BILINGUAL PUBLISHING CO.
Pioneer of Global Academics Since 1984

Journal of Geographical Research

https://ojs.bilpublishing.com/index.php/jgr

ARTICLE

Land Conversions and Forest Dynamics in a Riparian Forest Zone in South East Nigeria

Nwabueze I. Igu[1*] Joseph O. Duluora[2] Uzoamaka R. Onyeizugbe[2]

1. Department of Geography and Meteorology, Nnamdi Azikiwe University, Awka
2. Department of Environmental Management, Nnamdi Azikiwe University, Awka

ARTICLE INFO

Article history
Received: 26 November 2019
Accepted: 20 December 2019
Published Online: 30 April 2020

Keywords:
Climate change
Biodiversity conservation
Ecosystem services
Livelihoods
Sustainable forest use
Tropical ecosystems

ABSTRACT

The rate at which forest ecosystems are lost and modified across tropical landscapes are alarming, yet proper documentation and proactive measures to curtail this still remains a huge challenge in most areas. This research focused on elucidating the ongoing land use change patterns of a riparian forest landscape, its current impacts on the ecosystem and land surface temperature, as well as its likely future scenarios for the zone. LANDSAT images were downloaded for 1988, 2003 and 2018 and used to show the dynamics for the zone, its drivers and their varying temperatures. Maximum Likelihood Classification algorithm was used for the classification and the land-use classes were categorized as: Water body, Farms and Sparse Vegetation, Built-up Areas, Bare Surface, and Thick Vegetation. Furthermore, Markov Chain Analysis was employed for understanding the future patterns of land use change in the zone. Land use categories experienced changes over the three epochs, but among all, farmlands/ sparse vegetation and thick vegetation had the most significant changes from 7.70 to 58.67 percent and 73.56 to 20.58 percent, respectively; implying that much of the forestland use/cover (which constituted the bulk of the land initially; 73.56 percent) were converted to agricultural land use. This same trend at which agriculture grew in the zone was seen to affect the land surface temperature for zone (Pearson correlation coefficient of 0.99 with $p = 0.0058$ at 0.05 level of significance). Future projection for the zone equally showed that agricultural land use will likely dominate the entire landscape in the coming years and a consequent impact on the climate and ecosystem expected as well. On that note, intensive agricultural practices that seek to maximize allocated farm units were advocated. Such initiatives will help to ensure that agricultural growth is contained within delimited zones so that haphazard cultivations, reductions in ecological value of the forest landscape and consequent climatic impacts could be managed across the region.

1. Introduction

Much of the terrestrial ecosystem and their biodiversity have been altered across the globe. Land use change and intensification are to a large extent responsible for these changes globally [4] and for each spatial scale where they occur, consequent impacts abound. Such changes threaten forest biodiversity, responsible for the modification of spatial patterns

**Corresponding Author:*
Nwabueze, I. Igu,
Department of Geography and Meteorology, Nnamdi Azikiwe University, Awka;
Email: nwabuezeigu@gmail.com, nik.igu@unizik.edu.ng

 DOI: https://doi.org/10.30564/jgr.v2i4.1449

in forest landscapes and ultimately lead to biodiversity loss across spatial scales [11,12]. Though these changes affect ecosystems globally, they are quite significant across tropical landscapes. This is a major source of concern especially because tropical landscapes are incidentally where much of the terrestrial biodiversity are found [15] and so calls for concerted attention. Since such changes pose threats to the bulk of terrestrial biodiversity (which are found in tropical ecosystems) [7] and affect ecosystem services, functions and livelihoods that depend on them [8], it is imperative and needful that such concerns are addressed.

Disruptions going on in tropical ecosystem are thought to constitute a greater peril for global biodiversity than any other contemporary phenomenon [3,10,18] and have become a major concern because the bulk of ecosystem services especially carbon storage and climate regulation are dependent on it [9]. The pattern this is seen to occur vary across the tropics but on the whole, agriculture appears more prominent though with variations in what is being grown [1,14,19]. Such trends in modifications have grave concerns and consequences for tropical landscapes and endanger much of its biodiversity which are continually fragmented in a bid to pave way for a vast array of anthropogenic activities. Such patterns of change affect the African landscape in diverse ways and its attendant impacts are thought to vary according to the activities and the stochastic factors that define the varied ecosystems.

Land use change is growing in magnitude across Nigeria as in other tropical zones and as the population index continues to accelerate, so will the attendant environmental degradation associated with pressure on the ecosystems escalate as well. With agricultural land use occupying a major part of the global land surface area [2], Nigeria and south eastern part in particular are seen to follow similar trend, though at different proportions. Modifications and dynamics surrounding land use change in south eastern Nigeria are not known to receive attention in the interior or sub-urban zones and its riparian corridors possibly because the high population density and the attendant indices for which the zone are known of are not concentrated there. With this, the rate at which forests in the zone are converted to other land uses such as agriculture is not really accounted for and so no visible conservation strategy is carried out across the zone. In a bid to understand the magnitude of this ongoing process across the region, this study was focused on a local government area where agricultural activities have grown in recent time in relation to other land use change drivers. This study is aimed at assessing the drivers of land use change in the region; especially agricultural land use change in relation to other drivers within the region. It equally elucidates the land absorption and conversion rate, effects on land surface temperature and likely pattern of change expected in the future.

2. Materials and Methods

2.1 Study Area

The study region (Figure 1) is located within the humid tropics where mean annual rainfall varies between 1500mm to 22500mm. Temperature condition of the area is high with mean annual temperature range of 27^0 C to 28^0 C and a peak of about 35^0C between February and April [13]. It is characterized by a thick sequence of shale and sandstones formed in the Paleocene age. Soils that typify the zone are lithosol, juvenile soil, ferralitic soils and hydromorphic soils that formed under the dominant influence of the prevailing factors of geological formations of the study area [16]. It is known for its fertile soils which are seen as the underlying factor for much of the agricultural activities that dominate the zone. Crops such as yam, rice, maize and legumes are produced in large quantities in the region. Rice production have dominated the zone for a long time and with the establishment of the Anambra-Imo River basin authority, it has received much impetus and greater output.

Anyamelum is a land abundant zone and other activities aside agriculture such as trading and agro-allied industries have equally grown in magnitude across the zone.

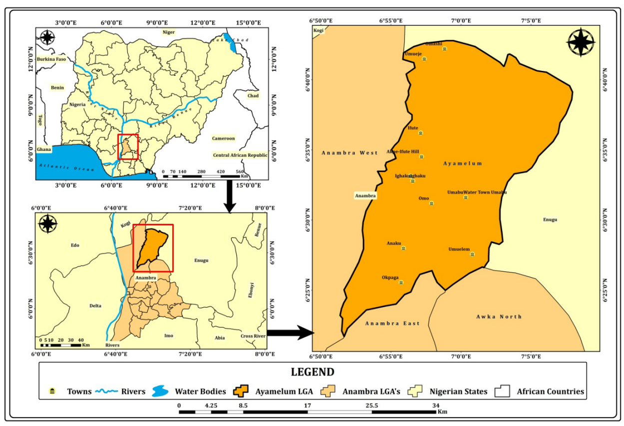

Figure 1. Map of the study area with the map of Anambra state and Nigeria inset

2.2 Data Collection

The medium resolution satellite data were downloaded from USGS Earth Explorer using the LANDSAT dataset module. The Thematic Mapper (TM) image was downloaded for 21st December, 1988. The Enhanced Thematic

DOI: https://doi.org/10.30564/jgr.v2i4.1449

Mapper plus (ETM+) image was downloaded for 24th October, 2003 and the Operational Land Imager (OLI) for 28th December, 2018. The Landsat satellite data have 30m spatial resolutions, and the TM and ETM+ images have spectral range of 0.45-2.35 micrometer (µm) with bands 1 to 7 and 8 respectively, while the Operational Land Imager (OLI) extends to band 11.

2.3 Image Classification

For the Landsat TM, ETM+ and OLI, a False Colour Composite (FCC) operation was performed using the ArcGIS 10.4 software and the images were combined in the order of band 5, 4 and 1 for Landsat TM and ETM+ while that of Landsat OLI was in the order of band 6, 5 and 3 due to change in sensor. The images were then clipped to the boundary of Ayamelum. A supervised classification scheme with the Maximum Likelihood Classification algorithm was used for the classification. The supervised classification was performed by creating a training sample, and based on spectral signature curve and visual interpretation. The following land-use classes were created: Water body, Farms and Sparse Vegetation, Built-up Areas, Bare Surface and Thick Vegetation.

2.4 Land Conversion Rate and Land Absorption Coefficient

Land Conversion Rate (L.C.R) is the measure of compactness which indicates a progressive spatial expansion of a city while Land Absorption Coefficient (L.A.C) is a measure of change in the consumption of new urban land by each unit increase in urban population [17].

The Land Conversion Rate (L.C.R) and Land Absorption Coefficient (L.A.C) was determined for the study area using the equations as shown below:

$$LCR = \frac{A}{P} \quad (1)$$

where, A is the Areal extent of the study area in sq km

P is the Population

$$LAC = \frac{A_2 - A_1}{P_2 - P_1} \quad (2)$$

where, A1 and A2 are the areal extents for the early and later years, while P1 and P2 are their population, respectively.

The growth rate used for estimating the population of Ayamelum LGA was determined to be 2.67%. The equation used is given as:

$$P_t = P_o \times (1 + \frac{r}{100})^t \quad (3)$$

Here, t = number of years; Pt= Population after 't' years; Po= Population at the start; r = the annual growth rate.

2.5 Land Surface Temperature

Land surface temperature of the zone for the three years: 1988, 2003 and 2018 were extracted from the Landsat remote sensing lab.gr site for the month of February/March for the years under review. Mean temperature for 1988 was downloaded for 7th February, that of 2003 was downloaded for 4th March and that of 2018 was downloaded for 1st February.

2.6 Future Projection

Markov Chain Analysis being a convenient tool for modelling land use change was employed for understanding the future patterns of land use change in the zone since its process allows the future state of a system to be modelled purely on the basis of the immediately preceding state. It describes land use change from one period to another and uses this as the basis to project future changes [20]. This was used to predict the land use land cover (LULC) situation in each LULC type for the year 2028 based on the 2003-2018 scenarios in Ayamelum. The 10 (ten) year LULC projection for the future was done using Markov chain model incorporated in the IDRISI-SELVA software. The change between 2003 and 2018 was used as the basis for the prediction. The results were displayed in a table, and were converted to square kilometres from pixel count. This was done to enable easy discussion.

Pearson correlation was used to show the relationship between agriculture (farmlands) and land surface temperature (LST) of the zone.

3. Results and Discussion

Land use and land cover changed significantly over the years under review. These are presented in the following imageries:

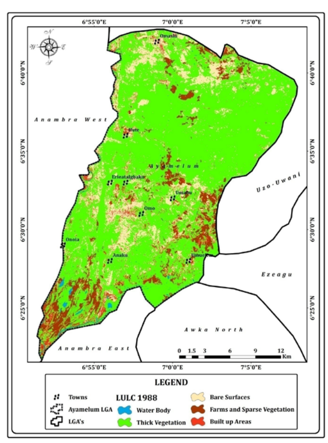

Figure 2. Land use and land cover change for 1988

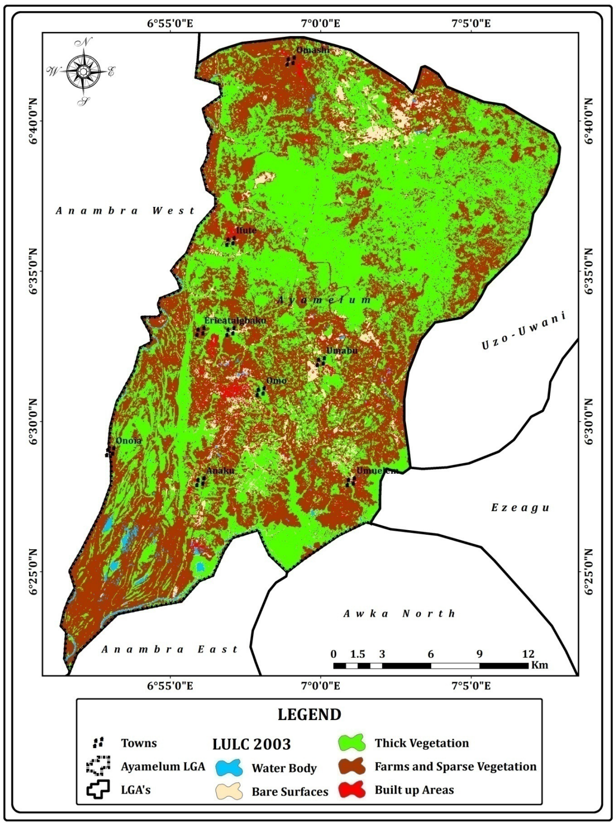

Figure 3. Land use and land cover change for 2003

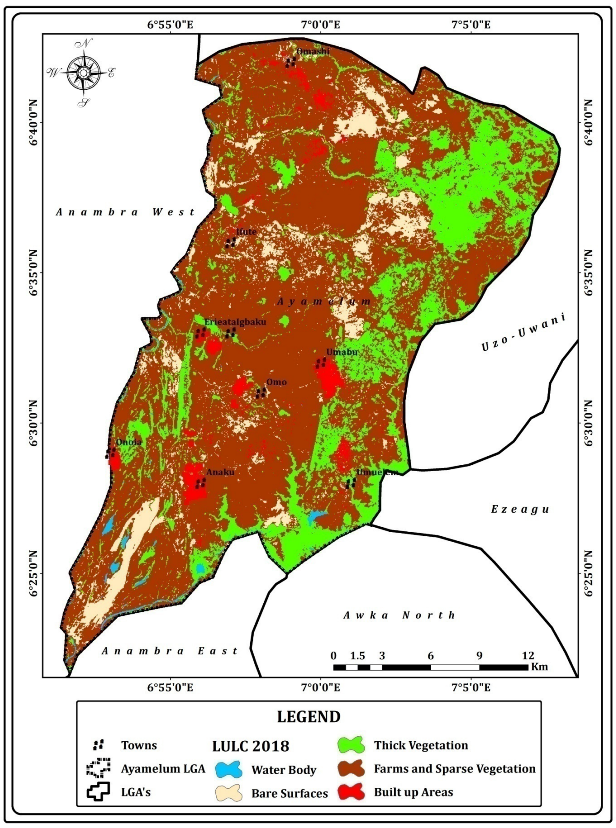

Figure 4. Land use and land cover change for 2018

A summary of all the changes encountered throughout the period is given in the table below:

Table 1. Total detection for land use and cover changes from 1988 - 2018

Class Name	Initial year 1988	1988 to 2003	2003 to 2018	1988 to 2018
Water Body	3.44	-0.25	0.56	0.31
Bare Surfaces	94.03	-37.46	21.09	-16.37
Thick Vegetation	434.74	-148.13	-164.99	-313.12
Farms and Sparse Vegetation	45.51	169.74	131.49	301.23
Built up Areas	13.24	16.17	11.57	27.74

The area under study changed visibly over the years (1988 – 2018) with some land uses recording more changes than others. Water body, bare surfaces and built up areas both increased and decreased slightly over the study period. They did not have significant variations in total land areas and were not the major causes of land use change in the region (Figure 2- 4). The fluctuations in the area of land covered with water were mainly from the variations experienced in flooding in the zone per year. Being a swampy and flood prone zone that experiences a yearly flooding regime, it was characterized by variations in the area of land that were inundated with water yearly; with some years experiencing more or less volume of flood water than another. On the other hand, bare surfaces reduced in the area of coverage between 1988 – 2003, but increased between 2003 – 2018. Such areas with little or no vegetation cover are rarely used for agricultural purposes in the zone and are at the risk of becoming more parched as the micro climate of the zone changes over time. Since the area has ample parcels of land which are increasingly turned into agricultural lands, much thought is not given to the reclamation of the land for such purposes and so are allowed to lie fallow.

Built up areas equally increased over the study period but did not have much impact in terms of land use alterations in the zone. As at the initial year of 1988, it occupied 13.24 sq km of the land area and increased up to 27.74sq km by 2018. It meant that the population of the area only grew gradually and there were not much need for housing units as would be seen in urban areas. This further explains why the land conversion rate and land absorption coefficient as at 2018 were only 0.000196 and 0.000226, respectively. On the other hand, it equally meant that the increasing scale of agricultural activities could not have been promoted only by people living within the area, but also from interested stakeholders who operate from outside the zone and have no need of rooming

DOI: https://doi.org/10.30564/jgr.v2i4.1449

space in the locality.

Agricultural activities had much impact in the area and were to a great extent responsible for the reduction of thick vegetation in the zone to sparse vegetation. Alongside sparse vegetation, farmlands were seen to increase from the initial year size of 45.51sq km to 301.23sq km by 2018 (Figure 2- 4). Conversely, thick vegetation lost much of its extent and cover (mainly to agricultural land use) as it was seen to lose as much as 313.12sq km between 1988 to 2018. (Figure 2 -4).

Projected change in land use and cover (table 2) showed that while modifications in land use are expected for the different categories, farms and sparse vegetation will still constitute the most extensive land use in terms of land coverage.

Table 2. Projected land use and cover change for 2028 being the next 10 years from 2018

	Probability of changing to in sq. km.				
Given Class	**Water Body**	**Built up Areas**	**Bare Surface**	**Farms and Sparse Vegetation**	**Thick Vegetation**
Water Body	0.11	0.04	0.28	1.12	4.73
Builtup Areas	0.001	23.42	4.5	3.84	1.3
Bare Surface	0.26	19.61	20.72	18.14	5.69
Farms and Sparse Vegetation	0.94	37.4	8.41	43.06	31.13
Thick Vegetation	1	7.27	13.83	33.26	27.03

Land surface temperature for the period under review showed increased mean temperatures of 29, 33 and 36^{0}C for 1988, 2003 and 2018, respectively.

Implications for Land Conservation and Regional Climatic Patterns

Land use across the zone changed mainly due to agricultural activities and affected the capacity and extent of other land use categories. Though agricultural expansion is a global phenomenon, it continues with less restraint or modification in land consumption/absorption pattern in the zone as in many parts of Africa because of the notion that land is abundant [6]. This location has much unoccupied land than is normally the case in many parts of Anambra state where it is located; hence, acquiring more land seemed easier over the years. Such land acquisitions and extensions were done at the expense of the forests (thick vegetation) which shrunk in size as the farmlands increased; with consequent losses and impacts on the biodiversity of the zone.

There is need to utilize the already existing farmlands maximally rather than a haphazard and quick conversion of the vegetation thick zones to farmlands. Since the conversions have been unregulated and uncoordinated to a large extent, the remaining sparse vegetation found within the converted zones occurs as tiny mosaics with almost no ecological value and conservation prospects. This could have been much avoided if agricultural intensification is much promoted in the zone. Such initiatives ensures that farmers utilizes the available farmlands maximally by improving soil fertility and engaging improved farming techniques within the parcels of land where they already farm [5]. On the other hand, farming plots should be planned, properly apportioned and monitored, even if they have ample agrarian farm lands in the zone. This will help to reduce forest fragmentation and equally ensure that the remaining forest patches (though small) are together and become more ecologically useful.

Results of the correlation between agricultural land use and land surface temperature showed a strong relationship of 0.99 ($p = 0.0058 < 0.05$ level of significance). This meant that as the vegetation cover of the zone declined over the years; it affected (increased) the land surface temperature of the area. Vegetation cover reduces the direct impact of sun in a zone and in turn reduces or normalizes the temperature of an area. The reverse becomes the case when the vegetation of such a zone become so sparsely distributed or in extreme cases, are turned into zones that is bare of vegetation. Future land use projections for the area showed that more vegetation dense zones will be converted to other land uses such as agriculture and built up areas (table 2) and by implication suggests that the micro climate will become altered. Since these are grave concerns facing the zone, there is then every need to engage in climate friendly agricultural innovations that will accommodate both agricultural and climate regulation initiatives.

4. Conclusion

Land use and cover across many tropical landscapes are undergoing changes and modifications as a result of varied forcings. As it concerned the region under review, such changes were mainly as a result of the increase in the area of land under cultivation. This was to a great extent responsible for the loss of thick vegetation, subsequent modification to sparse vegetation and increase in land surface temperature for the zone. Reducing encroachment to forest areas and engaging in climate friendly and resilient strategies for agriculture and building purposes will help reduce loss of more forest areas and adverse climatic impacts for the region.

References

[1] Abood S. A., Lee J. S. H., Burivalova Z., Gar-

cia-Ulloa J., Koh L. P.. Relative contributions of the logging, fiber, oil palm, and mining industries to forest loss in Indonesia. Conserv. Lett., 2015, 8: 58–67.

[2] Asai, M., Reidsma, P., Feng, S.. Impacts of agricultural land-use changes on biodiversity in Taihu Lake Basin, China: a multi-scale cause-effect approach considering multiple land-use functions. International Journal of Biodiversity Science, Ecosystem Services and Management, 2010, 6(3-4): 119-130.

[3] Bradshaw, C.J.A., Sodhi, N.S, Brook, B.W.. Tropical turmoil- A biodiversity tragedy in progress. Front. Ecol. Environ, 2009, 7: 79-87.

[4] Butchart, S. H. M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J. P. W., Almond, R. A. E., Baillie, J. E. M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K. E., Carr, G. M., Chanson, J., Anna, M.. Global biodiversity: indicators of recent declines. Science, 2010, 328(5982); 1164-1168.

[5] Byerlee, D., Stevenson, J., Villoria, N.. Does intensification slow crop land expansion or encourage deforestation? Global Food Security, 2014, 3: 92-98.

[6] Chamberlin, J., Jayne, T. S., Headey, D.. Scarcity amidst abundance? Reassessing the potential for cropland expansion in Africa. Food Policy, 2014, 48: 51-65.

[7] Gardner, T.A., Barlow, J., Chazdon, R., Ewers, R.M., Harvey, C.A., Peres, C.A., Sodhi, N.S.. Prospects for tropical forest biodiversity in a human-modified world. Ecology Letters, 2009, 12: 561-582.

[8] Igu, N. I.. Swamp forest use and loss in the Niger Delta: Contextual and underlying issues. Open Journal of Forestry, 2017, 7: 34-47.

[9] Igu, N. I., Nzoiwu, C. P., Anyaeze, E. U.. Biodiversity and carbon potentials of a Nigerian forest reserve: Insights from the Niger Basin. Journal of Environmental Protection, 2017, 8: 914-922.

[10] Laurance, W.F., Useche, D.C., Rendeiro, J., Kalka, M., Bradshaw, C.J.A., Sloan, S.P., Laurance, S.G., Campbell, M., et al.. Averting biodiversity collapse in tropical forest protected areas. Nature , 2012, 489: 290-294.

[11] Lindenmayer, D.. Land use intensification in natural forest settings. In: Lindenmayer, D., Cunningham, S., Young. A. (Eds) Land use intensification: effects on agriculture, biodiversity and ecological processes. CSIRO Publishing, Australia, 2012: 113-121.

[12] Lindenmayer, D. Interactions between forest resource management and landscape structure. Current lands Ecol Rep. 2016, 1 (1): 10-18.

[13] Monuanu, P.C.. Temperature and sunshine, in: Ofomata, G.E.K(ed). Nigeria in Maps: Eastern states. Ethiope, Publishing House, Benin City,1975.

[14] Nepstad D., McGrath D., Stickler C., Alencar A., Azevedo A., Swette B., Bezerra T., DiGiano M., Shimada J., Seroa da Motta R., Armijo E., Castello L., Brando P., Hansen M. C., McGrath-Horn M., Carvalho O., Hess L.. Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. Science, 2014, 344: 1118–1123.

[15] Norris, K.. Agriculture and biodiversity conservation: opportunity knocks. Conservation Letters, 2008, 1: 2-11.

[16] Ofomata, G.E.K.. Nigeria in Maps: Eastern States .Ethiope, Publishing House, Benin City, 1975.

[17] Paria, P. and Bhatt, B.. A spatio-temporal land use change analysis of Waghodia taluka using RS and GIS. Geosci. Res, 2012, 3 (2): 96-99.

[18] Pimm, S.L. and Raven, P.R.. Biodiversity: Extinction by Numbers. Nature, 2000, 403: 843-845.

[19] Tyukavina, A., Hansen M. C., Potapov, P., Parker, D., Okpa, C., Stehman, S. V., Kommareddy, I., Turubanova, S.. Congo Basin forest loss dominated by increasing smallholder clearing. Science Advances, 4, 2018, 2993: 1-12.

[20] Zubair, A. O.. Change detection in land use and land cover using remote sensing data and GIS: A case study of Ilorin and its environs in Kwara state. M.Sc thesis, University of Ibadan, Nigeria, 2006.

DOI: https://doi.org/10.30564/jgr.v2i4.1449