Tropical Ecology **57**(2): 193-203, 2016 ISSN 0564-3295

www.tropecol.com

Landuse change within Okomu and Gilli-Gilli Forest Reserves, south-western Nigeria: its climatic and societal implications

AYANSINA AYANLADE

Department of Geography, Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract: The study evaluated the climatic and societal implications of vegetation degradation in Okomu and Gilli-Gilli Forest Reserves (OGFRs) of Nigeria. Both remote sensing and non-remote sensing data and methodologies were used. Landsat data between 1984 and 2011 were used as quantitative data while social survey was carried out for qualitative data collection and assessment. Both remote sensing classification and Normalized Difference Vegetation Index (NDVI) methods were used in this study. The results show that deforestation resulting from farmland encroachment has increased in Okomu Forest Reserves (OFR) but was relatively low in Gilli-Gilli Forest Reserves (GFR). In 1984, about 17 % of the reserves were deforested, and this increased to 37 % in 2011 in OFR. These values reveal a massive deforestation. Forest disturbance within the GFR is much less than OFR possibly because high rate of illegal oil palm development in OFR. The result shows no significant impacts of vegetation degradation on local climate, but people in the communities around the reserves reported several climatic extreme events as a result of vegetation removal. However, the study could not reveal direct significant impact of vegetation degradation on local climate but there were rather indirect impacts from climate events. The results from social survey show that over 80 % of local people perceived high rate of heavy erosion and flooding mostly from year 2000 to 2011. It is obvious from the social survey that unrestrained felling of forest in the region has also rendered the soil vulnerable to erosion and flooding since forests tend to reduce the impact of erosion and floods. There is a need for proper enforcement of forest conservation laws in order to reduce the rate of deforestation, not only in OFR and OGR but also in all forest reserves in the country.

Key words: Drivers of deforestation, remote sensing, vegetation degradation.

Handling Editor: Demel Teketay

Introduction

Tropical countries have been experiencing environmental degradation over the years. Environmental change not only affects bio-physical components but also socio-economic activities (Serneels & Lambin 2001). The spatial and temporal rate at which humans utilize environmental resources for social and economic purposes, usually, determines the pattern and rate of environmental change in a region (Lambin & Ehrlich 1997). Earlier studies have reported that pressure from agricultural activities, increasing population, industrial and other social-economic activities engaged by humans have impacts on forest reserves in Africa (Lambin & Ehrlich 1997; Lambin *et al.* 2003; Shi *et al.* 2002). For example, a study by Sarker *et al.* (2014) monitored and mapped environmental correlation of vegetation distribution in tropical Juri forest, Bangladesh. The study noted that both human activities and biophysical variation were identified as the most influential soil variables responsible for vegetation variation. Out of 966 registered forest reserves in

Corresponding Author; e-mail: aayanlade@oauife.edu.ng

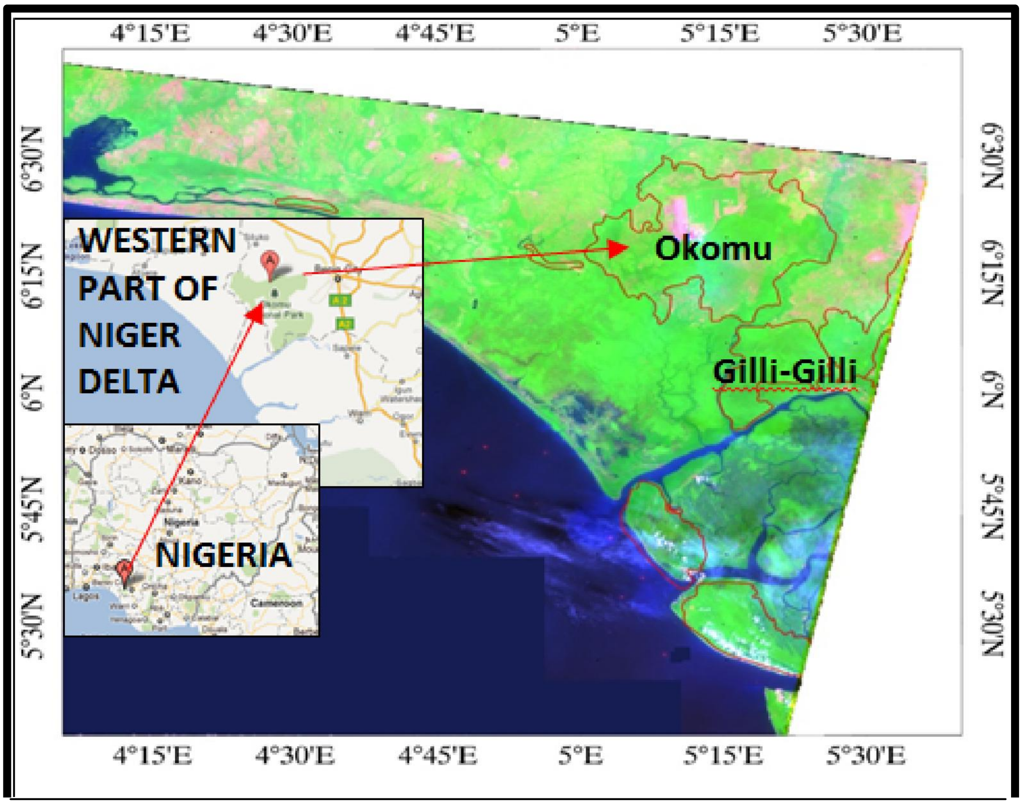

Fig. 1. Map of the study area: the western part of the Niger Delta of Nigeria, showing location of Okomu and Gilli-Gilli Forest Reserves (Source: Landsat image bands combinations analysis for this study).

Nigeria, over 70 are found in the Niger Delta Region (Ite 2005; Oates 1995; Phil-Eze 2001). The majority of these reserves have been affected by anthropological activities. Protected Areas in the Niger Delta can be classified into four major categories: forest reserves, limited-access strict nature reserves, national parks and game reserves and traditional-use conservation areas. The majority of these forest reserves are under the control of Forest Department of Federal Ministry of Environment, Nigeria. Other protected areas in the Niger Delta can be found in the Traditional-use conservation areas, which are the sacred groves protected by communities. However, these areas are not very large and usually used for pastoral, traditional religious sacred and cultural purposes. These are forms of community protection areas, and some of which are inhabited by certain species of wildlife (NDRDMP 2006).

Most of the forest resources of the Niger Delta are declining either because of being converted to farmland or destroyed by logging activities or oil exploration. Firewood collection by local people and clearing of the forest for agricultural purposes are other severe environmental problems. People in the region depend on forest for firewood, which is the main source of fuel for domestic cooking. Aside from these, most of the communities in the region are agrarian societies who apply bush burning method to clear their farm during the dry season for easy planting in wet season (Ite 2005). Also, communal logging for purposes of shelter is a common practice in the communities of Niger Delta. Commercial logging, firewood collection and bush burning have begun to have a severe impact on the forest within the region as tree canopies and shrubs are also damaged in the process (Ite 2005). Consequently, one important feature observed in the region is the almost complete absence of primary forests (Uyigue & Agho 2007). Illegal logging of forest trees is not only peculiar to Nigeria; a study by Gandiwa *et al.* (2014) has noted the same scenario in southeastern Zimbabwe. Though the study recommended that conservation awareness and education in adjacent communal areas around the forest reserves in southeastern Zimbabwe would help to reduce illegal removal of forest resources and conservation. The fact remains that these environmental problems are often difficult to anticipate without effective scientific investigation (Geist & Lambin 2001; Lambin *et al.* 2001). It is pertinent, therefore, to comprehend suitable methods and techniques to assess and monitor these changes. Hence, understanding of environmental change would provide better knowledge of environmental management in the Delta. The objective of this study was, therefore, to model spatial and temporal change within OGFRs using remote sensing and geographical information system (GIS) techniques. The study also evaluated the agro-climatic and societal implication of this change on the people living around OGFRs.

Materials and methods

Study areas

The study was carried out in Okomu and Gilli-Gilli Forest Reserves (OGFRs) (Fig. 1), which are located in Ovia South-West Local Government Area of Edo State, Nigeria. They occur between 6°00′ and 6°30′ North and 5⁰01′ and 5°30′ East. OGFRs are homes of much threatened wildlife, including White-throated monkey, Forest elephant and African buffalo (USAID/Nigeria 2008). Akinsorotan *et al.* (2011) also noted that OGFRs house three species of antelope: Maxwell duiker (*Cephalophus maxwelli*), Yellow-backed duiker (*Cephalophus silvicultor*) and Red-flanked duiker (*Cephalophus rufilatus*), four primate species; Red-capped mangabey (*Cercocebustor quatus*), Mona monkey (*Cercopithecus mona*), White-throated monkey (*C. erythrogasterpocoki*), and Putty-nosed monkey (*C. nictitansludio*) and a species of mangoose (*Herpestes* sp.).

Methods

Remote sensing, GIS and social survey methodologies were employed in the study. The Landsat imageries from 1984 to 2011 were acquired from the archive of US Geological Survey. The social field survey was carried out in January 2012. The Landsat imageries have spatial resolution of 32 m and a swath width of 183 km. Over 40 scenes of Landsat images were available for the study area, out of which only 13 scenes have cloud cover that is less than 10 %. As a result, six date images (between 1984 and 2011) with cloud cover less than 2 % were selected for multi-temporal image analyses. The following image enhancement techniques were used in the transformation of the satellite data: False Colour Composite (FCC) and Principal Component Analysis (PCA). Several combinations of false colour bands were tested on the images collected for this zone. Colour composites generated using the combination of bands 7, 4 and 3 for red, green and blue, respectively, were the most effective for these analyses.

Landsat Image pre-processing, which includes image calibration, geometrical correction and atmospheric correction were performed. The research activities included assessing spatio temporal change in landuse within the forest reserve using classification, post-classification and GIS overlaying methods and examining vegetation degradation using Normalized Difference Vegetation Index (NDVI). Maximum likelihood classification techniques were used in this study since maximum likelihood classifier evaluates quantitatively both the variance and covariance of the category spectral response patterns when performing classification. Major advantage of maximum likelihood method over other classification methods is that it takes into account the variance and covariance within the class distribution, and its accuracy performs better than other methods.

Computation of NDVI was carried out from reflectance in the red and near infrared (NIR) bands of the image. Thus, a simple combination of red and NIR waveband data were used to produce an index that corresponds to the presence of vegetation in the study area. This technique actually minimises background noise of Landsat images.

To facilitate post-classification comparisons, the first task was to calculate the percentage change for each year (inter-annual change), and these was determined using the following equation:

$$Int_{LUC} = \frac{[logC_{t1} - logC_{t0}]}{t_1 - t_0} \times 100$$

where, Int_{LUC} is intra-annual landuse change, t_1 is final year, and t_0 is initial year and C is the landuse class percentage .

Satellite-derived climatic data, i.e. monthly rainfall and temperature, were used in the study. The data were extracted from Climate Prediction Center Morphing Technique (CMORPH). The daily precipitation data were estimated and aggregated to monthly totals on a 0.25 x 0.25 degree latitude/longitude grid. Generally, CMORPH produces global precipitation analyses at high spatial and temporal resolution. This technique exclusively uses precipitation estimates of 0.25 x 0.25 degree that have been derived from low orbiter satellite microwave observations (Joyce *et al.* 2004). The study used mixed methods approach to

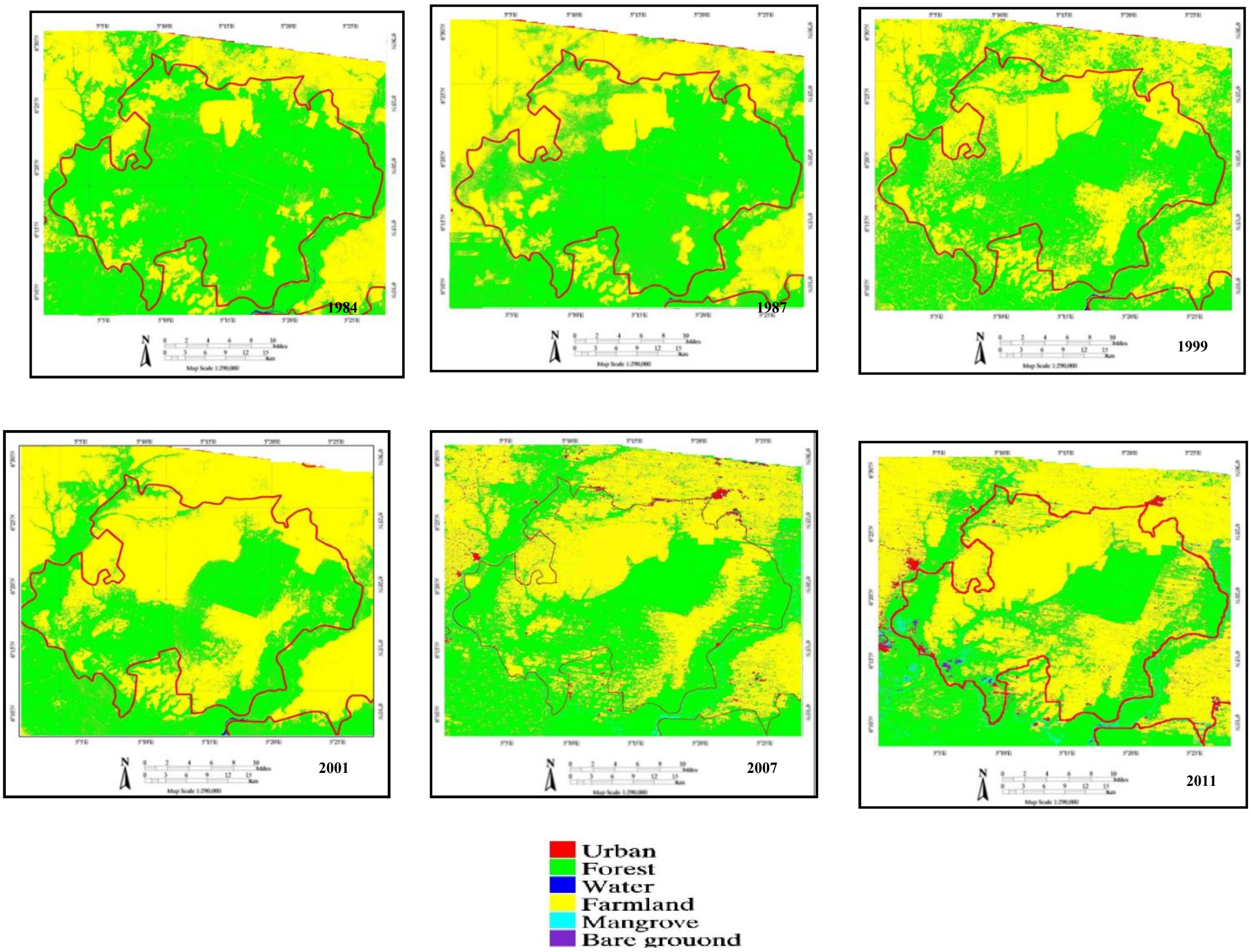

Fig. 2. Changes in Okomu and Gilli-Gilli Forest Reserves.

obtain social data relating to impacts of forest change in the forest reserves as observed from remote sensing analyses.

Questionnaires survey and focused group discussion (FGD) methods were used. One hundred questionnaires were administered in the villages around the forest reserves using systematic sampling techniques while focused group discussion was carried out in the evening with 6 to 15 participants. The FGD was aimed at obtaining in-depth information about the social and climatic implications of deforestation on the communities.

Also, ground truthing and accuracy assessment of change maps were carried out to assess reliability of the remote sensing results. The mixed methods approach was carefully selected and used in this study based on the objectives and in order to answer the research questions. The study used mixed methods approach because it is effective not only for the purpose of triangulation but also because the strength of one method complements the weakness of the other (Clark & Creswell 2008).

The main research questions for the social survey were: What are the local-climatic implications of vegetation degradation in OGFRs? Are the people living around OGFRs aware of the potential impacts of change in the environment? What are the perspectives of the people about the effects of the changes?

Results and discussion

The results of classification analysis show that rate of deforestation has increased both spatially and temporally within OGFR over the past decades (Figs. 2 & 3). The general trend in NDVI and percentage of change in forest, subsistence agriculture and oil palm plantation in the reserve are shown in Figs. 4 - 6 while Tables 1 & 2 show percentage changes in plantation farmland

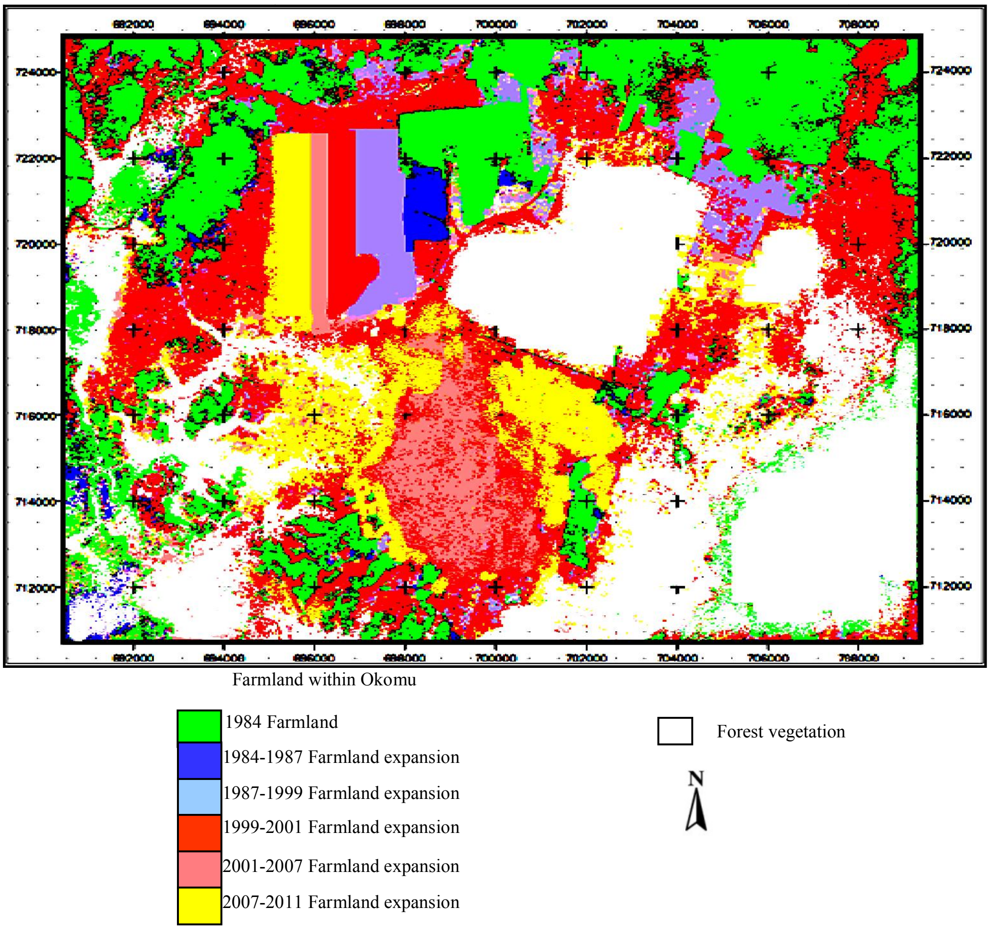

Fig. 3. Rate of farmland in Okomu and Gilli-Gilli Forest Reserves.

Table 1. The rate of change in plantation land within Okumu and Gilli-Gilli Forest Reserves between 1999 and 2011.

	1984 Km²	1987 Km²	1999 Km²	2001 Km²	2007 Km²	2011 Km²
Urban	34.8	35.5	35.6	38.3	38.4	38.8
Forest	1117.8	1019.3	937.0	799.6	689.5	602.7
Subsistence farmland	162.2	232.9	171.6	294.6	348.4	364.6
Plantation farmland	34.3	51.6	123.1	134.8	150.1	160.3

within OGFRs from 1984 to 2011. It is apparent that deforestation resulting from farmland encroachment has been increasing in OGFRs. Initially, both subsistence and plantation farmland were classified together (Fig. 7). But, it was considered important to differentiate the impacts of oil palm plantation from subsistent farming as the image interpretation suggested that plantation expansion was an important deforestation mechanism. Thus, for the forest reserves these two types of farmland were classified separately.

By separating these two major landuses within OGFRs, the results show that plantation farmland has expanded greatly within OGFRs between 1984 and 2011 (Fig. 3). In 1984, the oil palm plantation covered about 3.1 % of the OGFRs but the area cover expanded to about 14.3 % in 2011 (Table 2 & Fig. 6). In total, farmland increased by approximately 35 % of the entire surface area of OGFRs (Figs. 5 & 6). Furthermore, inter-annual rate of deforestation in the reserve varied. In 1980s, deforestation resulting from subsistence and plantation land uses was 1.7 and 1.4 %, respectively (Table 3). 1990s experienced the highest annual

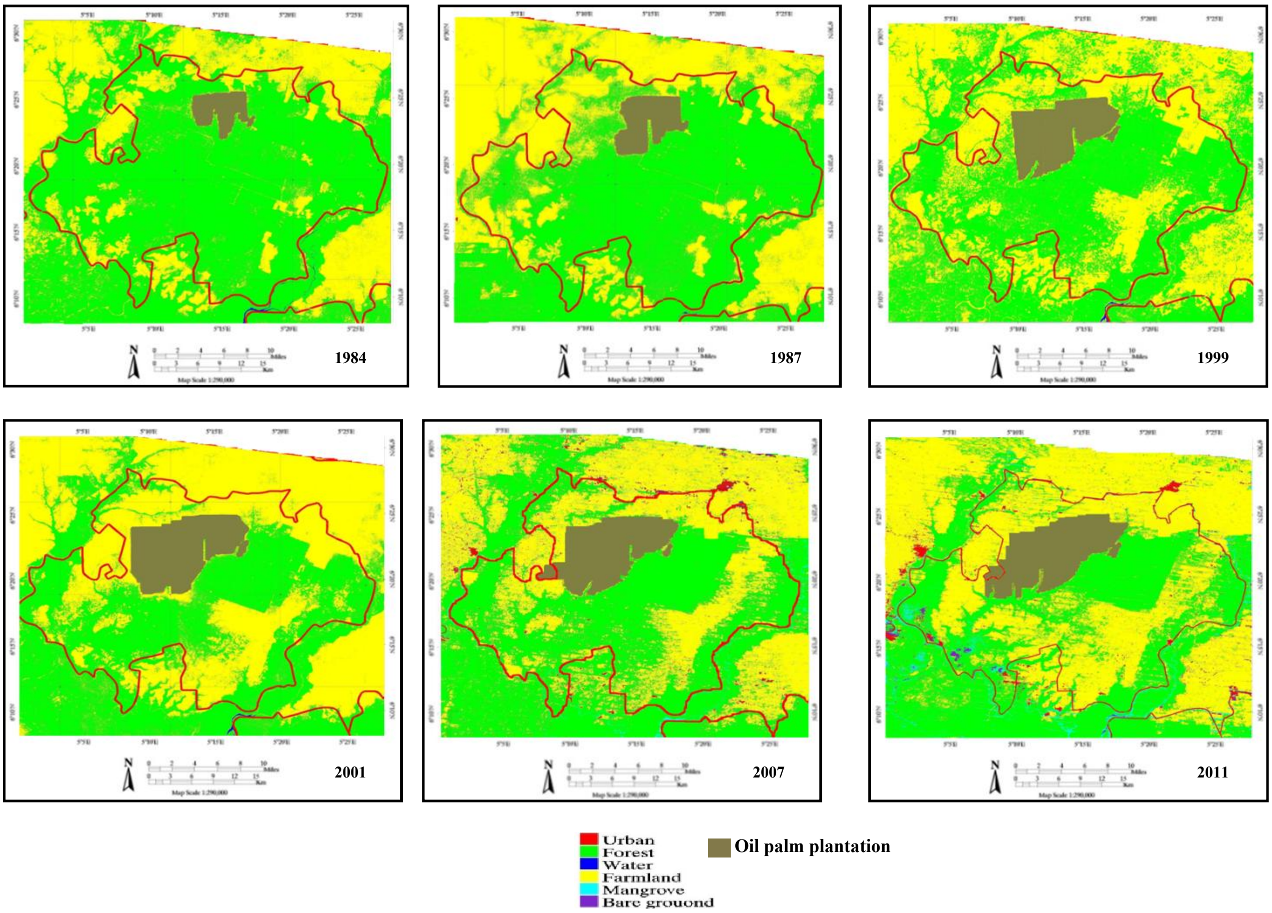

Fig. 4. Landuse in Okomu and Gilli-Gilli Forest Reserves.

rate of deforestation, i.e. 2.1 % for subsistence and 2.4 % for plantation landuse (Table 3). The rate declined slightly in 2000s to 1.6 % for subsistence and 2.3 % for plantation landuse. High annual rate of deforestation noted in 1990s accounted for the increased annual rate of change in forest OGFRs. In all, annual rate of expansion of plantations was very high from 1990s to 2000s. These values imply that the expansion of plantations was the major cause of deforestation within OGFRs (Tables 2 & 3).

The NDVI results show a severe reduction in the mean values of NDVI over the study periods (Figs. 6 & 7). These values imply that the remaining forest vegetation that was not affected by oil plantations is increasingly being degraded in the reserves perhaps due to logging and fuel wood collection and subsistence farming under the forest canopy. It is interesting to look at the major location of change within OGFRs. Forest degradation is very high in the northern part of the forest reserve, largely due to oil palm plantation expansion. But, there are major changes also in southeastern part of the reserve, which was caused by subsistence farming (Fig. 7).

Table 2. Percentage change in plantation land within Okumu and Gilli-Gilli Forest Reserves between 1999 and 2011.

Year	Percent increase in area cover
1984	3.1
1987	4.6
1999	10.9
2001	11.9
2007	13.4
2011	14.26

Implications of vegetation degradation on local climate and people.

From the results, it appears that there are no direct impacts of vegetation degradation on the

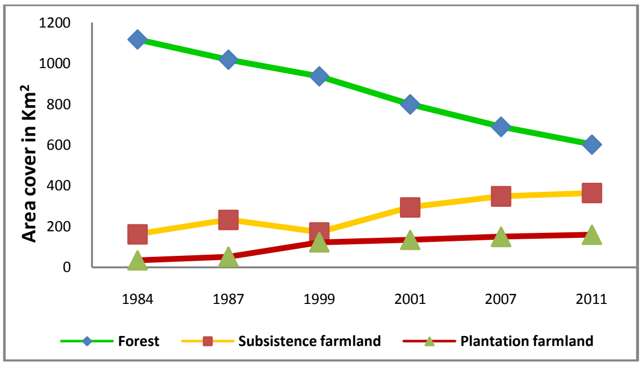

Fig. 5. Changes in forest, subsistence and plantation farmland around Okomu and Gilli-Gilli Forest Reserves.

Table 3. Annual rate of change in Okomu (%).

Change (%)	1980s	1990s	2000s
Forest	0.9	1.3	1.2
Subsistence farmland	1.7	2.1	1.6
Plantation farmland	1.4	2.4	2.3

Table 4. Flooding incidence as perceived by local people living around Okomu and Gilli-Gilli.

	High (%)	Low (%)	No sure (%)
1980s	10	84	6
1990s	20	78	2
Early 2000s (2000-2005)	82	9	3
Late 2000s (2006-2011)	87	8	5

local climate in OGFRs. Rather, there appears to be indirect implications of vegetation change resulting into extreme climate events, such as severe erosion and flooding. The local rainfall and the temperature values are not influenced by the change in forest reserves (Figs. 8 & 9). Temperature is relatively constant throughout the year over the entire region with the average annual temperature of about 27 °C. The results of this study show no notable change in the local temperature during the study period, but little variability in its intensity obvious (Fig. 9). The main reason for this is because temperature is uniformly high in tropics with little seasonal variation. Also, the rainy period is typically from June to September with average monthly rainfall of over 250 mm and a little dry spell in August. Even during this little dry spell, not less than 150 mm of rainfall is recorded in the region while the least amount of rainfall occurs in December and January (Figs. 8 & 9).

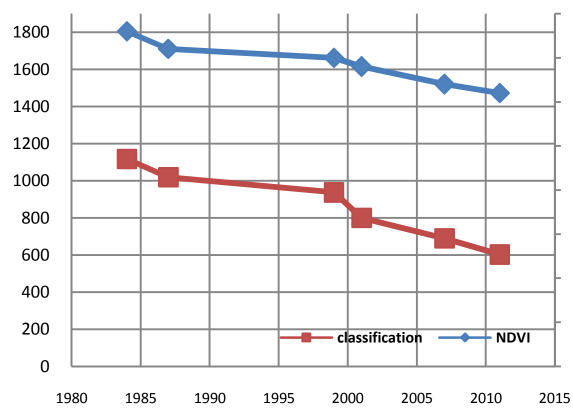

Fig. 6. Changes in mean NDVI (in blue) and change in classification (Km²) (in red) for Okomu and Gilli-Gilli Forest Reserves.

In consequential impacts of vegetation degradation on the local climate of the region might be because the region experiences a tropical climate with an alternating wet and dry season. Generally, the location of OGFRs is influenced by the general circulation patterns of air in the equatorial tropics associated with the relative position of the Inter-tropical Convergent Zone (ITCZ) (CEDA 1997). It is governed by two air masses: the South-Westerly monsoon wind and the North-Easterly trade wind. The southwesterly wind originates from Atlantic Ocean and is associated with the rainy season. The north-easterly wind prevails during the dry season and originates from the Sahara Desert. Ayoade (1988) has extensively described the characteristic features of the ITCZ and the associated weather condition in Nigeria. Traditionally, the monsoon has been thought to be the result of variability in ITCZ and seasonal differences in temperature and humidity between the Sahara and the Equatorial Atlantic Ocean. The ITCZ moves northward from the Atlantic (in March) towards the western part of Africa and migrates backward to the south by October (Okonny 1988).

Though there have been no significant direct impacts of deforestation on local climate around OGFRs, the result from the social survey show that a little heavy rainfall causes much damage, leading to severe erosion and flooding. The results

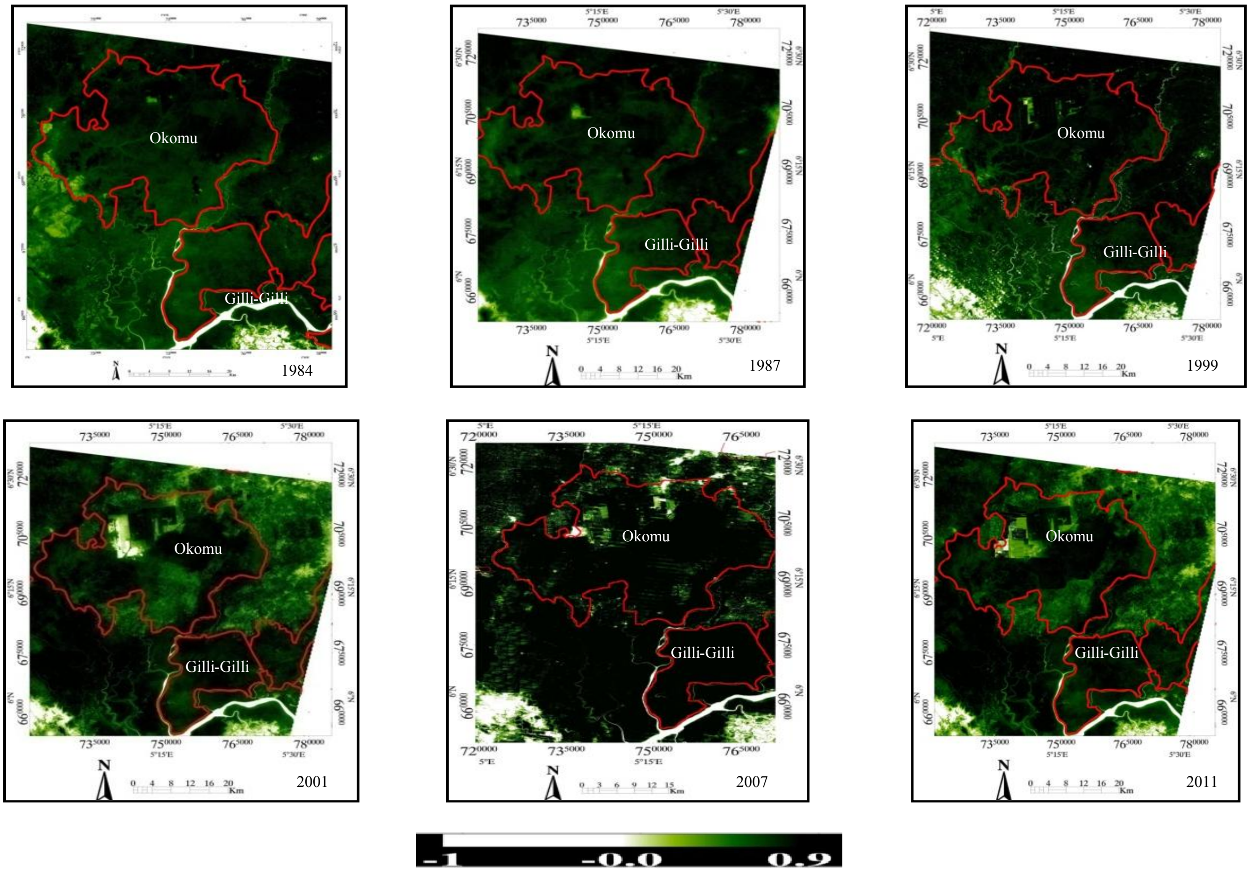

Fig. 7. NDVI maps of Okomu and Gilli-Gilli over the period between 1984 and 2011.

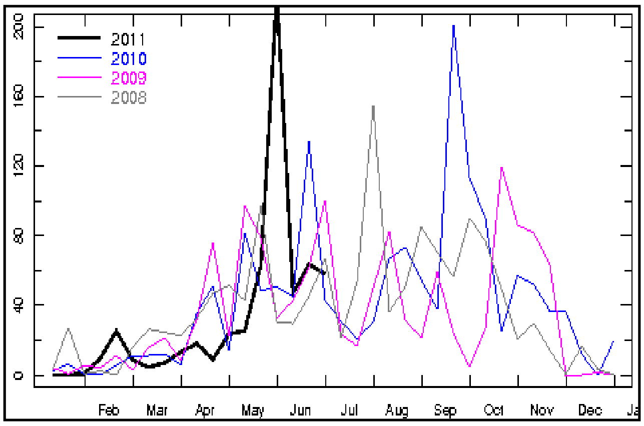

Fig. 8. Recent variation in monthly precipitation in Okomu-Gilli-Gilli Forest Reserves.

from social survey show that over 80 % of local people perceived high rate of heavy erosion and flooding from year 2000 to 2011 (Table 4). The majority of people around OGFRs perceived that severe flood events were noted during the years 2003, 2008, 2010 and 2011. It is obvious as well from climatic analysis that these years were periods of high rainfall (Table 4 & Fig. 9). The implication from the social results and climate data analysis is that just a little rainfall above normal led to severe flood events (Fig. 4) in the settlements around OGFRs. The blue colour in Fig. 4 represents the location of flood event in 2011. What is obvious from this result is that unrestrained felling of forest in the reserves has rendered the environment very vulnerable to erosion and flooding. Since considerable parts of the vegetation in the reserves have been removed over the study period, a little increase of rainfall above normal made the region susceptible to flooding in low topography, coupled with poor drainage. The local people perceived that the impacts of flooding have assumed increasingly significant proportions in recent years (Table 4). Accurate statistics about this dilemma are not actually available. The majority of people in focus group discussion stated that “a typical example is the unprecedented flooding, which submerged houses, displaced some residents in many villages and paralyzed agricultural activities in 2011”.

When the results from Okumu Forest Reserve

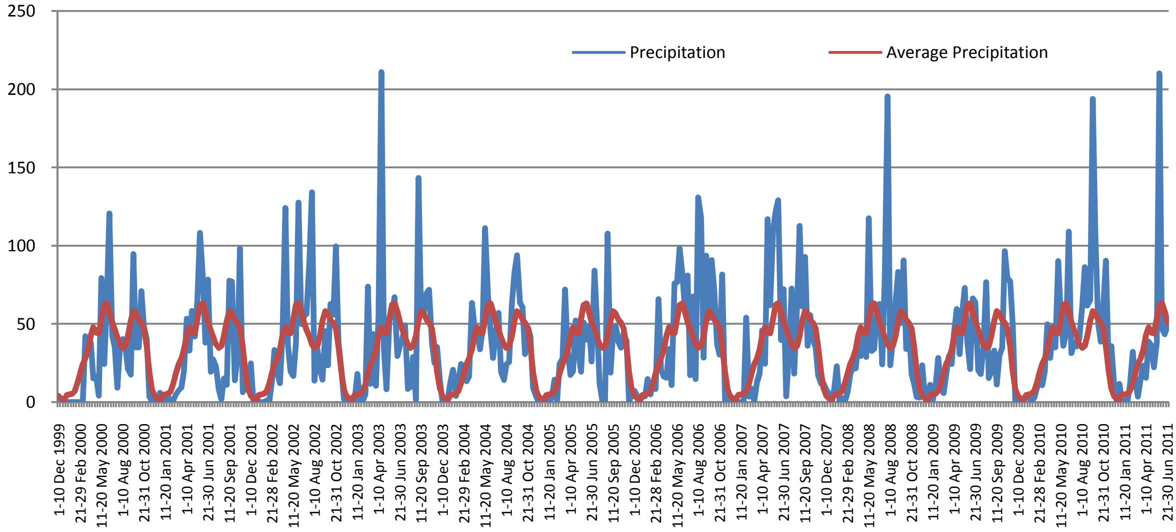

Fig. 9. Variation in daily precipitation in Okomu-Gilli-Gilli Forest Reserves, 1999-2011.

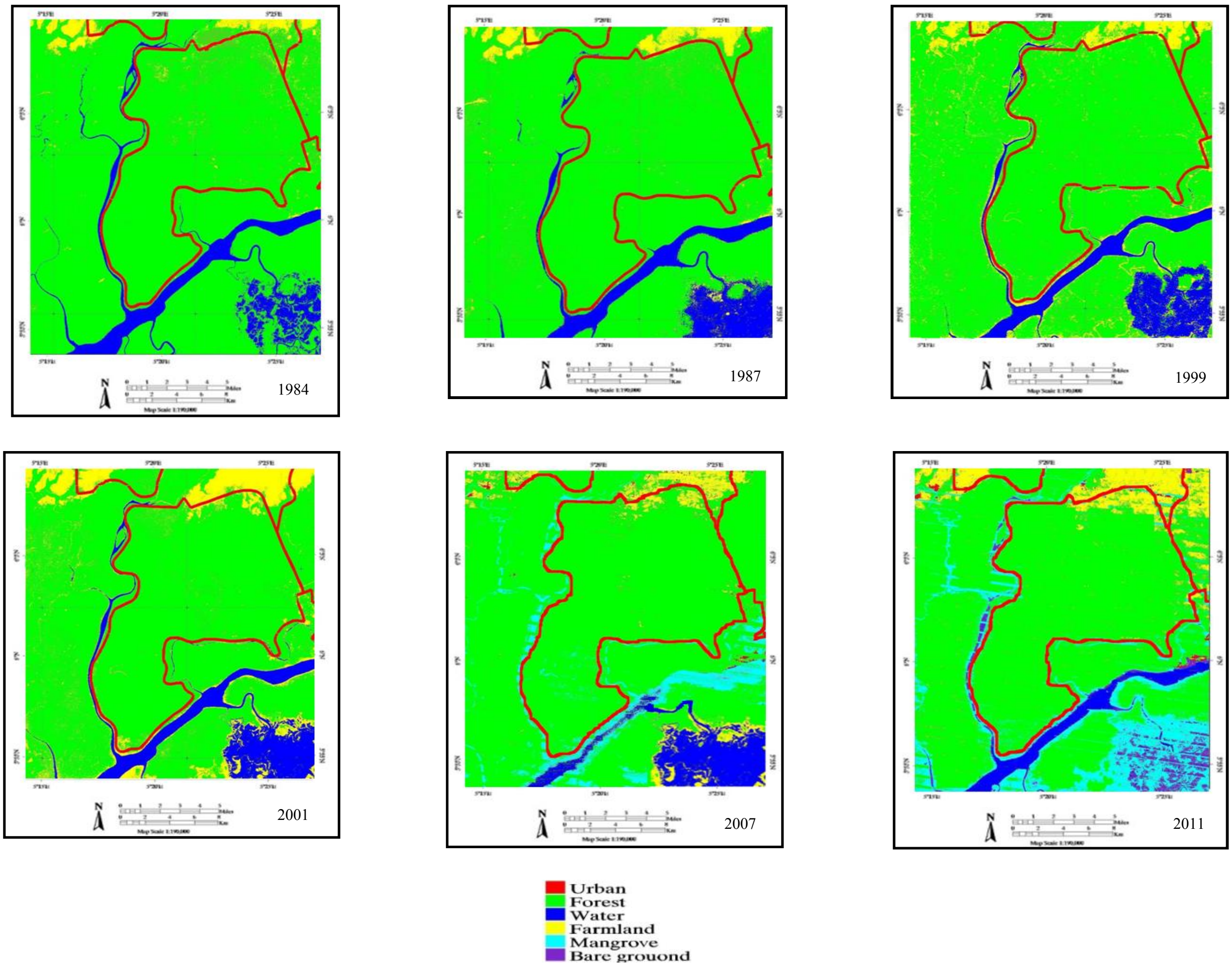

Fig. 10. Changes in forest and farmland around Gilli-Gilli Forest Reserve.

(OFR) are compared with that of Gilli-Gilli Forest Reserve (GFR) (Figs. 4 & 10), a large difference is observed. Forest disturbance within the GFR is much less than OFR, consisting of a little forest degradation on the northern side of GFR (Figs. 2 & 10). Variation in the rate of deforestation between the two forest reserves can be attributed to the fact that several parts of OFR have been removed due to introduction of *Taungya system* of farming and to accommodate landuse demand from increasing population. Low rate of degradation in GFR might be due to the fact that a few settlements are located around it and up until the period of our study, *Taungya system* has not been introduced in the area. Deforestation appears to be predominant in the northern part of the zone, gradually spreading towards southeast over time. OFR has been largely consumed by this wave of expansion and GFR appears to be experiencing the first effects along its northern margin.

The results show that deforestation within OFR is not only due to the fact that agriculture is the major occupation of the increasing population around the reserve but also is a result of unlawful expansion of palm oil plantations. Also, the majority of earlier studies concluded that rural people in the Niger Delta cut down trees for domestic purposes and selling forest products as means of income (Ite 2001, 2005). However, this is not the only cause of forest degradation in the region. It is also evident from the present study that the major cause of deforestation in OFR is illegal oil palm development.

Conclusions

The results revealed the possible impact of vegetation degradation on local climate of OGFRs. No significant impacts of vegetation degradation was observed on local climate, but people in the communities around the reserves reported several climatic extreme events as a result of vegetation removal. Though implications of vegetation degradation on local climate are not obvious presently, it is needless to say that the future cumulative effect of this change on the region may not be ignored. The results show that unlawful expansion of oil plantation in the reserve is a big contributor to deforestation. Earlier studies have shown that a conservation project that started in OFR in 1987 by Nigerian Government was not effective (Coastal News 2010; Oates 1995; Ogbeibu 2001). For example, Coastal News (11 July 2010) reported that Oil Palm company has over 4,500 hectares of plantation within OFR and other forests scattered around. Besides, there are about 3,000 hectares of other farmland owned by private people in the local government. It is obvious from these results that several areas of land within OFR have been used for farming purposes by the local government. Also, Edo State Government has alleged that the Oil Plantation Company is operating an illegal sawmill within OFR removing about 734 logs of various species of trees over the years (Adekunbi 2011). These are contrary to Section 41 of the Bendel (Now Edo) State Law of 1976. This deforestation caused by palm oil plantations appears to be happening in conjunction with rapid agricultural expansion. Oates (1995) also noted that the OFR conservation project of the 1770s focused initially on protection, but the emphasis later shifted to a programme of agricultural development assistance to migrant farmers in the reserve. This approach appears to hasten rather than prevent deforestation in Okomu.

Based on the findings above the following recommendations are suggested. There is a need to improve conservation policies not only in the OGFRs but also in other forest reserves in the country. This conservation system should involve restoration activities. Such activities according to Srinivasan *et al.* (2015) should factor in environmental preferences. This will aid in eradicating further deforestation and loss of biodiversity in the region. What is obvious from this study is that illegal logging, clearing of forest for plantation agriculture, such as OGFSs have led to depletion of natural vegetation and biodiversity loss. Therefore, effective enforcement of environmental and conservation laws to reduce rate of deforestation in the OGFSs should be a priority.

Acknowledgements

The author would like to thank the United States Geological Survey for providing access to Landsat data used in this study and the Department of Geography King's College, University of London, UK for founding part of the field work.

References

Adekunbi, E. 2011. The rot in okomu oil. *The Tell Magazine,* Monday, 23 May 2011.

Akinsorotan, O. A., B. G. Ogunjemite & T. Afolayan. 2011. Assessment of the large mammals of Arakhuan range, Okomu National Park, Nigeria.

Ethiopian Journal of Environmental Studies and Management **4**: 25-37.

Ayoade, J. O. 1988. *Introduction to Climatology for the Tropics*. Abiprint and Pak Limited, Ibadan.

Center for Environmental and Development in Africa (CEDA). 1997. *Coastal Profile of Nigeria.* Federal Environmental Protection Agency, Large Marine Ecosystem, Project for the Gulf of Guinean. CEDA, Nigeria.

Clark, V. L. P. & J. W. Creswell. 2008. *The Mixed Methods Reader*. Sage Publications, USA.

Coastal News. 2010. *Irele Local Government*. Ondo state Nigeria. Sunday, 11 July 2010 (09:48).

Gandiwa, E., P. Zisadza-Gandiwa, L. Mango & J. Jakarasi. 2014. Law enforcement staff perceptions of illegal hunting and wild life conservation in Gonarezhou National Park, southeastern Zimbabwe. *Tropical Ecology* **55**: 119-127.

Geist, H. J. & E. F. Lambin. 2001. What drives tropical deforestation? A meta-analysis of proximate and underlying causes of deforestation based on sub national case study evidence. *LUCC Report Series.* No. 4.University of Louvain, Louvain, Belgium.

Ite, U. E. 2001. *Global Thinking and Local Action, Agriculture, Tropical Forest Loss and Conservation in Southeast Nigeria*. Ashgate Publishing, England.

Ite, U. E. 2005. Tree integration in homestead farms in southeast Nigeria: propositions and evidence. *The Geographical Journal* **171**: 209-222.

Joyce, R. J., J. E. Janowiak, P. A. Arkin & P. Xie. 2004. CMORPH: A method that produces global precipitation estimates from passive microwave and infrared data at high spatial and temporal resolution. *Journal Hydrometeorology* **5:** 487-503.

Lambin, E. F. & D. Ehrlich. 1997. Land-cover changes in sub-Saharan Africa (1982-1991): Application of a change index based on remotely-sensed surface temperature and vegetation indices at a continental scale. *Remote Sensing of Environment* **61**: 181-200.

Lambin, E. F., H. Geist & E. Lepers. 2003. Dynamics of land use and cover change in tropical regions. *Annual Review of Environment and Resources* **28**: 205-241.

Lambin, E. F., B. L. Turner, H. Geist, S. Agbola, A. Angelsen, J. W. Bruce, O. Coomes, R. Dirzo, G. Fischer, C. Folke, P. S. George, K. Homewood, J. Imbernon, R. Leemans, X. Li., E. F. Moran, M. Mortimore, P. S. Ramakrishnan, J. F. Richards, H. Skånes, W. Steffen, G. D. Stone, U. Svedin, T. Veldkamp, C. Vogel & J. Xu. 2001. The causes of landuse and- cover change: Moving beyond the Myths. *Global Environmental Change* **11**: 261-269.

Niger Delta Regional Development Master-Plan (NDRDMP). 2006. *Niger Delta Regional Master Plan.* Facilitated by the Niger Delta Development Commission (NDDC) in partnership with the nine states' governments, LGAs, Oil Companies, Civil Society Organizations and Communities in the Niger Delta, Nigeria.

Oates, J. F. 1995. The degers of conversation by rural development- a case study from forest of Nigeria. *Oryx* **29**:115-122.

Ogbeibu, A. E. 2001. Distribution, density and diversity of dipterans in a temporary pond in Okomu Forest Reservoir, Southern Nigeria. *Journal of Aquatic Science* **16**: 43-52.

Okonny, I. P. 1988. The historical geology of the Niger Delta. pp. 21-58. *In:* E. J. Alagoa, F. N. Anozie & N. Nzewunwa (eds.) *The Early History of the Niger Delta.* Hamburg, BuskeVerlag **88**.

Phil-Eze, P. O. 2001. Biodiversity and environmental problems in Nigeria. pp. 33-52. *In*: G. E. K. Ofomata & P. O. Phil-Eze (eds.) *Geographical Perspectives on Environmental Problems and Management in Nigeria.* Jamoe Enterprises, Enugu, Nigeria.

Sarker, S. K., S. Rashid, M. Sharmin, M. M. Haque, S. S. Sonet & M. Nur-Un-Nabi. 2014. Environmental correlates of vegetation distribution in tropical Juri forest, Bangladesh. *Tropical Ecology* **55**: 177-193.

Serneels, S. & E. F. Lambin. 2001. Proximate causes of land-use changes in Narok District, Kenya. *Agriculture, Ecosystems and Environment* **85**: 65-82.

Shi, Z., R. C. Wang, M. X. Huang & D. Landgraf. 2002. Detection of coastal saline land uses with multi-temporal Landsat images in Shangyu City, China. *Environmental Management* **30**: 142-150.

Srinivasan, M. P., S. Bhatia & K. Shenoy. 2015. Vegetation-environment relationships in a South Asian tropical montane grassland ecosystem: restoration implications. *Tropical Ecology* **56**: 201-217.

United States Agency for International Development (USAID/Nigeria). 2008. Nigeria biodiversity and tropical forestry assessment. Contract No. 620-C-00-05-00077-00 June 2005, Nigeria.

Uyigue, A. & M. Agho. 2007. *Coping with Climate Change and Environmental Degradation in the Niger Delta of Southern Nigeria.* Community Research and Development Centre (CREDC), Nigeria.

(Received on 15.05.2013 and accepted after revisions, on 16.06.2014)