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The Study of Urban Sprawl and its Effect on the Flood Plains of the Curly River, Jos, Nigeria: A Remote Sensing and Gis Approach

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Abstract: This paper presents the use of geoinformatic to studying urban sprawl. Urban sprawl has led to people converting flood plains and rock outcrops for housing development. In Jos Nigeria, the sprawl is associated with the Tin mining that started since the colonial rule and this development has resulted in people suffering from environmental hazards such as flood.Remote Sensing and GIS was used to estimate the extent of growth along the Curly River between 1992 and 2010. Quickbird images of 2005 and 2010 at 0.5m in combination with the greater Jos map of 1992 at a scale of 1:2000 were used in a GIS environment to assess the spatial growth of the city along the Curly River and delineate areas that are vulnerable to flood. The study revealed that there had been more growth between 2005 to 2010 as compared to 1992 and 2005. The rate of urban sprawl between 1992 and 2005 is 0.49 Hectares /annum, between 2005 – 2010 is 0.74 Hectares/annum and 0.56 Hectares/annum between 1992 to 2010. Built-up areas within 5 meters to 50 meters are all vulnerable to flooding because they are on the low elevation areas of Jos, which is between 1114 meters to 1196 meters.

Key words: Geoinformatic · Urban Sprawl · Flood · Environment

INTRODUCTION

One of the major causes of flood in urban areas is the conversion of flood plains to built-ups and other uses coupled with heavy rainfall. Urban growth can be attributed to the migration of community dwellers from rural areas to urban areas [1-13]. Flooding has been a prevalent problem in urban cities all over the world and Jos City is no exception.

Jos a city in Central Nigeria, witnessed population growth from 400, 000 in 1960 to 736,016 in 2006 [8]. The United Nations' population forecast has predicted that Nigeria's population will increase from 167 million to 367 million by 2050 [6]. The direct implication of such urban encroachment is the change in land use and land cover of the area. On Sunday, July 22nd of 2012, a flash flood occurred along the Delimi River, Jos, Nigeria killing over 35 people and destroying more than 200 houses along the flood plains of the river. The flood was as a result of torrential rain which started in the evening on Sunday and continued past midnight making the Delimi River overflow its banks [9]. Several structures along the river were submerged in water as seen in Fig. 7. The Curly River is a tributary to River Dilimi. Due to non-availability of land, urbanization has extended to areas like flood plains and forest reserves thereby causing loss in natural ecological areas. According to [10], indiscriminate refuse dumping in River Aluko, Nigeria is the main reason for the increased risk of flooding in Aluko. In India, the major causes of urban flooding are unplanned urbanization, indiscriminate refuse dumping, encroachment of floodplains and development in floodplain areas [11].

To better understand a phenomenon such as urban sprawl, remote sensing and GIS will suffice because they are both land based information technologies. The urbanization processes of many cities like Jos are most times uncoordinated. According to [12], coordinated and controlled urban growth has been witnessed in some countries and states in Africa such as Accra in Ghana and Abuja in Nigeria. The application of GIS and Remote

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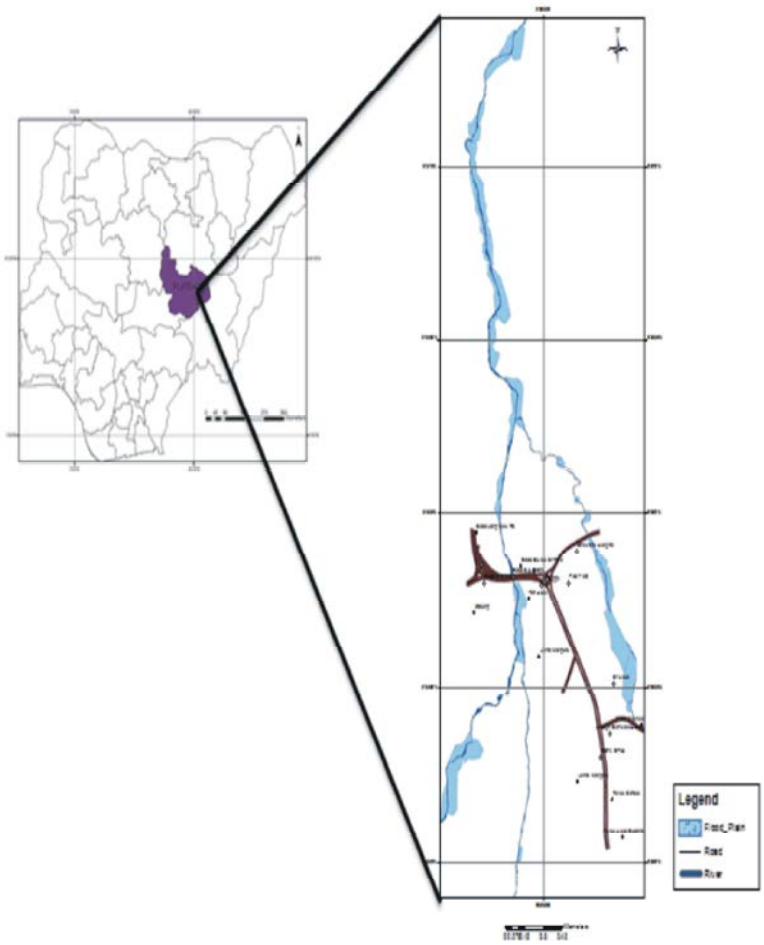

Fig. 1: Map of Nigeria showing study area

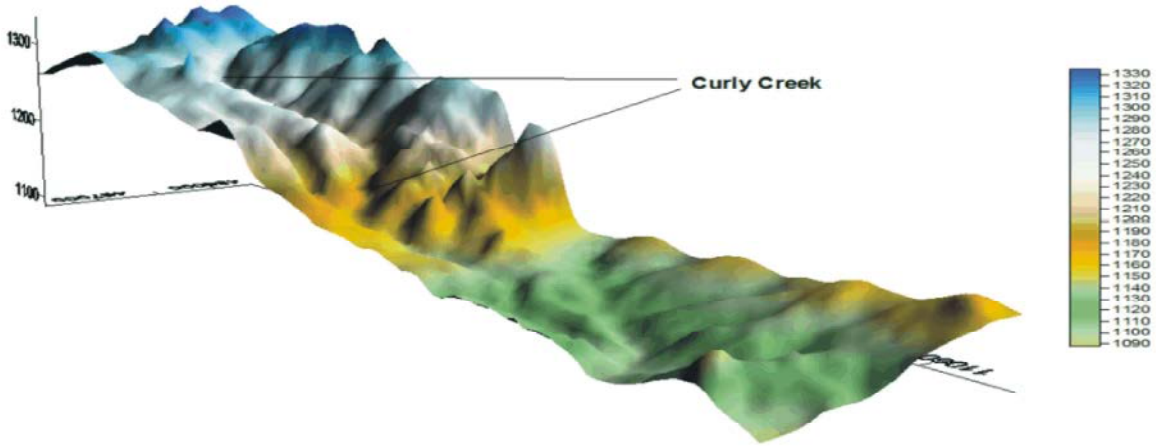

Fig. 2: 3D of the Study Area

sensing help to study the characteristics of urban encroachment, for example, pattern of urban encroachment [2]. Remote sensing and GIS was used in twin city Minnesota USA to know the extent of land use change for 1986, 1991, 1998 and 2002 with the use of Landsat images [4]. The aim of this paper is to examine urban Sprawl on the flood plains of the Curly River, Jos, Nigeria and delineate areas vulnerable to flood using remote sensing and GIS between 1992 to 2010 [14].

Study Area: The Curly river is located in Jos North area of Plateau State, Nigeria between Latitude 9°51□ 40" N, 10°00□ 00" N and Longitude 8° 51□ 00" E and 8°53□ 00" E as seen in Fig. 1. Temperature in Jos ranges from 18°C to 32°C, rainfall is high at 1305mm and characterised with the wet and dry season [7]. The Jos Plateau falls within the Younger Granite Province. The Younger Granites were first defined by Falconer [3] as cross-cutting alkali granites containing biotite characterized by chilled margins against their country rocks. He recognized that the Younger Granites as the source of tin mineralization of the Jos plateau. These granites are about 160 million years old. The Curly River is structurally controlled by several faults trending N-S, NE-SW and NW-SE.

MATERIALS AND METHODS

Images Used for the Study: The greater Jos map of 1992 which was a vector data in combination with the QuickBird images of 2005 and 2010 were used for the change detection in Built-ups for this study see Fig. 3. The QuickBird images have a spatial resolution of 2.5m multispectral. The greater Jos map of 1992, the QuickBird images of 2005 and 2010 were acquired from the National Centre for Remote Sensing Jos, Nigeria. Other materials such as GPS points were derived from field observations, Erdas Imagine and ArcGIS software were used for the analysis [14].

Image to Image Co-Registration: The images were reprojected to Universal Transverse Mercator (UTM) using WGS 1984 and UTM 32 North. The QuickBird of 2010 was geometrically corrected when it was obtained but 2005 QuickBird image was not. Therefore to geometrically correct the 2005 image, QuickBird image of 2010 was used as the reference image for rectification using auto sync program in Erdas imagine. Approximately 40 Ground Control Points (GCP) was taken to rectify the 2005 image. The output correction method used was the polynomial second order. The geometrical registration accuracy root mean square (RMS) was 0.2m/cell.

Subset of the Image: To speed up the image processing, unnecessary data were eliminated using the clip method in ArcGIS. This was done to cover only the study area around the Curly River and to ensure that the different data sets are of the same size.

Changes in Land Use and Land Cover Analysis: To understand urban sprawl in the study area, changes in land use were determined by classifying the QuickBird images of 2005 and 2010 with the greater Jos Map of 1992 into different land use and land cover classes such as built-ups, river, roads and flood plains which were created as feature classes in the geodatabase of the Arc catalog. The built-up areas and flood plains were digitized as polygon while the river and road were digitized as line features.

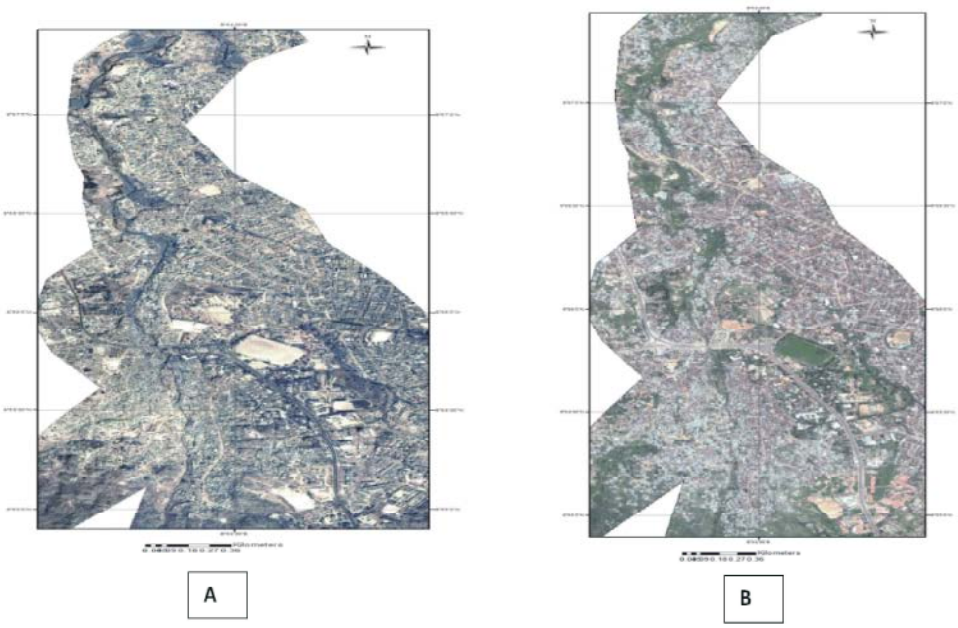

Fig. 3: Quickbird of 2005 (A) and 2010 (B)

Buffering and Within Distance Analysis: In other to demarcate the study region into areas that are more vulnerable to flood and other environmental hazards from the other areas that are less vulnerable, a buffer zone of 50m was established and was divided into zones of 5m, 10m, 15m, 20m, 30m, 40m and 50m with each zone assigned a unique color. Finally, a within distance analysis was carried out in ArcGIS to determine the exact number of built-ups in each of the buffer zones.

Field Verification: Several land marks picked from the maps were used during the 3 days of field ground observation to determine the accuracy of the map produced with the aid of a GPS. The observations made from the field were helpful in the interpretation of the result.

RESULTS AND DISCUSSION

A visit to the study area shows that the area is slummy with indiscriminate heaps of refuge dumps, swamps of flies and the stream is visibly polluted from household and industrial waste (Fig. 4 & 5).

Fig. 4: Buildings within channel showing septic discharging into the river at GadaBiu

Fig. 5: Curly River constricted buildings along west of mines

Table 1: Rate of urban encroachment from 1992 to 2010

Year	Rate of urban encroachment (Hectares/annum)
1992 – 2005	0.49
2005 – 2010	0.74
1992 – 2010	0.56

Table 2: Within distance Analysis

	No of built-up blocks		
Within distance of (m)	1992	2005	2010
5	32	150	167
10	35	300	346
15	40	470	544
20	44	661	761
30	52	1059	1200
40	61	1443	1657
50	70	1794	2084

To effectively understand urban sprawl, analysis of the changes in land use and land cover of the study area should be carried out [5]. The study reviewed a significant change in the built-up areas from 1992 to 2010 as area covered by Built-ups increased from 13.6 Hectares in 1992 to 23.7 Hectares in 2010 as seen in Fig.7. The indicator of urban sprawl along Curly River will be the increase in number of houses towards the river within 5m-50m buffer zones from 1992 to 2010, this is represented in Fig. 6. The rate of urban encroachment as seen in Table1 revealed that urban sprawl was higher from 2005-2010 as compared to 1992 to 2005. This is an indication that the sprawl is increasing yearly. The within distance analysis revealed the exact number of the buildings into the river between the study period as seen in Table 2. The results show that there were about 70 buildings in the 50m buffer zones but due to more people settling around the study area, the buildings had increased from 70 to 2084 in 2010. The Jos Metropolitan Development Board recommends a15m setback of built-ups areas from flood plains but unfortunately most of the urban built-ups in the study area are less than 15m from the channel of the Curly River. Field observations (Fig. 4 and 5) show people discharging waste from households and industries directly in to the river while the settlements down the river are using water from the river for domestic use. In 2012 according to [1] over 200 people were treated for diarrhea and dysentery after the flood outbreak in the study area. In 2012 also there was a flood event within the study area killing over 35 persons and destroying agricultural land and products along with over 200 properties [9] as seen in Fig. 8 & 9.

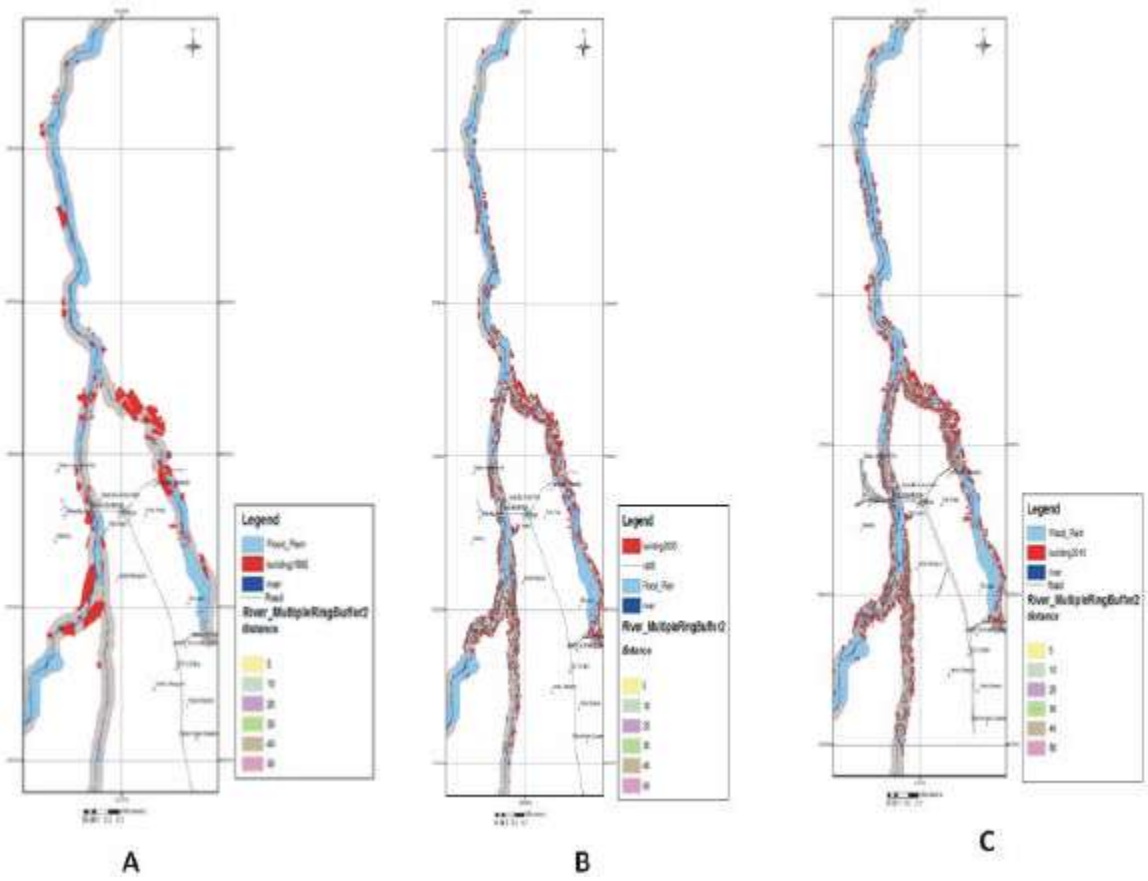

Fig. 6: Built-up areas shown in red; 1992 (A), 2005(B) and 2010 (C)

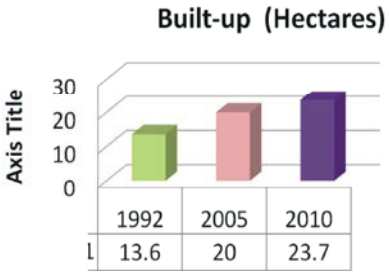

Fig. 7: Histogram showing increase in Built-up areas from 1992 to 2010

Fig. 8: Flood around the study area: Source NEMA 2012

Fig. 9: Damaged Agricultural Land as a result of flood around the study area: Source NEMA 2012

CONCLUSION

This study was carried out to examine urban Sprawl on the flood plains of the Curly River, Jos, Nigeria and delineate areas vulnerable to flood using remote sensing and GIS between 1992 to 2010. The geoinformatic approach determined the rate of urban sprawl in the study

area over the period of eighteen years (1992-2010) by studying the change in Built-ups. The study revealed that there was more growth between 2005 and 2010 as the rate of encroachment was 0.74 Hectares/annum as compared to 1992 – 2005 which was 0.49Hectares/annum and 0.56Hectares/annum in 1992-2010. From the buffer zones created and the within distance analysis carried out, built-ups within 5-15m buffer zone are highly vulnerable to environmental hazards such as flood and disease outbreak. Awareness should be created to let the policy makers as well as the populace know the dangers of building within the flood plains. Also there should be a policy to enforce flood mitigation measures such as tree planting and evacuating drainages. Further study to determine the socio-economic impact of the encroachment o n the Jos Curly River should be carried out.

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