ISSN:
Print - 2277 - 0755
Online - 2315 - 7453

Journal of Agricultural Science and Environment

AN ASSESSMENT OF URBAN ENCROACHMENT ON OGUN RIVER BANK PROTECTION ZONE IN ABEOKUTA CITY, NIGERIA

[*1]C.O. ADEOFUN, [2]J.A. OYEDEPO AND [1]T.I. LASISI

[1]Department of Environmental Management and Toxicology,
[2]Institute of Food Security, Environmental Resources and Agricultural Research,
Federal University of Agriculture, P.M.B. 2240, Postcode 110001 Abeokuta, Nigeria.
***Corresponding author**: Clemluv2000@yahoo.com **Tel**: +2348034042907

ABSTRACT

An assessment of urban sprawl in Abeokuta city, Nigeria from 1964 to 2008 was conducted. The study investigated the rate of encroachment of buildings on the Ogun River bank using Geographical Information Systems and remote sensing techniques. Topographic map of the city was scanned, imported into GIS, and digitized. Series of multi-date remote sensing satellite imageries were also acquired, processed, classified (where necessary) and vectorized to enable full assessment of the spread of built up area into the River bank Protection zone (RBPZ). A recent, high resolution satellite (Ikonos) image was utilized to assess the situation at present. Results of the assessment revealed progressive spatial expansion in the city and progressive encroachment on Ogun river right of way. Particularly, gross encroachments were pronounced in the aboriginal part of the city. A total of 34.1ha of built up area are completely within the protection zone as at 1964, this increased to 50ha in 1974, 77 ha in 1984 and 90 ha in 1994. In the year 2008, the encroachment was almost four times (123 ha) what it was in 1964. The study demonstrated that use of remote sensing and GIS is very useful and effective for the monitoring of urban sprawl. It provides a tool of the quantitative measurement that is needed for rapidly growing regions in identifying internal variations and temporal change of urban sprawl patterns in different periods.

Keywords: Ogun River, Encroachment, Urban sprawl, Remote sensing

INTRODUCTION

Rivers have been shown to lend enormous impact on societal developments. From the pre-historic era waterfronts, shorelines and river banks have been primarily selected as sites for human settlements, commercial activities and highly productive agriculture. In fact, inter-community and international communications originated in the coastal fringes (Barlet and Smith, 2001). Cities of the world built along waterlines have had rapid rates of developments relative to their land-locked counterparts. Often, this is because of the trade and mercantile opportunities that the water ways offer. Hence, throughout the history of mankind, boundaries between land and water have played important roles in civilization and maturity of social order. Lisabi, the legendary progenitor of the Egbas (Abeokuta citizens), was said to have found solace in two natural features or resources; a rock out crop (Olumo) which was said to protect Abeokuta from military invasion, and the Ogun River which also preserved the city through a range of services including navigation, irrigation for flood plain agriculture and water for domestic utilities. Abeokuta city thus owes its existence largely to the presence of Ogun River.

The name 'Abeokuta' meaning under the rock was derived from the protection Olumo rock was said to have given to the Egbas from external aggression. Dating back to 1825, Abeokuta owes its origin to the inroads of slave hunters from Ibadan and Dahomey which compelled the village population scattered over the open country to take refuge among the rocks that surround the city. The people constituted themselves into a free confederacy of many distinct groups, each preserving traditional customs, religious rights and their original names. Thus, Abeokuta city is a conurbation of five towns with distinct regency. The city is drained mainly by Ogun River which passes through and divides the city into two.

Population explosion and large human influx associated with urban expansion cause marginal areas such as farmlands, flood plains, hill slopes and green zones to be invaded by man for want of contiguous settlement space. When this happens, built-up areas may encroach on wetlands and even river banks. Hanson and Lindh (1993) noted that river banks and shorelines respond to anthropogenic activities by becoming physically very unstable. Quite often, natural vegetation resources and habitats along the river side are completely run down. Likewise, pollution from toxic domestic or industrial effluents, municipal solid wastes and sewages from human settlements do alter the delicate mechanism of marine or riverside ecosystem. This is closely trailed by serious negative impacts on biodiversity. In other words, negative shoreline trends resulting from natural habitat destruction, thermal or chemical pollution of the wetland ecosystem or general human perturbation of aquatic life leads to erosion of biological diversity on the long term.

Ogun River bank in Abeokuta is particularly vulnerable to impact of human activities. Available evidence indicates that the riparian vegetation along the river bank is seriously depleted and the ecosystem already upset (Adeofun and Oyedepo, 2008). Buildings can be seen close to the river channel (Plate 1).

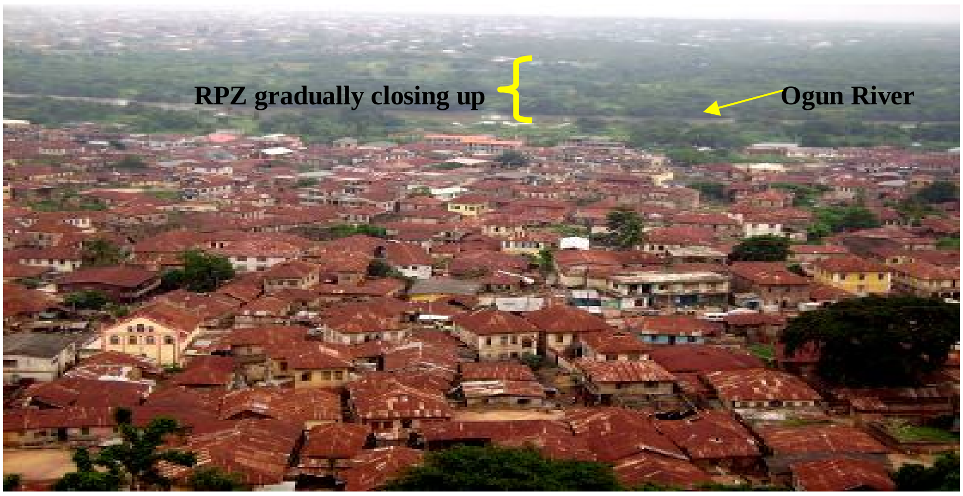

Plate 1: Photograph showing part of Abeokuta city closing in on Ogun River

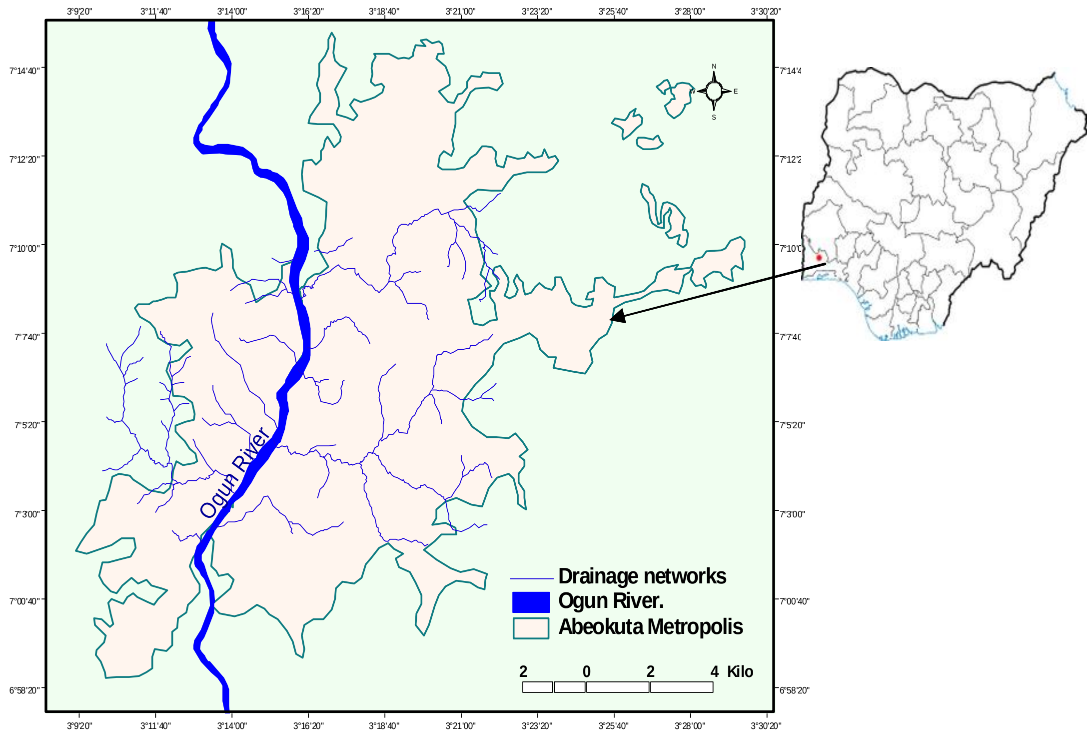

Fig. 1: Map of Abeokuta metropolis showing drainage networks

The natural habitats along the riverside are already being replaced by physical structures almost by the day. The urban encroachment status on Ogun riverbank, loss of wetlands and displacement of flood plains along the river is enough indication of the overbearing pressure. In the short and long term perspectives of environmental problems, the negative shoreline trend along Ogun riverbank will cause secondary effects that may affect the entire city through threats to human settlements, harbors, riverbank recreation areas, wetlands, wildlife niches among several others. These impacts are also likely to contribute to natural disasters like flooding which often do not have localized consequences. It may be argued that environmental degradation of this sort are the price to be paid for development, but society will have cause for concern as impact of human activities on natural resources get to an unacceptable level.

In Nigeria, government efforts at reducing environmental degradation and keeping natural resources depletion to a sustainable level included the creation of 200m setback regarded as the Riverbank Protection Zone (RPZ) along water ways (Ladan, 2009; Ladan, 2010; GEF, 2010). This corridor is expected to have minimal human influence; it is a right of way for rivers and a protection zone for wildlife habitats along the river. It is thought that such protection zone will give room for vegetal resuscitation which will in turn protect the water shed from drying up. The idea of green belts and green wedges is to keep the city environmentally healthy. Unfortunately, it is becoming increasingly difficult for planners to keep pace with the rate of indiscriminate, unplanned and probably unapproved buildings which spring up by the day in and around Abeokuta conurbation.

In this paper, an assessment of the extent of urban encroachment on the river bank protection zone in Abeokuta city is conducted. The paper attempts at determining the stability of the Ogun RPZ since 1964 and calculates the annual rate of urban intrusion. It examines the temporal pattern of urban sprawl with focus on Ogun riverbank. Finally the paper suggests a GIS-based solution that may aid planners in forestalling continued uncontrolled infringements.

METHODOLOGY

Description of the Study Area

Abeokuta, the study area is located in the sub-humid tropical region of Southwestern Nigeria (Lat 7°5'N to 7°20'E and Long 3°17'E to 7°27'E). Abeokuta is underlain by crystalline Pre-Cambrian basement complex of igneous and metamorphic origin (Oyawoye, 1964) and many outcrop of which can be seen in different places.

As of 2005, Abeokuta and the surrounding area had a population of 593140 (Wikipedia, 2010; NPC, 2010) spread over about 125,600 hectares of land at present. The occupation of the indigenes varies from local fabric, commercial vehicle operating, to farming, stone quarrying and sand dredging.

Reconnaissance survey and Ground truthing

The study commenced with a reconnaissance survey conducted around the study area coordinates of features identified on the satellite image were obtained on the ground with the aid of hand-held GPS receiver. Features on the imagery were equally verified on ground.

Data types and data acquisition

Since the study involves some element of change assessment or time series analysis, it was necessary to acquire multi-date satellite remote sensing data of the study area. The base year for the study is 1964 when no satellite imagery existed; hence the topographic map of Abeokuta prepared from the photographs of the over-flights of 1960 – 63 was relied upon for baseline year information. However, medium satellite imageries (Landsat MSS, TM and ETM) are available in the archive of National Oceanic and Atmospheric Administration (NOAA) from 1975 to date. These provided the data for 1975, 1985, 1995 and 2005 periods. Ikonos image of Abeokuta (a high resolution image) from Space imaging was acquired over the study area for 2008; this gave a clear view of the present status of the city sprawl.

Data capture

The topographic map was scanned and imported into GIS (ArcView 3.2). The scanned image was registered (Geo-referenced) and the features on it were captured layer by layer through "on-screen digitising".

Image processing

Geometric Registration

For mapping purposes, it is essential that any form of remotely sensed imagery be accurately registered to the proposed map base. With satellite imagery, the very high altitude of the sensing platform results in minimal image displacements due to relief. As a result, registration can usually be achieved through the use of a systematic *rubber sheet* transformation process that gently warps an image based on the known positions of a set of widely dispersed control points. This was achieved by taking the coordinates of known features contained on the image and easily recognizable on the ground.

Principal component analysis and false colour composites of the imageries

Landsat imageries come in bands which must be stacked to generate a standard False colour composites for visual analysis. Color composites make fullest use of the capabilities of the human eye. However as observed by Liu (2000), Crude stacking of multispectral satellite image such as Landsat images will generate a composite that will require creating more training sets during supervised classification. To avoid this bottleneck, he suggested that a principal component analysis first be carried out on the image to collapse the several bands into a few components. In this study, 3 components were extracted from the seven bands and were eventually used to produce a colour composite.

Image classification

Computer-assisted interpretations of remotely sensed images are essential otherwise the satellite image is meaningless. There are 256 colours based on the spectral response of features on the earth, meanwhile the human eye can recognize on 16, hence the computer is usually employed to aid the classification. In this study the computer was guided or supervised (using information acquired from the field during ground truthing) on to how to classify the various features. In other words training sites on the satellite image were created to serve as guide for the computer to classify other pixels on the imagery after. Since the study is interested in the three kinds of features namely; human buildings or encroachment, vegetation or undisturbed area around the river course and the water body. Four categories were necessary namely: water body, vegetation, human building and others. The area occupied by human building and activities were then captured through raster to vector conversion of the classified image.

Ikonos Image

The Ikonos image was equally registered, and the built up area was captured directly through "on-screen digitising" at the same scale with the previous medium resolution images.

GIS ANALYSIS

Having derived the extent of built-up areas at the different periods; 1964 to 2008, the portion of these maps that encroached into the RPZ was determined through simple GIS overlay operation. Foremost the protected area was marked out as a new layer through creation of (200 meters) buffer along the length of Ogun River. The portion of the city for the different periods of time that encroached on Ogun River bank were then clipped within the RPZ and the areas were calculated in hectares. The land use map captured from the Ikonos image was equally clipped within the 200m buffer zone. This allowed the segregation of the encroachments along land use types.

RESULTS AND DISCUSSION

The results of the analysis compare the progressive increase in the size of urban intrusion on the RPZ with the city expansion from 1964 period to 2008. Percentages of encroachment to the actual city size per period were computed. The result as presented in Table 1 suggested that there is a progressive city expansion with concomitant encroachment on Ogun riverbank. From the percentage of the portion of the city that encroached per period, 1964 had the highest value of 4.09%. This only indicates that the community at that period was compact and development was rather localized around the river than spreading landward.

The inverse relationship between city size and % encroachment also point out a leap frog (decentralization) pattern of urban sprawl. At the moment, Abeokuta city is shared by four local governments in the state. The picture of the encroachment pattern is presented in the third column of Table 1. The communal pattern of existence tends to weaken as a settlement expands, and new buildings move away from the city centre. Thus the ratio of encroachment to overall city size reduces.

Table 1: Progressive city expansion and encroachment on Ogun Riverbank

Period	Area of city extent (Ha)	Area of Encroachment	% of City extent
1964	832.88	34.09	4.09
1974	1,716.96	49.86	2.90
1984	2,867.45	77.10	2.69
1994	5,375.02	90.57	1.69
2004	6,923.61	93.69	1.35
2008		123.36	1.18

The progressive city size expansion began in the late 1970s when Abeokuta became a state headquarter. Population increase resulting from migration lead to the construction of more buildings and large scale conversion of available land to residential and industrial uses. Figure 2A-D presents this graphically. The evolution of Abeokuta settlement into city is appreciated as the figure shows the city transition through time. Particularly noteworthy is Figure 2A, where the left half of the city across Ogun River was almost nonexistent in 1964. Meanwhile, with availability of physical and social infrastructures, such as good roads and bridges, the area began to expand even encroaching into Ogun River as depicted in Figures 2A-D.

The current land-use types of the city which reveals the current status of urban development in Abeokuta city is shown in Figure 3. The competing alternative land-uses can be understood with this figure. Geographical targeting of infrastructures may be a major reason for encroachment on the river bank. For instance, the new Lafenwa market will have no other suitable site than to extend the existing one into the adjacent open space which incidentally is within the RPZ. In Figure 4a-f the stages of urban encroachment on the river. The map shows the gradual cumulative intrusion of the city metropolis over the 44 year period is presented in Table 2. The table shows that cumulative area of encroachment was highest in 1984 and 2008 with a value of 28 ha apiece.

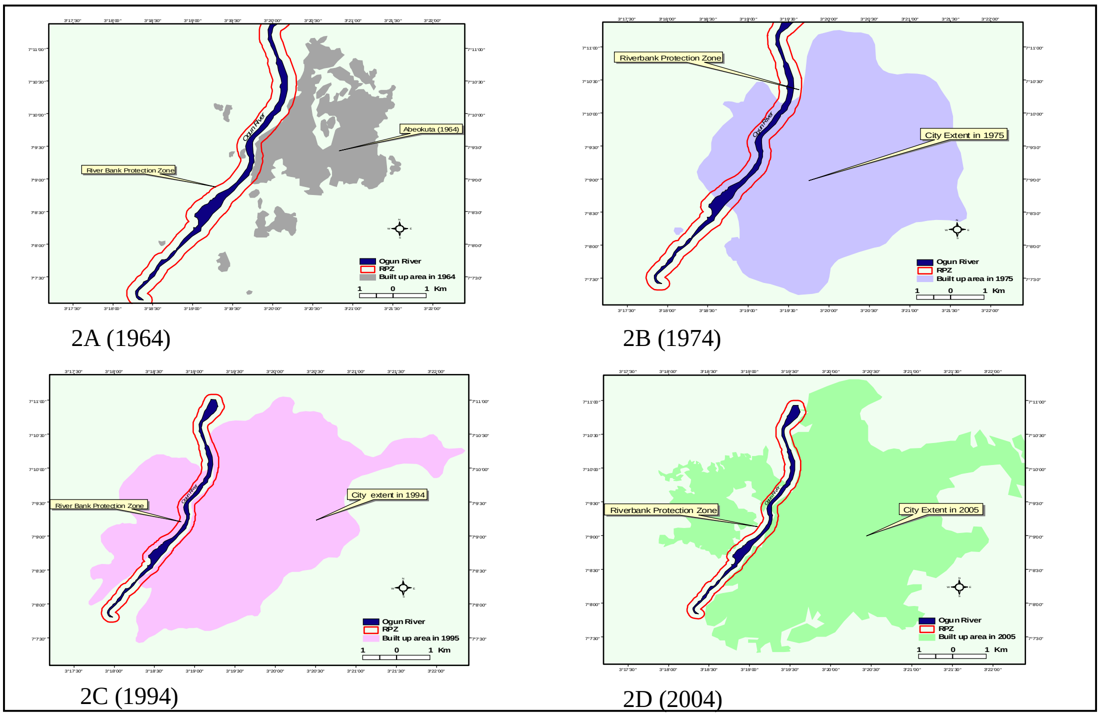

Fig. 2A-D: City extent and encroachment into the Riverbank Protection Zone from 1964 to 2004

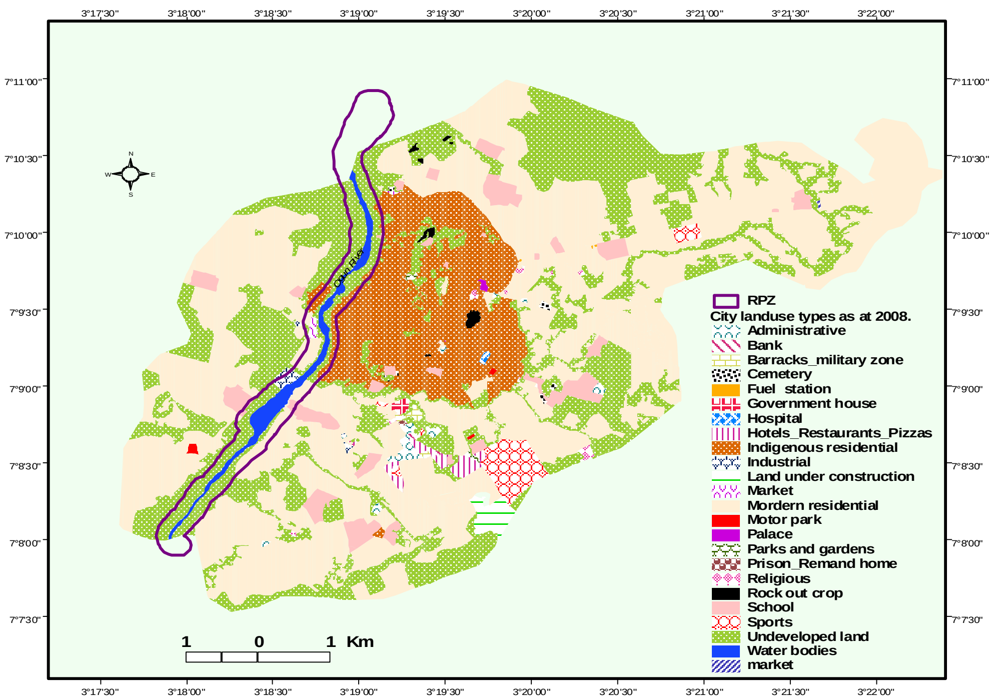

Fig. 3: Land-use / Land-cover map of Abeokuta city as extracted from Ikonos image

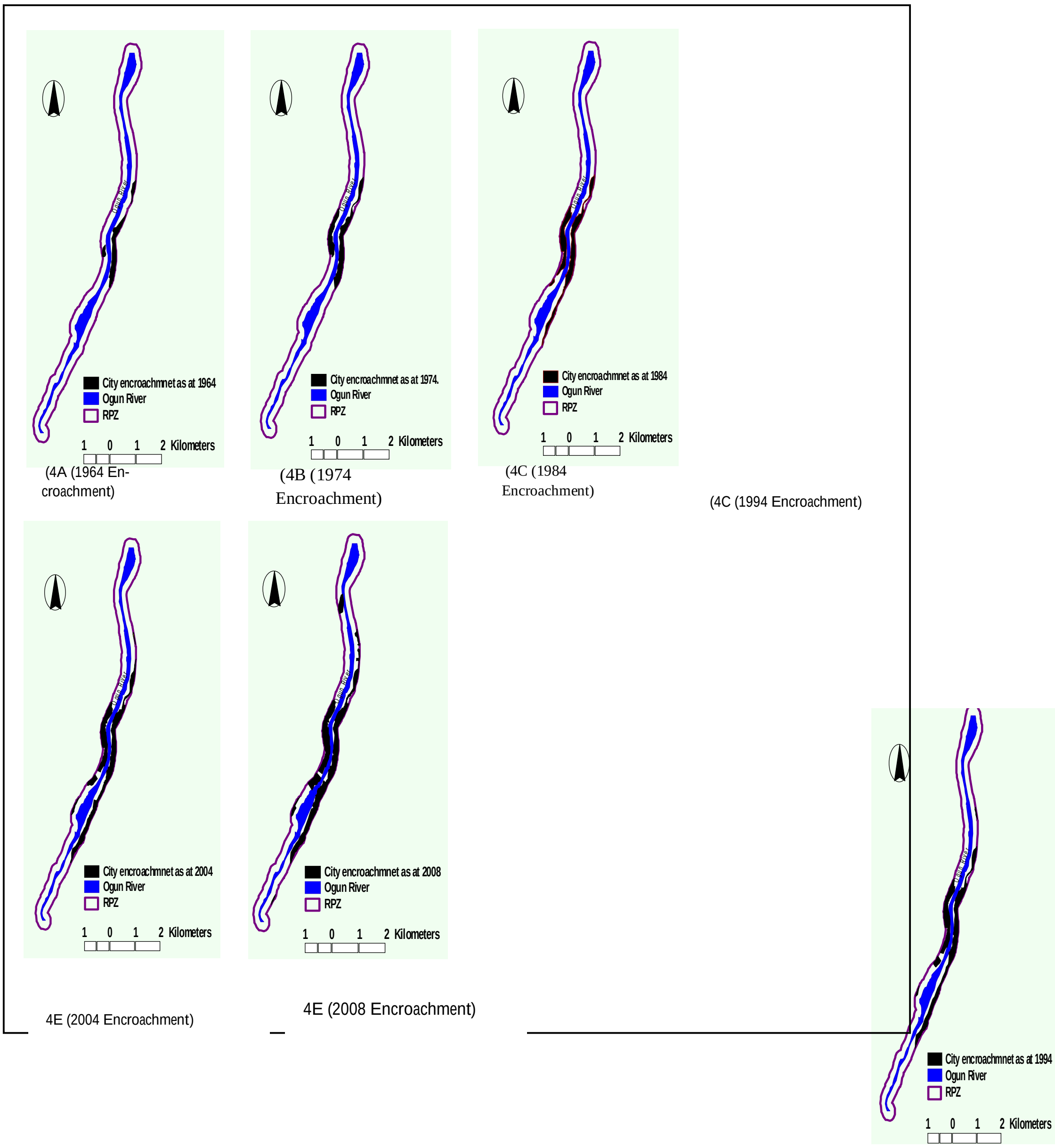

Fig. 4: A-F: Built up area (in black within protection zone from 1964-2008)

Table 2: Land area of periodic Intrusion into RPZ

Period	Area (Ha)	Cumulative Expansion (Ha)
1964	34.09	0
1974	49.86	15.77
1984	77.1	27.24
1994	90.57	13.47
2004	93.69	3.12
2008	123.36	29.67

Table 3: Land-use / Land-cover categories within protection zone

Categories	Area (Ha)	% of land area
Schools	5.6	2
Market	5.8	2
Industrial	8.2	3
Ancient buildings	62.36	25
Modern buildings	41.4	16
Undeveloped	129.3	51
Total	**252.66**	100

For 1984 it is understandable that city expansion was hinged on economic and political prosperity of the state. The 1974 – 1984 period coincided with the period when Abeokuta became a state headquarter, and as would be expected, government and private investments tend to lead to influx of people and proliferation of landed properties. The city also became a University town about the same period. Since people are risk averts, new private residences tend to cluster around existing ones rather than decentralising. The sprawl in the outskirts were hence initiated by the state governments inform of low cost housing estates such as the Asero housing estate in 1980 which was about the farthest from the city center. The government housing schemes motivated people to decentralise from the urban centre. Figure 4A-F is a panoramic graphical presentation of the cumulative growth of encroachment of human settlements on the river bank. The seemingly marginal difference between 1984 and 1994 was due to political instability in the country. The military era was deemed by many as unsafe for investment and as such economic recession prevented more landed properties from being developed. However, more government estates were constructed at the outskirts such as the Sam Ewang, Olomore, and Elega housing estates. And this was enough incentives to encourage more private property developments in the following decade. This explains the city expansion and also the encroachment on the RPZ in the new millennium.

In order to analyze the various categories encroachment within the RPZ, the of land use and land cover categories of the RPZ was developed and 7 classes were extracted from the Ikonos image. Thus while figure 5 present the map, Table 3 gives a summary of the land cover categories of the encroachment. Schools and markets occupied 2 %, Industries occupy 3% while residential buildings (ancient and modern) occupied 41% of the available land space. About 50% of the land area in the RPZ is not yet built up.

The encroachment rate can be calculated by finding the average of the cumulative expansion over period of ten years and dividing the result by 10.

Thus:

R_e = (Av. Cum Expansion)/10

R_e = 17.854/10 Ha yr^{-1}

The yearly rate of encroachment from the above calculation is 1.78 ha. By implication, half of the remaining natural habitats along Ogun River would be gone in the next four years and in the next 20 years no natural ecosystem along the riverbank may remain.

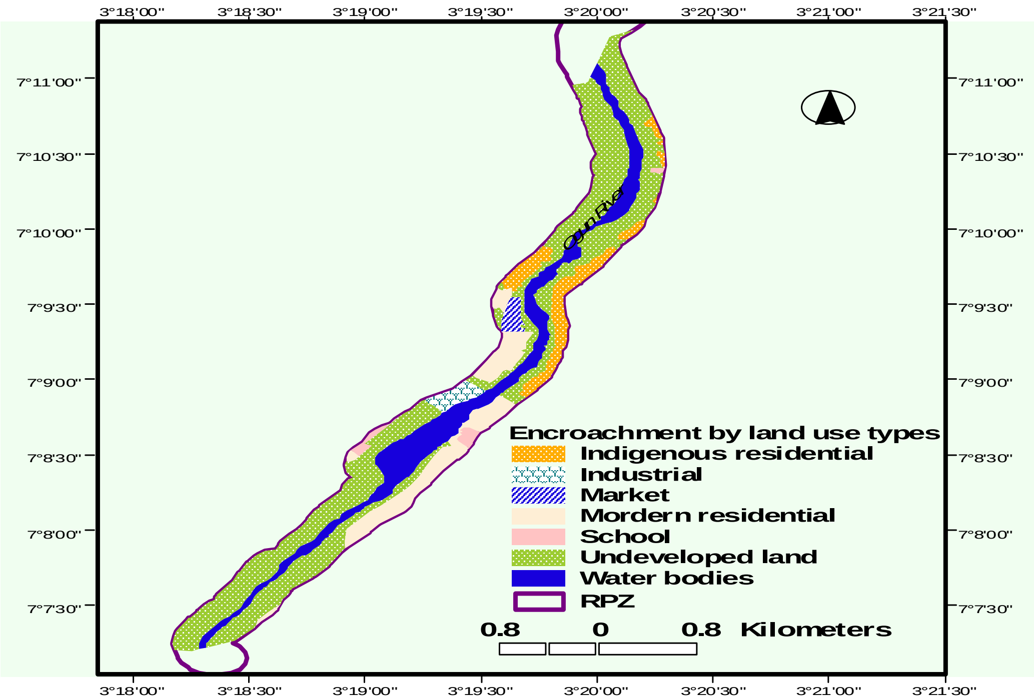

Fig. 5: Land-use categories of encroachments in the study area.

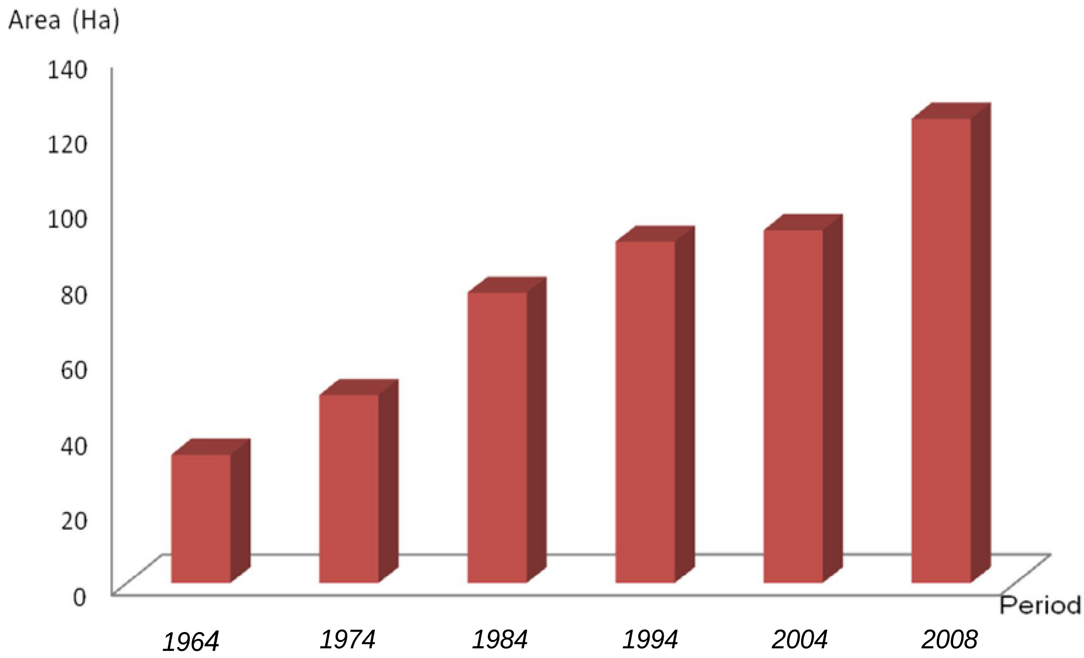

Figure 6: The cumulative increase in encroachment

CONCLUSION

The impact of urban sprawl on Ogun Riverbank as presented in this study is notable. The categories of city land-use encroachment portend grievous environmental problems which include industrial pollution, flood disasters on residents and biodiversity loss. The current rate of encroachment of 2ha per year holds a high significance on Ogun River in less than half the period of 60 years stipulated for the remaining 130 ha to become built up.

RECOMMENDATION

The project is recommended as a pilot project to be scaled up in every urban area settled along major river banks in Nigeria. It should also form the guide for policy formulation on the protection of river banks in Nigeria

REFERENCES

Adeofun, C.O., Oyedepo, J.A. 2008. Assessment of Wetland Ecosystem Loss in Lagos Coastal area using Remote sensing techniques. *Journal of Field Aquatic Studies,* 4(1).

Barlet, D.J., Smith, J. 2001. GIS for Coastal Zone Management, *CRC Press* Pg 310

Global Environmental Facility-National Fadama Office (GEF-NFO) 2008. Fadama II-Critical Ecosystem Management Project (FGN and World Bank)

Hanson, L. 1993. Coastal Erosion-An Escalating Environmental Threat. *Ambio.,* 22 (4): 188-195.

Jeh, D.N. 2002. Assessment of Urban Encroachment on the Delimi River, Jos Plateau State, Nigeria, Using Geographic Information System. A paper presented at the *4th International Conference of the African Association of Remote Sensing of the Environment.* Abuja Nigeria 14-18 October, 2002

Oyawoye, M.O. 1964. The geology of Nigeria basement complex. *Journal of Mining and Geology,* 87 – 102.

Ladan, M. 2010. National Environmental Regulations 2009 – A New Dawn for Environmental Protection in Nigeria. IUCN Academy of Environmental Law *e-Journal Issue* 2010 (1)

Ladan, M. 2009. Law, Cases and Policies on Energy, Mineral Resources, Climate Change, Environment, Water, Maritime and Human Rights in Nigeria (2009) Ahmadu Bello University Press, Zaria, Nigeria at pp 357-378.

Wikipedia , 2010. en.wikipedia.org/wiki/Abeokuta

National Population Commission (NPC) 2010. Report of the final 2006 census results. URL : http://www.population.gov.ng/state/ogunfinal.pdf

(Manuscript received: 4th November, 2010; accepted: 27th June, 2011).