International Journal of Innovative Human Ecology & Nature Studies 6(1):6-13, Jan.-Mar., 2018

© SEAHI PUBLICATIONS, 2018 www.seahipaj.org ISSN: 2467-849X

Effects of Human and Natural Activities on Land Cover Changes in Kwale Region, Delta State, Nigeria

Amukali[1], O., Imaitor-Uku[2], E. E., Obadoni[3], B. O. & Inainfe[2], N.

**[1]Geography & Environmental Management Department,
Niger Delta University, Bayelsa State, Nigeria**

**[2]Department of Geography,
Isaac Jasper Boro College of Education, Sagbama, Bayelsa State, Nigeria**

**[3]Department of Botany, Ambrose Alli University, Ekpoma, Edo State, Nigeria.
E-mail: amukaliogo@yahoo.com**

ABSTRACT:
The study area has undergone significant changes over time. In this study, settlement, bare surfaces, woodlands, shrublands, water bodies, marshlands and forest vegetation were the land cover parameters studied. Satellite images (ERS) of the study area for the years 1975, 1987, and 2001 were downloaded from global landcover resources website (http:www.glcf.com), while the 2008 NigSatI image of the country was obtained from the National Centre for Remote Sensing, Jos, Plateau state, Nigeria. ARCGIS, ERDAS and ILWIS were three softwares used to process the data. Results showed on the average that, between 1975 and 2008, bare surfaces decreased by 33,099 km² (93.51%), forest vegetation by 14,054 km² (30.98%), settlement by 5,654 km² (25.61%) and woodlands by 133,377 km² (37.19%) while marshlands, scattered cultivation, shrublands 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 showed that bare surfaces, forest vegetation, settlements and woodlands were gradually being replaced by marshlands, scattered cultivation, shrublands as well as water bodies. Settlements were found to be aggregating within specific geographic regions, over time. It is recommended that efforts should be devoted towards increasing gas flaring-reduction strategies, afforestation and cultivation
Keywords: Natural Activities. Land Cover Changes

INTRODUCTION

Kwale region falls within the Niger Delta area of Nigeria. The coastal areas of the Niger Delta are the home to oil exploration and exploitations in Nigeria (Nwilo & Badejo, 2005) and this is largely due to the huge deposits of crude oil and natural gas deposits within the region. In 2002, Nigeria was rated the fifth largest supplier of crude oil to the United States (EIA, 2003). Nigeria's proven oil reserves fuels the economy because it's almost exclusively dependent on earnings from the oil sector and this generates about 20% of GDP, 95% of foreign exchange and about 65% of budgeting revenues (CIA World fact Book, 2005). 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. Kwale region's landscape had undergone some level of environmental changes that is worth investigating. Accurate and timely spatial studies to large extent require depicting environmental changes in manners that would make management of such changes easier to understand and control.

Land use and land cover are very important parameters in highlighting environmental changes that within the earth's surface (Matiko et al, 2012). It has become one of the major issues for environmental change monitoring and natural resource management (Zhang et al, 2008). Thus, Fuchs (1996) aptly stated that land use and land cover and its impacts on terrestrial ecosystems including forestry, agriculture, and biodiversity have been identified as high priority issues in 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. For now, there are scarcely sufficient data on land use and land cover change and its impact on the study area's landscape. This formed the bases of this work.

Study Area

The study area falls within a low-lying height of not more there 3.0 meters 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*, 1999). It is located within longitudes 6.40 and 6.56^0 East and latitudes 5.55 and 5.69^0 North (DSML&S, 2009) (see Figure 1.1). The study area is located at the north western part of the Niger Delta complex and is characterized by structures which resulted from listric growth faults and their associated roll-over anti clines (Ekine & Iyabe, 2009). Ekine and Iyabe (2009), further reported that three different highs exist in Kwale region (which encompasses Okpai and Beneku); 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. However, further detailed stratigraphic sequence studies of the Cenozoic Niger Delta complex have been discussed by authorities like Murat (1972), Avbovbo & Ogbe (1978), Allen (1972) as well as Merki (1972). The prevailing climatic condition is that of equatorial type of climate based on Koppen's Af climatic classification (GGFRI, 2009). The study area experiences a tropical climate consisting of rainy season (April to November) and dry season (December to march) (Nwilo & Badejo, 2005). Fabiyi (2008) opined that the overall 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 rain falls and thunderstorms. The region is criss-crossed with distributaries and creeks. The studied area has been classified geomorphologically to consist of tidal flat and large flood plains lying between mean, low and high tides (Ibe, 1998).

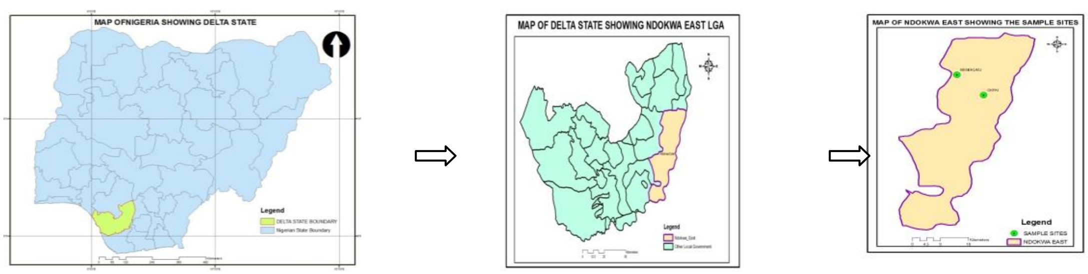

Figure 1.1 Map showing Sample Points Okpai and Beneku Delta State.
Source: Delta State Ministry of Lands and Survey (2009)

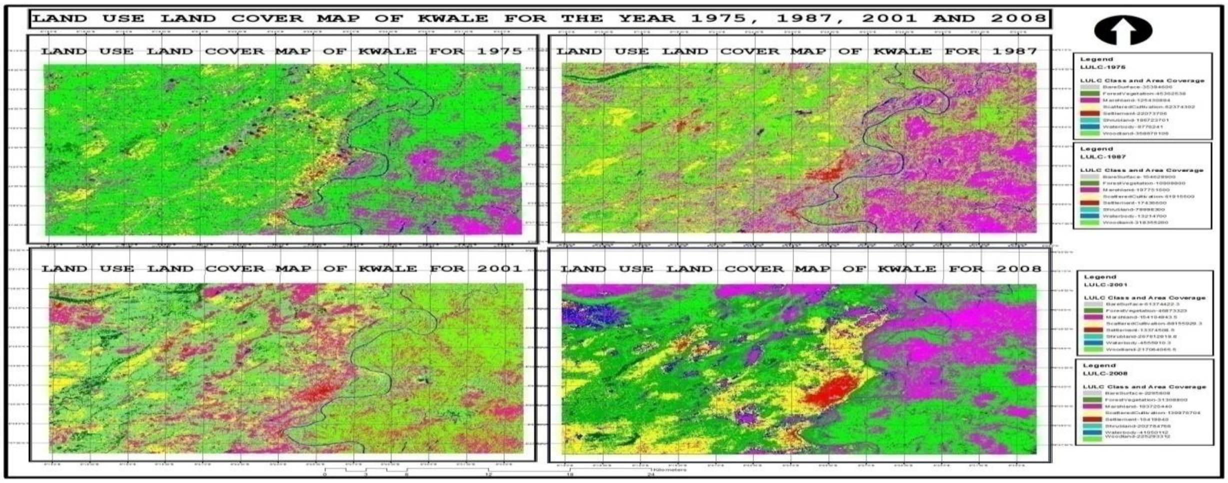

Figure 1.2 Imageries of the Study Area.
Source: Analysed Imageries of the Study Area for the four epochs.

This is further supported by Nwilo & Badejo (2005) when they stated that the region is characterized by surrounding permanent and seasonal swamp forests and low-lying rain forests. Crops grown by the peasant farmers include cassava, yam, beans, melon, plantain, pepper, etc. Anonymous (2011) estimated the population of Kwale geographical region at 242,000.

Method Of Acquisition And Processing Of Land Use Land Cover Data

Data for the analysis were basically satellite images (Environmental Resource Satellite) for 1975, 1987, 2001 and 2008. These Images were obtained from two different sources. Firstly, images of the study area for the years 1975, 1987, and 2001 were downloaded from ***global Landcover resources website (http:www.glcf.com)***, while the 2008 was NigSatI image of the country and this was obtained directly from the National Centre for Remote Sensing, Jos, Plateau state, Nigeria.

Table 1.1 Characteristics of the imageries

S/No.	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

Source: Authors' Analysis (2017)

Data Extraction Process

Following acquisition of the satellite images from their respective sources, 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 subset operation from the Ilwis 3.3 Academy software was used to carry out this task. Figure 1.1 showed the satellite image of the entire south - south corner of the country and the subsetted image of the study area.

Brief reconnaissance field survey was done to aid identifying specific notable spatial features in the study area and this helped in 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 surface and settlement 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 settlement and bare surface. This was followed by the acquisition of sample dataset from the extracted images of the study area to help in the supervised classification which followed the process. Eight (8) spatial land cover classes (features) have been observed to be predominant in the images of the study area and these are listed as follows:

Method of Land Use and Land Cover Analysis

Digital image processing for the Land use and land cover classification was immediately carried out using the supervised type of classification and this was carried out to identify the characteristics of the spectral signatures of spatial feature sets in the study area and was also used to train the image to recognize each of the eight identified classes. Furthermore, the maximum likelihood method of classification in the Ilwis 3.3 Academic software was later used to carry out the classification of the various images (1975, 1987, 2001 and 2008). The maximum likelihood method in itself 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. In classifying, it was assumed that sample sets for each class have a normal or 'Gaussian' distribution then used the training statistics to compute a probability value of whether it belongs to a particular land cover category class. This allowed for within-class spectral variance. 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 analyze the spatial data. ARCGIS was used for curve fitting processing while ERDAS Imagine was used for land use land cover classification, evaluating the input of the quality of input data and for ensuring that thematic maps were accurately classified. Finally, ILWIS was very useful in combining raster (image analysis), vectors and thematic data operations in one comprehensive phase. ILWIS was used for import/export of files, easily shaping files, digitizing, editing, analysis, display as well as production of quality maps.

RESULTS AND DISCUSSIONS

Table 1 showed that bare surfaces were minimal in 1975 with an approximate value of 35,395 km² but rose astronomically to 154,630 km² representing an area change of 119,235 km² (336.87%) in 1987. 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). This could be responsible for the increase from 1975 to 1987 when oil exploration and exploitation activities were at the peak. Gas flare sites are usually observed to feel hotter than non gas flare sites and on close observation, one finds that areas covered by thick oil sleeks after oil spillage, do become bare with time. This could be responsible for huge leap of bare surfaces from the 1975 and 1987. In 2001, there was a decrease in land area to 61,374 km², amounting to an area change of 25,979 km² (73.40%) whereas in 2008, a further decrease to 2,296 km representing -33,099 km² (-93.51%) was recorded. This gross reduction from the 1987 value to those of the 2001 and 2008 could be owing to 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 loosing their space to marshlands, scattered cultivation, shrublands and water bodies.

The area had a forest reserve that was recognized by the Federal Government of Nigeria as far back as 1975 (Amukali & Mensah, 2000). Also, the Green Revolution of 1978 and restrictions to entrance to the forested regions of the study areas must have encouraged the growth of plants, thus the initial increase in forest vegetation from 45,363 km² in 1975. In 1987, forest vegetation of the study area was observed to have a value of 10,910 km² amounting to an area change of -34,453 km² (-75.95%). The gross reduction could be due to the massive oil exploration and exploitation activities which went on without much regard to environmental impacts within the study area. By 2001, the figure rose to 46,873 km² representing an area change of 1,510 km² (3.33%) increase but later surprisingly fell to 31,309 km² representing an area change of -14,054 km² (-30.98) in 2008.

Table 1.2: Results of Changes in Land Use and Land Cover for the four years under study

Land Cover Class	1975	1987	2001	2008
Bare Surface (km²)	35,395	154,630	61,374	2,296
Forest Vegetation (km²)	45,363	10,910	46,873	31,309
Marshland (km²)	125,431	197,752	154,105	193,725
Scattered Cultivation(km²)	62,374	61,916	88,156	139,977
Settlement (km²)	22,074	17,437	13,375	16,420
Shrubland (km²)	196,724	79,998	267,613	203,046
Water Body (km²)	9,776	13,215	4,556	41,050
Woodland (km²)	355,979	317,258	217,064	225,293

This trend depicted a scenario where there was inconsistency in the nature and type of activities that went on the study area. Thus, the 1987 value could be attributable 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 region. 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. 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 later increased to 193,725 km² representing area change of 68,294 km² (54.45%) in 2008. Clearly, the study area is prone to massive deposition of organic agents like silt, clay, debris and a host of other decomposable materials.

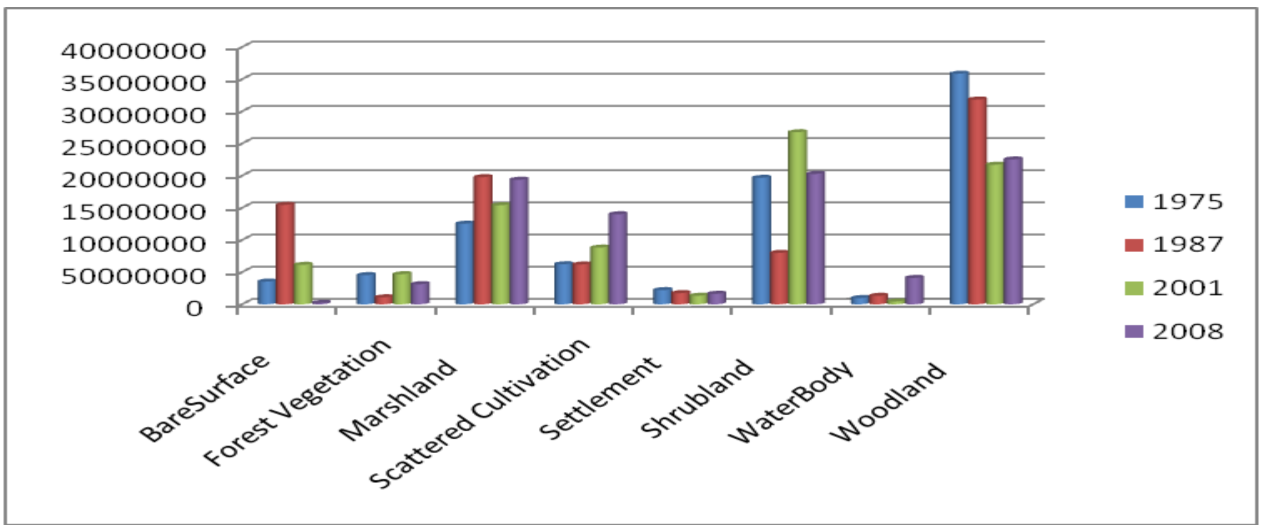

Figure 1.3. Histogram showing Land Cover Change over the four years under study

Thus, the increase in marshlands area prior to 1987 but when oil related activities increased within the study area, after the 1980's, easy formation, transportation and deposition of marshlands became affected and this could be responsible for the decrease in marshlands noticed in 2001 while the further increase in the 2008 value could be attributed to factors like lumbering, farming etc as well as those factors that earlier favoured increases. Amukali & Mensah (2000) stated that the people of the region are subsistence farmers. The scattered cultivation noticed in the area is evident of which. Unarguably, as the population increases, the rate of food production is bound to increase so as to feed the ever-increasing population.

Hence, in 1975, scattered cultivated areas were found to amount to about 62,374 km² which slightly decreased to 61,916 km² representing area change of -458 km² (-0.73%) in 1987. In 2001, there was a massive increase to 88,156 km² representing area change of 25,782 km² (41.34%) and this continued till 2008 where an increase of 139,977 km² representing area change of 77,603 km² (124.42%). The slight decline of scattered cultivated areas from 1975 to 1987 must have been influenced by farmers giving up farming for juicy jobs in the oil industry. Also, after 1987, the increased value of scattered cultivation was because most of the farmers couldn't abandon their farms completely for juicy jobs in the oil industry, maybe because they lacked the prerequisite qualification for such jobs. Scattered cultivation could also contribute to land and water degradation/contamination through agricultural pollutants finding their ways into surface waters and later into ground water sources. Settlement areas decreased from 22,074 km² in 1975 to 17,437 km² representing area change of -4,637 km² (-21.01%) in 1987 and later to 13,375 km² representing area change of -8,699 km² (-39.41%) in 2001. However, by 2008 the areas covered by settlements were observed to show be 16,420 km² representing area change of -5,654 km² (25.61%), respectively. As observed from images from Appendix I, 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.

From these settlements, household, domestic as well as industrial wastes were generated and discharged either directly into waters or on land from where they find their ways into water bodies. Gas flare sites as noticed in the 1987, 2001 and 2001 remotely sensed imageries but were absent in the 1975's directly discharge thick fumes into the air, warming up the air, thus increasing temperatures and releasing thick black fumes that could contaminate the air, from where they could be condensed by cloud before falling back as rain to mix up with surface waters. Shrub lands decreased from 196,724 km² in 1975 to 79,998 km² representing area change of -116,726 km² (-59.34%) in 1987. This later increased to a record-high value to 267,613 km² representing area change of 70,889 km² (36.04%) in 2001but slowed down in 2008, where it was estimated to be 203,046 km² representing area change of 6,322 km² (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 value to that of 1987 and later from 2001 to 2008 respectively. It is also suspected that emphasis on afforestation program as part of the oil companies' environmental remediation efforts must have also influenced the trend.

Water bodies were found to approximately cover 9,776 km² in 1975 and this later increased to 13,215 km² representing area change of 3,439 km² (35.18%) in 1987 but surprisingly dwindled to 4,556 km² representing area change of -5,220 km² (-53.40%) in 2001. In 2008, water bodies increased to its record highest by covering an estimated area of 41,050 km² representing area change of 31,274 km² (319.91%). Seasonality must have influenced the trend as noticed by the area covered by water bodies during the period under 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 loose same to ground, surface and atmospheric sources. As the quantity of water decreases, the capacity to neutralize contaminants also decreases, thus predisposing such waters to higher tendencies to get polluted. Woodlands reduced from 355,979 km² in 1975 to 317,258 km²m in 1987 representing area change of -38,721 km² (-10.88%) and later to 217,064 km² representing area change of -138,915 km² (-39.02) in 2001. Finally, in 2008, the area covered by woodlands was observed to be 225,293 km representing area change of -130,686 km² (-36.71). Increased lumbering within the study area, must have contributed to decreased woodland from 1975 to 1987 and later 2001while afforestation efforts as part of environmental remediation must have contributed to the impressive increase in 2008.

CONCLUSION

The delicate balance of nature and fragile ecosystem of the Kwale region have unarguably been altered by natural and human factors over time. Thus, this study was able to model the long term land use and land cover changes between 1975 when the area was still virgin to oil exploration and exploitation activities to 2008 when oil-related activities have peaked and provide analysis of LUCC information in the area which helped in showing significant trends. Results provided by this work showed that, generally between 1975 and 2008, that bare surfaces decreased by 33,099 km² representing 93.51%, forest vegetation by 14,054 km² amounting to 30.98%, settlement by 5,654 km² which is equivalent to 25.61% and woodlands by 133,377 km² representing about 37.19%. Furthermore, scattered cultivation, shrublands 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 showed that bare surfaces, forest vegetation, settlements and woodlands were gradually being replaced by marshlands, scattered cultivation, shrublands as well as water bodies. Settlements were found to be getting more concentrated within specific geographic regions, between the periods under study. Also, as water body increases, it influences formation of more marshlands, positively. This is a clear indication of subsidence going on within the study area. Settlements were found to be concentrating within specific geographic locations. Therefore, its recommended that efforts should be made to reclaim more of the areas occupied by bare surfaces and marshlands and such areas be converted into agricultural lands. Also, further efforts should be devoted towards increasing gas flaring-reduction strategies, afforestation and cultivation while discouraging lumbering, oil spillage as well as gas flaring within the study area.

REFERENCES

Allen, J.R. (1972): Late Quarternary of the Niger Delta and Adjacent Areas. *Sedimentary Environments and Lithofacies. AAPG 49*: 547-600.

Amukali, O. & Mensah, J.K. (2000*): Effects of Developmental Projects on the Soil and Vegetation of the Niger Delta Ecosystems.* A. B.Sc. Seminar work submitted to the Department of Botany, Ambrose Alli University, Ekpoma, Edo State. (Unpublished).

Anonymous (2011): People In Country Profile-Kwale. Available at http://www.joshuaproject.net. Retrieved on 28/02/2011.

Avbovbo, A.A.& Ogbe, F.G. (1978): *Tertiary Lithostratigraphy of the Niger Delta.* A.A. PG. Bull; 62:285-300.

CIA (2008): *CIA-World Fact Book*. United Kingdom available online at http://www.cia.gov/library/publications/the-world-factbook/print/uk.litml

Delta State Ministry of Lands and Survey (2009): *Map of Ndokwa East, Delta State, Nigeria*. 23p.

Dublin-Green, C.O., Awobamise, A. & Ajao, E.A. (1997): *Large Marine Ecosystem Project for the Gulf of Guinea.:Coastal Profile of Nigeria. Nigerian Institute of Oceanography*. 36p.

Ehlers, M. M. A., Jadkowski, R. R., Howard & Brostuen, D. E., (1990). "Application of SPOT Data for Regional Growth Analysis and Local Planning". *PhotogrammetricEnginering and Remote Sensing.*

Ekine, A.S. & 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.

Energy Information Administration (2003*); Country Analysis Briefs: Nigeria.* Available at http://www.eia.docgov/emec/cabs /nigenv.html.

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.

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.

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.

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 .accessed. February 11, 2004.*

Ibe, A.C. (1988*)* Coastline Erosion in Nigeria University Press, Ibadan, Nigeria. 10-19

Keddy, P.A. 2010. *Wetland Ecology: Principles and Conservation* (2nd edition). Cambridge University Press, Cambridge, UK. 497 p

Matiko, M., .Mtalo, I. F. & 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.

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.*

Merki, P. (1972): *Structural Geology of the Cenozinc Niger Delta*. In African Geology eds.

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.

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.

Nwilo, P.C. & Badejo, O.T. (1995): Management of Oil Spill Dispersal along the Nigerian Coastal Areas. *J. Envtal Mgt. 4;*42-51.

Oboli, H.O.N. (1978): *A New Outline Geography of West Africa*. George and Harrap and Company. 78p.

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

Salami, A.T. & 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.

Treitz, P. M., P. J. Howord, & P. Gong. (1992). "Application of Satellite and GIS Technologies for Land-Cover and Land-Use Mapping at the Rural-Urban Fringe".*Photogrametric Engineering and Remote Sensing* 58(4):439-448.

Twumasi, Y.A. & 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.

Weng, Q. (2001). "*Modeling Urban Growth Effects on Surface Runoff with the Integration of Remote Sensing and GIS.*, Springer-Verlag. New York.

Woodgate, P. & Black, P. (1988) *Forest Cover Changes in Victoria*. Department of Conservation, Forests and Lands. Melbourne, Australia.

World Encyclopedia. "Marshes". Retrieved 4 February 2012.

Zhang, Z., Peterson, J., Zhu, X. & Wright, W. (2007) 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.