α σ ρ: Department of Geography, University of Maiduguri, Borno State, Nigeria. e-mails: tonydami@yahoo.com, hkayuba@yahoo.com, johnodihi@gmail.com*

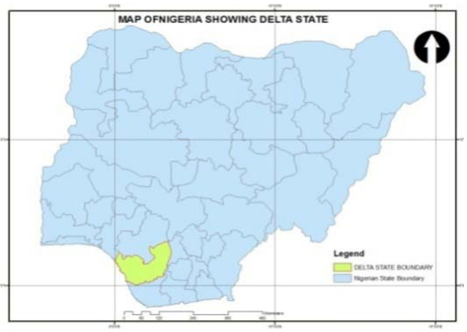


*Figure 1a :* Nigeria showing Delta State


*Source: Delta State Ministry of Lands and Survey (2009)*

*Figure 1b :* Delta State showing Ndokwa East LGA

The coastal areas of the Niger Delta are the home to oil exploration and exploitations in Nigeria (Nwilo and Badejo, 1995). This is largely due to the huge deposits of crude oil and natural gas deposits within the region. The World Bank report of 2002 succinctly stated that Rivers and Delta states alone produced about 75% of Nigeria's petroleum, which represents over 50% of national government's revenues. The report also rated, Nigeria as the fifth largest supplier of crude oil to the United States (EIA, 2003). Nigeria's proven oil reserves drives the economy because it is almost exclusively dependent on earnings from the oil sector, which generates about 20% of GDP, 95% of foreign exchange and about 65% of budgeting revenues (CIA World fact Book, 2008). No doubt, human activities like oil exploration and production have impacted negatively on the delicate balance of nature and the fragile ecosystems of the study area.

Land use and land cover have become very important parameters in highlighting such environmental changes that have taken place over time within the earth's surface (Matiko *et al,* 2012). It has become one of the major parameters for environmental change monitoring and natural resource management (Zhang *et al*, 2008). Thus, Fuchs (1996) aptly stated that land use and land cover and impacts on terrestrial ecosystems including forestry, agriculture, and biodiversity have been identified as high priority issues at global, national, and regional levels. The indirect impact of land-use and land cover is altering climate on the waters (Weng, 2001) while the direct effect could be compromising water quality (Rogers, 1994). Kwale region is not alone with respect to deterioration of its landscape. Woodgate and Black (1988) reported that an estimated 66% of Victoria's native vegetation has been cleared as a result of the growth and economic development of the State.

According to Dami *et al* (2011) the environmental impacts of land use change are usually distinguished according to their spatial level i.e. global, regional and local. As regards global environmental impacts of land use and cover change, land use and cover are relatively new additions to the core concerns of global environmental change research (Meyer and Turner, 1996 Yemefack, 2005). Land use/cover change impacts are basic to environmental changes as the local changes cumulatively affect the whole globe. Large-scale environmental phenomena like land degradation, desertification, biodiversity loss, habitat destruction and species transfer happen at local scales but they cumulatively manifest as regional and global changes. Landuse changes cause a multitude of environmental impacts at the lower spatial levels of urban, suburban, rural and open space areas, which have been extensively documented (Salami and Balogun, 2006, Odeyemi, 1999; Yuliang et al, 2004, Turner and Meyer 1994, Turner et al 1995, LUC 1988, 1999). The impacts include changes in the hydrological balance of the area, increase in the risk of floods and landslides, air and water pollution.

Geographic Information Systems (GIS) Global Positioning System (GPS) and Remote Sensing (RS) have become indispensable tools in almost all environmental endeavors (UN, 1986). These concepts have been employed in various studies including atmospheric studies (Fagbeja, 2008), lithospheric (Maruo *et al,* 2002), hydrologic (Nwilo and Badejo, 1995) biodiversity (Salami and Balogun, 2006), assessment of developmental change over time (Twumasi and Merem, 2006), land use and land cover categories (Ehlers *et al.,* 1990; Treitz *et al.,* 1992) as well as ground water (Maruo *et al*, 2002). Kwale region's landscape had undergone environmental changes over a long period of time as a result of oil exploitation in the area. This environmental change, therefore, has necessitated the need to carry out a holistic approach to land use and land cover inventory of the area with a focus of establishing the geospatial infrastructure for policy makers as well as for proper planning and management of the environmental conditions of the region.

## II. Methodology

The types of data acquired for this study are shown in Table 1. They were sourced from ***global Land cover resources website (http:www.glcf.com),*** while the image from the Nigsat1 2008 was obtained from the National Centre for Remote Sensing, Jos, Plateau State, Nigeria.

*Table 1 :* Satellite imageries and its characteristics

| S/No | Satellite imagery | Year | Resolution |
|---|---|---|---|
| 1 | Landsat MSS | 1975 | 60m |
| 2 | Landsat TM | 1987 | 28.5m |
| 3 | Landsat_ETM | 2001 | 28.5m |
| 4 | Nigsat 1 | 2008 | 28.5m |

## III. Data Extraction Process

Following the acquisition of the required satellite images from their respective sources for the aforementioned years, the extraction of the study area portion from the entire image covering the entire South Western /South Southern corner of the country was done using ArcGIS. The georeferencing of the satellite data as well as the subset operation using ILWIS 3.3 Academy software was performed.

## IV. Digital Image Processing and Analysis

The stage of analysis include a reconnaissance field survey (ground truthing) with GPS to obtain coordinates of each location; the 1975 topographic sheet (1: 25,000) covering the entire region was used to aid in identifying notable spatial features of the area. This process proved very useful in unraveling, demystifying and harmonizing the disparity between what was observed on ground and their respective spectral signatures displayed in the images. In this regard however, it was observed that both bare surfaces and settlements exhibited somewhat similar spectral characteristics as both randomly did have a mix of cyan and white color, which are the standard color representations for both settlements and bare surfaces.

The procedure developed for the sample dataset of the submap was carried out based on the supervised classification techniques using the eight (8) land use/cover classes (features) of the area as indicated in Table 2.

*Table 2 :* Codes and Class of Land uses Recognized in the Study Area

| Code | Class |
|---|---|
| 1. | Bare Surface |
| 2. | Forest Vegetation |
| 3. | Marshland |
| 4. | Cultivated land |
| 5. | Settlement |
| 6. | Shrubland |
| 7. | Water Body |
| 8. | Woodland |

*Sources : Adapted from Dami (2003)*

Furthermore, the maximum likelihood method of classification (MLC) in the ILWIS 3.3 Academic software was adopted for the classification. The maximum likelihood method is a statistical decision rule that examines the probability function of a pixel for each of the classes, and assigns the pixel to the class with the highest probability. The classifier assumes that the training statistics (sample sets) for each class have a normal or 'Gaussian' distribution. The classifier then uses the training statistics to compute a probability of whether of a pixel belonging a particular land cover. This allows for within-class spectral variance. MLC usually provides the highest classification accuracies. Accordingly, it has a high computational requirement because of the large number of calculations needed to classify each pixel (Natural Resources Canada, 2005).

Three softwares were used to analyse the spatial data. ARCGIS was used for curve fitting processing while ERDAS Imagine was used for land use land cover classification, evaluating the quality of input data and ensuring that thematic maps were accurately classified. Finally, ILWIS (Integrated Land and Water Information System) was very useful in combining raster (image analysis), vectors and thematic data operations in one comprehensive phase.

## V. Results and Discussion

Table 3 shows that bare surfaces rose astronomically from 35,395 km² in 1975 to 154,630 km² in 1987 representing an area change of 119,235 km² (336.87%). This could be due to the establishment of the Agip Gas Plant. which started operation within the area in 1975 (NAOC, 2007). Oil exploration and production activities abound in the region (Oboli, 1978). From 1975 to 1987 oil exploration and exploitation activities were at their peak. Close observation reveals that areas covered by thick oil sleeks after oil spillage, do become bare with time (Fabiyi, 2008). This could be responsible for huge leap of bare surfaces from the 1975 and 1987. In 2001, there was a significant decrease in land area to 61,374 km², accounting for 25,979 km² (73.40%) area change. By 2008, there was a further significant decrease to 2,296 km representing -33,099 km² (-93.51%) area change. This gross reduction from the 1987 estimates to those of the 2001 and 2008 could be as a result of the frantic efforts of prospecting oil and gas companies at carrying out environmental remediation and mitigation mainly through phytoremediation within the study area. This showed that bare surfaces are losing their space to marshlands, cultivated lands shrub lands and water bodies (Figure 2).

The area had a forest reserve that was recognized by the Federal Government of Nigeria as far back as 1975 (Mensah and Amukali, 2000; Ekine and Iyabe, 2009). Also, the Green Revolution of 1978 and restrictions to entrance to the forested area of the region must have encouraged the growth of plants, thus the high areal coverage of forest vegetation (45,363 km²). While the bare surface increased significantly, forest vegetation decreased from 45, 363 km2 to 10,910 km² in 1987 accounting for -34,453 km² (-75.95%) area change. The gross reduction could be due to the massive oil exploration and exploitation activities which went on without much regard to environmental consideration in the region. By 2001, forest cover increased to 46,873 km² representing an area change of 1,510 km² (3.33%) increase. Unfortunately, forest cover decreased to 31,309 km² representing an area change of -14,054 km² (-30.98) in 2008.

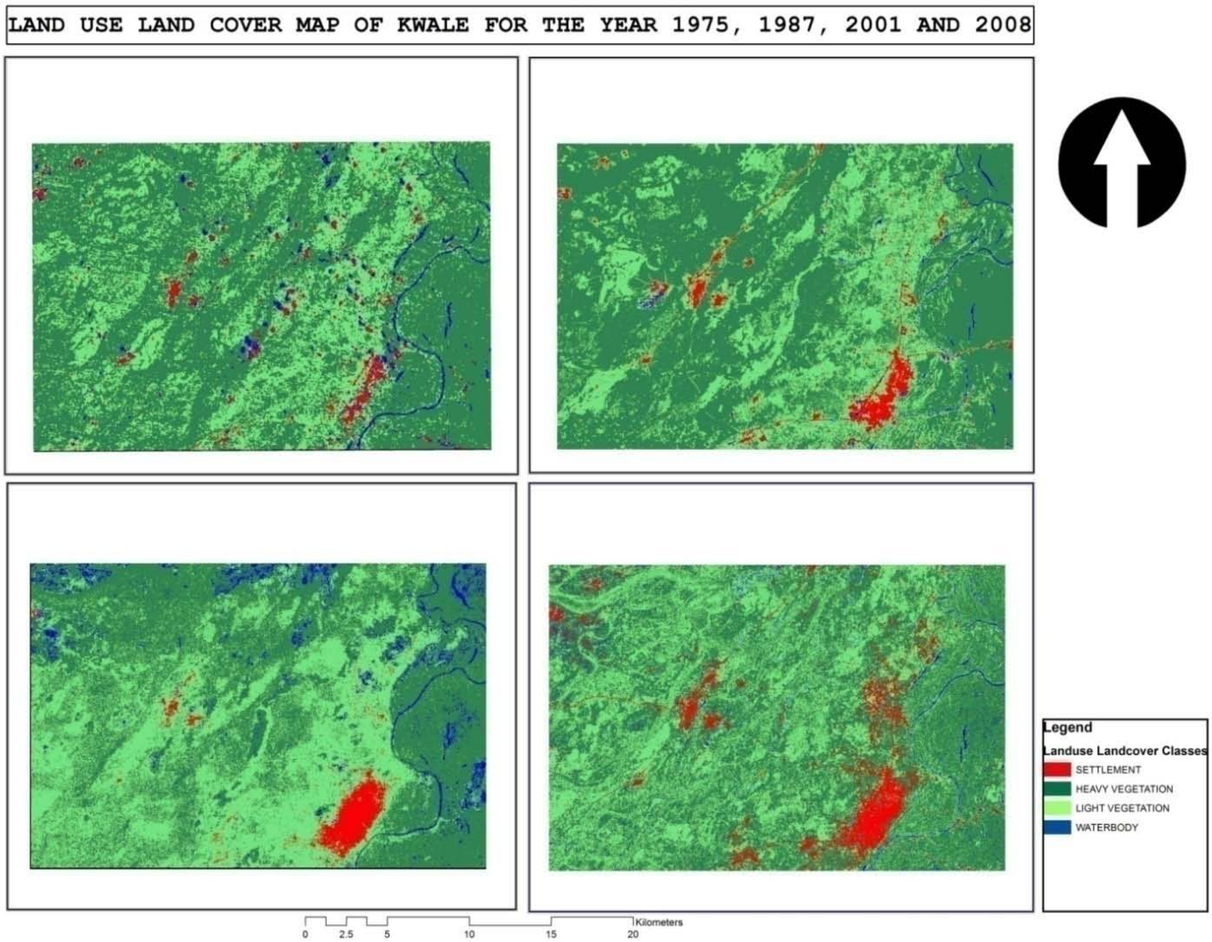


*Figure 2 :* Land Use Land Cover Map for 1975, 1987, 2001 and 2008

This trend depicts a scenario where there is inconsistency in the nature and type of human activities going on in this part of the region. Thus, the 1987 estimate could be attributed to increased human and economic activities within the area partly owing to a general relaxation of the restrictions on the Forest Reserve which lost its status and the huge presence and activities of prospecting and production oil companies in the area. The global agitation for more environmentally-friendly practices and subsequently the various mitigative tendencies of oil companies must have influenced the trend in 2001 while the further reduction in forest vegetation in 2008 could be due to increased exploration and exploitation activities of the area.

Marshlands increased from 125,431 km² in 1975 to 197,752 km² representing an area change of 72,321 km² (57.66%) in 1987 but decreased to 154,105 km² in 2001 representing an area change of 28,674 km² (22.86%) and increased to 193,725 km² representing area change of 68,294 km² (54.45%) in 2008. Field observations revealed that the study area is exposed to massive deposition of organic agents like silt, clay, debris and a host of other decomposable materials as supported by (GGFRI, 2009 and Allen, 1972). Thus, the increase in marshlands area prior to 1987, but when oil related activities increased within this area, after the 1980's, easy formation, transportation and deposition of marshlands became affected and this could be

*Table 3 :* Main Land Use/Land Cover in Kwale 1975, 1987, 2001 and 2008

| Main Landuse/ Cover Class | 1975 | 1987 | 2001 | 2008 |
|---|---|---|---|---|
| Bare Surface ( $km^2$) | 35,395 | 154,630 | 61,374 | 2,296 |
| Forest Vegetation ( $km^2$) | 45,363 | 10,910 | 46,873 | 31,309 |
| Marshland ( $km^2$) | 125,431 | 197,752 | 154,105 | 193,725 |
| Scattered Cultivation( $km^2$) | 62,374 | 61,916 | 88,156 | 139,977 |
| Settlement ( $km^2$) | 22,074 | 17,437 | 13,375 | 16,420 |
| Shrubland ( $km^2$) | 196,724 | 79,998 | 267,613 | 203,046 |
| Water Body ( $km^2$) | 9,776 | 13,215 | 4,556 | 41,050 |
| Woodland ( $km^2$) | 355,979 | 317,258 | 217,064 | 225,293 |

responsible for the decrease in marshlands noticed in 2001 while the further increase in the 2008 value could be attributed to factors like lumbering and farming as well as those factors that earlier favored increases. Mensah and Amukali (2000) described the rural communities in the area as rural subsistence farmers. In 1975, scattered cultivated areas were estimated at 62,374 $km^2$ which slightly decreased to 61,916 $km^2$ representing area change of -458 $km^2$ (-0.73%) in 1987. In 2001, there was a massive increase to 88,156 $km^2$ representing area change of 25,782 $km^2$ (41.34%) and this continued till 2008 where an increase of 139,977 $km^2$ representing area change of 77,603 $km^2$ (124.42%) occurred.. The slight decline of scattered cultivated areas from 1975 to 1987 must have been influenced by farmers giving up farming to taken in juicy jobs in the oil industry. Settlement areas decreased from 22,074 $km^2$ in 1975 to 17,437 $km^2$ representing area change of -4,637 $km^2$ (-21.01%) in 1987 and later to 13,375 $km^2$ representing area change of -8,699 $km^2$ (-39.41%) in 2001. However, by 2008 the areas covered by settlements were shown to be 16,420 $km^2$ representing area change of -5,654 $km^2$ (25.61%), respectively. As shown from the interpreted satellite images (Figure 2), settlements were initially seen to be scattered but in 2008, the settlements became more concentrated within specific geographical regions. This trend could be explained by the recent resettlement of some communities within the study area to pave way for more oil exploration and exploitation. Shrub lands decreased from 196,724 $km^2$ in 1975 to 79,998 $km^2$ representing area change of -116,726 $km^2$ (-59.34%) in 1987. This later increased to 267,613 $km^2$ representing area change of 70,889 $km^2$ (36.04%) in 2001 but decreased 203,046 $km^2$ in 2008 representing area change of 6,322 $km^2$ (3.21%). Afforestation efforts or seasonal regeneration of plants during the 1990's as at the time the images were captured must have been responsible for the increase noticed from 1987 to 2001. It could also be due to decreased activities of oil prospecting and production companies within the area owing to the activities of militants, increased agricultural cultivation and spread of settlement areas must have contributed to the initial increase in shrub lands but later unavoidable reduction in shrub lands in the area. This scenario depicts high amount of human and economic activities within the area after 1975. But, since most shrubs are seasonal plants that grow massively during rainy seasons, it could be deduced that the time the images were taken could have influenced the results, hence the huge jump from the 1975 to that of 1987 and later from 2001 to 2008 respectively. Water bodies area were calculated to be 9,776 $km^2$ in 1975 and increased to 13,215 $km^2$ representing area change of 3,439 $km^2$ (35.18%) in 1987 but dwindled to 4,556 $km^2$ representing area change of -5,220 $km^2$ (-53.40%) in 2001. In 2008, water bodies increased to an estimated area of 41,050 $km^2$ representing area change of 31,274 $km^2$ (319.91%). Seasonality must have influenced the trend as observed in the study.

Massive accumulation of marshlands, drastic reduction in the number of forest vegetation, shrub lands and woodlands all expose surface water bodies to the direct influences of the vagaries of weather, thereby contributing to increased evaporation. Thus, water-holding capacities of soils decrease, making them lose same to ground, surface and atmospheric sources. Woodlands reduced from 355,979 $km^2$ in 1975 to 317,258 $km^2$m in 1987 representing area change of -38,721 $km^2$ (-10.88%) and to 217,064 $km^2$ representing area change of -138,915 $km^2$ (-39.02) in 2001. Finally, in 2008, the area covered by woodlands as shown in Table 3 was 225,293 $km^2$ representing area change of -130,686 $km^2$ (-36.71). Increased lumbering activities in this part of the country, must have contributed to decreased woodland from 1975 to 1987 and 2001 while afforestation efforts as part of environmental remediation must have contributed to the increase in 2008.

## VI. Conclusion

The delicate balance of nature and fragile ecosystem of the Kwale in Ndokwa-East Local Government area has been altered by natural and human factors over time. This study was able to model the long term land use and land cover changes between 1975 when the area was still free of exploration and exploitation activities to 2008 when oil-related activities reached their peak and provide analysis of LUCC information in the area which helped in showing significant trends. The results of this study showed that between 1975 and 2008, bare surfaces decreased by 33,099 km² representing 93.51%, forest vegetation to 14,054 km² amounting to 30.98%, settlement to 5,654 km² which is equivalent to 25.61% and woodlands 133,377 km² representing 37.19%. Furthermore, scattered cultivation, scrublands and water bodies correspondingly increased by 68,294 km² (54.45%), 77,603 km² (124.42%), 6,322 km² (3.21) and 31,274 km² (319.91%), respectively. This indicate that bare surfaces, forest vegetation, settlements and woodlands were gradually being replaced by marshlands, scattered cultivation, shrublands as well as water bodies. This study therefore, recommends the reclaiming of the areas occupied by bare surfaces and marshlands to agricultural activities to reduce poverty and improved food security in the region.

## VII. Acknowledgement

The authors gratefully acknowledge the contribution of O. Amukali, a graduate student of the Department of Geography, University of Maiduguri who collected the data for this work.

## References Références Referencias


1. Amukali, O. and Mensah, J.K. (2000): Effects of Developmental Projects on the soil and vegetation of the Niger Delta Ecosystems. A. B.Sc. Project Dept of Botany, A.A.U, Ekpoma, Edo State. (Unpublished). Anonymous (2011): People In Country Profile-Kwale. Available at http://www.joshuaproject.net/peopleprofile.php?peo3=15699&rog3=NI. Retrieved on 28/02/2011.
2. Allen, J.R. (1972): late Quarternary of the Niger Delta and adjacent areas. Sedimentary Environments and Lithofacies. AAPG 49: 547-600.
3. Avbovbo, A.A. and Ogbe, F.G. (1978): Tertiary Lithostratigraphy of the Niger Delta. A.A. PG. Bull; 62:285-300.
4. CIA (2008): CIA-World fact Book: United Kingdom available online at http://www.cia.gov/library/publications /the-world-factbook/print/uk.litml
5. Dami, A; Adesina, F. A. and Garba, S. S. (2011):"Land Use Changes in the Adjoining Rural Land of Maiduguri between 1961- 2002: Trend and Implication in Environmental management in Borno State, Nigeria" Journal of Environmental issues and Agriculture in Developing Countries, Volume 3 Number 2 August. Pp-159-168.
6. Delta State Ministry of Lands and Survey (2009): Map of Ndokwa East, Delta State, Nigeria. 23p.
7. Dublin-Green, C.O., Awobamise, A. and Ajao, E.A. (1997): Large marine ecosystem project for the Gulf of Guinea.: Coastal profile of Nigeria. Nigerian Institute of Oceanography. 36p.
8. Ehlers, M. M. A., Jadkowski, R. R., Howard, and Brostuen, D. E., (1990). "Application of SPOT data for regional growth analysis and local planning". PhotogrammetricEnginering and Remote Sensing.
9. Energy Information Administration (2003); Country Analysis Briefs: Nigeria. Available at http: //www.eia.docgov/emec/cabs /nigenv.html.
10. Ekine, A.S. and Iyabe, P. (2009): petrophysical characteristic of the Kwale Reservoir Sands (Oml 60) from wire-logs, Niger Delta, Nigeria. J. Appl. Sci. Environ, Mgt. 13 (4): 81-85.
11. Fabiyi, O. (2008) Mapping Environmental Sensitivity index of the Niger Delta to oil spill: The policy, Procedures and policies of oil spill response in Nigeria. University of Ibadan, Nigeria. Pp 1-20.
12. Fagbeja, M. (2008): Applying remote sensing and GIS techniques to air quality and carbon management: A case study of gas flaring in the Niger Delta. A Ph. D. Thesis. University of the west of England, Britain. 53pp.
13. Fuchs, R., (1996). Global change system for analysis, research and training (START). Proceedings of Land Use and Cover Change (LUCC) Open Science Meeting, Amersterdan, The Netherlands.
14. GGFRI (2009) Global Gas Flaring reduction Initiatives Report on consultants with stakeholders. World Bank Group in collaboration with the government of Norway. http://www.worldbank.org /ogmc/files/global-_gas_flaring_initiative.pdf .accessed. February 11, 2004.
15. Ibe, A.C. (1988) Coastline Erosion in Nigeria University Press, Ibadan, Nigeria. 10-19.
16. Keddy, P.A. (2010). Wetland Ecology: Principles and Conservation (2nd edition). Cambridge University Press, Cambridge, UK. 497 p.
17. Leroux, M. (2001). The Meteorology and Climate of Tropical Africa. Praxis publishing limited, Chichester, UK. 548p.
18. Maruo, T., Hiwot, A.G., Lulu, S. and Gorfu, S. (2002): Application of GIS for ground water resource management: Practical experience from groundwater development and water supply .Training Centre. UNECA. Available online at http://www.uneca.org/groundwater/Docs/Application%/20%20 GIS-%20-JICA%20NO-12.pdf.
19. Matiko, M., Mtalo, I. F. and Mwanuzi, F. (2012) Land Use and Land Cover Changes in Kihansi River Catchment and its Impact on River Flow. Department of Water Resources Engineering, University of Dar Es Salaam, Dar Es Salaam, Tanzania. 22p.

20. Merki, P. (1972): Structural geology of the cenozinc Niger Delta. In African Geology eds.
21. Meyer, W.B. and Turner, B.L. II. (1996), "Change in landuse and land cover change: Challenges for geographers". Geojournal 39(3) Pp 237 – 240.
22. Murat, R.C. (1972): Stratigraphy and paleogeography of the bcretaceous and lower tertiary Southern Nigeria. In African Geology. Ed. T.J.F. Dessanvagie ie and A.J. Whiteman, University of Ibadan Press, Ibadan. Pp. 635-648.
23. NAOC (2007): First Monitoring Report on Recovery of associated gas that would otherwise be flared at Kwale Oil-Gas Processing Plant, Nigeria. Kwale Monitoring report. CDM Registration No 0553. pp 1-7.
24. Nwilo, P.C. and Badejo, O.T. (1995): Management of Oil spill dispersal along the Nigerian Coastal Areas. J. Envtal Mgt. 4;42-51.
25. Oboli, H.O.N. (1978): A New Outline Geography of West Africa. George and Harrap and Company. 78p.
26. Salami, A.T. And Balogun, E.E. (2006): Utilization of Nigeria Sat-1 and other satellites for forest and biodiversity monitoring in Nigeria. National space Research and Development Agency (NASRDA), Abuja, Nigeria. 142pp.
27. Odeyemi, Y.A. (1999): "Landuse inventory and change detection in the urban – Rural fringes of Ilesa Area." M.Sc Dissertation (unpublished) Department of Geography, Obafemi Awolowo University, Ile-Ife. Pp. 3-39.
28. Olaniran, O.J. (1986): On the Classification of Tropical Climates for the Study of Regional Climatology: Nigeria as a Case Study. Geography Annaler. Series A. Physical geography. 68 (4) Pp. 233-244.
29. Oseji, J.O. and Ofomola, M.O. (2010): Determination of Groundwater Flow Direction in Utagba Ogbe Kingdom, Ndokwa Land Area of Delta State, Nigeria. Archives of applied science Research. 2(4) Pp. 324-328.
30. Rogers, P. (1994). Hydrology and Water Quality. Pages 231-258 in W. B. Meyer and B.I. Turney II (ed), changes in land use and land cover: A global Perspective. Cambridge University Press, Cambridge.
31. SPDC (1999). People and Environment Report. In: Shell Nigeria Annual report, 2006. Shell Visual Media Services, London. 18p.
32. Treitz, P. M., P. J. Howord, and P. Gong. (1992). "Application of satellite and GIS technologies for land-cover nad land-use mapping at the rural-urban fringe". Photogrammetric Engineering and Remote Sensing 58(4):439-448.
33. Turner, Turner, B.L. II. and Meyer, B.L. (1994): "Global landuse and land cover change: An overview in changes in landuse and land cover: A global perspective," (eds.) Meyer, W.B. and Turner, B.L.II. Cambridge: Cambridge University Press. Pp. 3-10.
34. Turner, B.L. II; Skill, D., Sanders, S., Fischer, G., Fresco, L., and Lemmas, R. (1995): Landuse and land cover change; Science/Research Plan. IGBP Report No. 35, HDP Report No. 7 IGBP and HDP Stockholm and Geneva. PP.8-16.
35. Twumasi, Y.A. and Meren, E.C. (2006): GIS and remote sensing application in the assessment of change within a coastal environment in the Niger Delta region of Nigeria. Int. Journal Environ. Res. Public Health. 3 (1) 98-106.
36. United Nations, Un (1986): Principles relating to remote sensing of the earth from space. 95th Plenary meeting of the General Assembly, Dec. 3, 1986.
37. United Nations Development Programme, UNDP (2006): Niger Delta Human Development Report. UNDP, Abuja, Nigeria 48p.
38. Weng, Q. (2001). "Modeling Urban Growth Effects on Surface Runoff with the Integration of Remote Sensing and GIS", Springer-Verlag. New York.
39. Woodgate, P. and Black, P. (1988). Forest Cover Changes in Victoria. Department of Conservation, Forests and Lands. Melbourne, Australia. World Encyclopedia. "Marshes". Retrieved 4 February 2012.
40. Zhang, Z., Peterson, J., Zhu, X. and Wright, W., (2008). Modelling land use and land cover change in the Strzelecki Ranges. Proceedings of International congress on modelling and simulation (MODSIM07), Christchurch, New Zealand, pp.1328-1334.

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