An Analysis of Urban Expansion and Loss of Vegetation Cover in Lokoja, Using GIS Techniques

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An Analysis of Urban Expansion and Loss of Vegetation Cover in Lokoja, Using GIS Techniques

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ABSTRACT
Since Lokoja became an administrative headquarters of Kogi State in 1991, it has been experiencing rapid expansion, urbanization and significant changes in its physical landscape – land use and land cover changes. This study uses remote sensing and GIS techniques combined with field checks and survey to map land use and land cover changes and to measure the rate of urban expansion and loss of vegetation in Lokoja between 1987 and 2005. There was a considerable change in land use types over the said period of the study. The built-up area, vacant land, cultivated land and other land use types increased at the expense of vegetation cover. Indicating that the annual rate of expansion is about 187.8 hectares. Urban expansion has also led to environmental and ecological problems such as increase in surface temperature, erosion and major reduction in vegetation cover in Lokoja. Policy makers are requested to incorporate afforestation and establishment of parks within and around Lokoja into its town planning scheme

Key words: GIS, Land Use, Satellite Imagery, Urban Expansion, Vegetation

INTRODUCTION
Man’s interaction with his environment has been recognized as a major force shaping the biosphere, mostly its landscape. Human actions rather than natural phenomena are the source of most contemporary changes in the state and flow of the biosphere (Fasal, 2000).

Fasal (2000) asserted that land transformation is one of the most important fields of human induced environmental transformation. The rapid land use changes by the growing population reduce natural vegetation cover in most countries of the world (Nicolson, 1987). The process of urbanization expresses itself through a distinct set of land use and human behaviours. It brings about phenomenal socio-economic transformation in the surrounding areas. The propagation of urban influence has marked differential radial tendency measurable in terms of demographic component and land use assemblages (Nanda, 2005) and has also led to serious environmental and ecological problems (Zhao et al, 2006). Kalmay and Cai (2003) asserted that urban expansion can alter the local climate both in urban and surroundings areas.

A settlement represents the most profound human alteration of the natural environment through the construction of structures such as buildings, paved surfaces and compacted soil on the ground surface. For centuries nearly everyone lived in rural areas. In 1800, only 3 per cent of the world’s population lived in urban centers of 5000 or more and many of these behaved like large villages in their socio economic activities (UNCHBP, 1974). By 1900, 14 per cent of the world’s
population was living in urban centers and this proportion is increasing rapidly and today over 60 per cent of the population are living in urban centers (UNCHBP, 1974).

In Nigeria the growth and complexity of human settlements and in particular the process of urbanization have been phenomenal. In 1950, the percentage of the total Nigerian population living in urban centers was less than 15 per cent; by 1975, this proportion had risen to some 23.4 per cent. By year 2000, the proportion had gone up to more than 43.5 per cent and it has been projected to be more than 50 per cent by the year 2010 (Thematic Committee, 2001).

While the urban centers are growing in population and extent, the peri-urban areas are undergoing a two-fold transformation: with arable land coming under increasingly intense cultivation and both arable and non arable land being increasingly built over to provide space for commercial, industrial and residential establishments (Heimlich and Anderson, 2001).

There is hardly any vegetation that has not been affected by human activities in the world. Farming, logging, grazing, hunting, urbanization and other development activities by the rapidly expanding population have together reduced natural vegetation cover to patches on the surface of the earth.

In Nigeria, 400,000 hectares of vegetation cover is lost annually (Adesina, et al, 1999). Most of this vegetation is deliberately removed to make way for mineral exploiting, development of infrastructure such as roads and railway and expansion of settlements (Adesina, 2005). And also households across the nation have continued to rely on fuelwoods for domestic energy supply.

The loss of natural vegetation has great implications. Adesina (2005) listed the following as some of the implications:

i. Destruction of wildlife habitat;
ii. Depreciation or outright wiping off of genetic pool;
iii. Loss of food and medicinal herbs;
iv. Promotion of desertification and drought among others; and
v. Building up of green house gasses.

Urban areas are dynamic and complex in nature making conventional methods of data collection very tedious and tasking. Remote sensing and Geographic Information System (GIS) are effective and efficient tools for urban studies (Amujabi, 2006) because it is economical and easy to use in quick updating of maps than aerial photographs. However, GIS as shown to be a tool that is changing sources, interpretation and dissemination of viable information (Ifatimehin, 2005).

Lokoja’s development was largely due to its administrative status as a seat of government and also as the gateway and terminus for transit passenger. In the last few years, the town and its surroundings have undergone radical changes, including the expansion of its built up area and a transformation in its population’s occupational structure.

**OBJECTIVE OF THE STUDY**

The GIS Laboratory, Department of Geography and Planning, Kogi State University utilized remote sensing and GIS techniques to map the State administrative headquarters’ (Lokoja) natural and human resources and to examine how anthropogenic factor had disrupted the ecological system through poor land use and the increasing pressure put upon the available resources by the expanding population.

Based on the above circumstances, the objective for this study was to examine the extent of vegetation losses through urban expansion in Lokoja.
STUDY AREA

Lokoja is located on latitude $7^\circ\ 45'\ N \ - \ 7^\circ\ 51'\ N$ and longitude $6^\circ\ 41'\ E \ - \ 6^\circ\ 45'\ E$ (See Figure 1). Lokoja is the administrative headquarters of Kogi State. It is well connected and accessible through state and Federal highways. It is the gateway and the transit point between the North, East and Southern parts of the Country. It is also at the confluence of the two major rivers in Nigeria – River Niger and Benue.

The climate is characterized by wet and dry season - Aw type of climate as classified by Koppen and situated in Guinea Savanna region. The annual rainfall is between 1016mm and 1524mm with its mean annual temperature not falling below 27.7°C. A number of intermittent valleys exist, with streams criss-crossing the breadth of the town. And it is dominated by fine and medium grained sandstones.

In 1987, the town had 36603 inhabitants and a density of 6 persons per hectare. And by 1991, 43,784 inhabitants with a density of 7 persons per hectare. It was then estimated to have 81,673 persons by 2005 with a density of 13 persons per hectare.

Fig. 1 Map of Kogi State showing the study area

Source: GIS Lab, 2006
MATERIALS AND METHODS OF DATA COLLECTION

This study is based on remotely sensed data – satellites imageries combined with extensive field checks and surveys.

The study examines an 18 year time span (1987 - 2005). This span of year is to determine the trend of change in Lokoja between the time before it acquired the status of being a state capital and after. The urban land use and transformation mapping of Lokoja and its surrounds was done with the help of LandSat TM satellites imagery on a 1:250,000 scale acquired in 1987 and NigeriaSat 1 satellite image on a 1: 250,000 scale acquired in 2005. These imageries have a spectral resolution of 30 metres and 32 metres respectively.

The Flow chart (Figure 2) below shows the image processing and analysis methods applied in the research objective. During field survey, land use types were identified and marked with GPS. Commercial and residential buildings were not separated because the buildings in the area were serving both purposes.

![Flowchart of methods applied in the study](image)

**Geometric correction of Landsat TM and NigeriaSat 1 data**

All the imageries were georeferenced with coordinates in latitude and longitude and Universal Transverse Mercator (UTM). All the imageries were sampled to 30m to 30m pixel size using Nearest Neighbour.

**Visual Interpretation of Landsat TM and NigeriaSat 1 data**

The imageries were in False colour Composite (FCC) which gain better visualization and recognition of heavily vegetated areas, cultivated areas, water body and settlements.
Classification of remotely sensed data

Mather (1999) considered classification to be the process of pattern recognition of the pattern associated with each pixel position in an image in terms of the characteristics of the objects or materials present at the corresponding point of the Earth’s surface. Its major functions are spatial, spectral and temporal pattern recognition (Syed and Abdulla, 2002). Maximum likelihood classification algorithm was used.

Training sample sets were collected based on the ground truth data gathered during field checks. Following completion, it was run on mosaic. Statistical data was then extracted from the classified sample set. Most of the work was done in a GIS environment provided by ILWIS academia 3.2 software. Because the use of GIS techniques coupled with remote sensing are essential elements for the preparation of an integrated development plan. Fasal (2000) asserted that both can provide the means for the rapid production of accurate and up to date databases for planners at all levels.

RESULTS AND DISCUSSION

Urban Land use in Lokoja

It is evident from Table 1 and figure 3 that the older part of the town has become increasingly congested while the town has expanded outwards haphazardly covering cultivated land and vegetation in the fringe.

<table>
<thead>
<tr>
<th>Land use type</th>
<th>1987 Area (ha)</th>
<th>%</th>
<th>2005 Area (ha)</th>
<th>%</th>
<th>% change 1987-2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacant Land</td>
<td>25</td>
<td>0.39</td>
<td>252</td>
<td>4.0</td>
<td>908</td>
</tr>
<tr>
<td>Built-up Area</td>
<td>34</td>
<td>0.53</td>
<td>1031</td>
<td>16.2</td>
<td>2932.3</td>
</tr>
<tr>
<td>Cultivate Land</td>
<td>1822</td>
<td>28.55</td>
<td>3818</td>
<td>59.8</td>
<td>109.6</td>
</tr>
<tr>
<td>Natural Vegetation</td>
<td>4221</td>
<td>66.14</td>
<td>841</td>
<td>13.1</td>
<td>-401.9</td>
</tr>
<tr>
<td>Others</td>
<td>280</td>
<td>4.39</td>
<td>440</td>
<td>6.9</td>
<td>57.1</td>
</tr>
<tr>
<td>Total</td>
<td>6382</td>
<td>100</td>
<td>6382</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Laboratory and field observation, 2006

The various land use classes in the study area recorded significant increase during the study period with the exception of vegetation which is declining. Table 1 shows a substantial increase of the built-up area (2932.3 per cent) followed by vacant land (908 per cent), cultivated land (109.6 per cent) and others – paved surfaces, water bodies etc, (57.1 per cent). All these increases were at the cost of vegetation cover which was reduced by 401.9 per cent. The salient characteristics which emerge by comparing the two maps in Figures 3a and 3b are outlined below:

Lokoja has recorded a significant increase in the built-up area mainly due to population growth and development in its formal and informal sectors of the economy. But the expansion has been haphazard and unplanned even the most recent housing estate projects being built by the Government. This has contributed to road traffic congestion, overflowing of drainages and improper waste disposal.

Importantly, despite the growth in population and the increase of the built-up area, there has been little change in infrastructure provision and services in the town. It is clear from Figures 3a and 3b that the city is expanding mainly to the south; this is because the built-up area is sandwiched between Patti ridge and River Niger. Another important feature of the town land use
change is the large increase in the amount of vacant land (908 per cent). Vegetation is being cleared and fenced for the development of infrastructure. At present, this land is neither used for urban development nor for agricultural purposes, the landowners await increase in land values.

**Land Transformation in Lokoja**

Natural and Human processes make land to be in a continuous state of transformation. Table 2 shows land transformation during the period of study.

i. Vacant land increased from 25 hectares to 252 hectares gaining land from the built-up area (4 hectares), vegetation (109 hectares) and cultivated land (126 hectares). This as a result of Land speculation and urban renewal.
Table 2: Land Transformation in Lokoja (1987 - 2005)

<table>
<thead>
<tr>
<th></th>
<th>Vacant Land</th>
<th>Built-up Area</th>
<th>Cultivated Land</th>
<th>Vegetation</th>
<th>Others</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacant Land</td>
<td>1</td>
<td>25</td>
<td>126</td>
<td>109</td>
<td>-</td>
<td>252</td>
</tr>
<tr>
<td>Built-up Area</td>
<td>2</td>
<td>12</td>
<td>34</td>
<td>124</td>
<td>865</td>
<td>1031</td>
</tr>
<tr>
<td>Cultivated land</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>1822</td>
<td>2246</td>
<td>3818</td>
</tr>
<tr>
<td>Vegetation</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>4221</td>
<td>-</td>
<td>841</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>160</td>
<td>280</td>
<td>440</td>
<td>440</td>
<td></td>
</tr>
</tbody>
</table>

Source: Laboratory and Field observation, 2006.

Notes: Figures in Bold (diagonally) are area under that particular land use in 1987, while figures in the same column represent the shift in area to other land uses. Similarly, figures in the same row are increase in area captured from the land uses.

ii. The built-up area increased from 34 hectares to 1031 hectares, gaining land from vacant land (12 hectares), cultivated land (124 hectares) and vegetation (865 hectares);

iii. Cultivated land increased from 1822 hectares to 3818 hectares, gaining 2246 hectares from vegetation;

iv. Paved surfaces, water bodies etc, increased from 280 hectares to 440 hectares, gaining 160 hectares from vegetation.

It is evident as shown in Table 3 that the effect Lokoja’s expansion was on natural vegetation cover alone, decreasing from 4221 hectares to 841 hectares.

Loss of Natural Vegetation due to urban expansion

Tables 1, 2, and 3 and Figures 3a and 3b show that the area under vegetation cover has declined. There was indeed a tremendous increase in the urban area while a total of 3380 hectares of vegetation cover was lost due to the town’s expansion.

Table 3: Loss of Natural vegetation cover in Lokoja environs, 1987 - 2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural vegetation cover area</th>
<th>Loss of natural vegetation cover</th>
<th>Time in years</th>
<th>Arithmetic mean loss per year</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hectares</td>
<td>%</td>
<td>Hectares</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>4221</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>841</td>
<td>3380</td>
<td>193.5</td>
<td>18</td>
<td>187.8</td>
</tr>
</tbody>
</table>

Source: Laboratory and Field observation, 2006

Table 2 shows that of the 3380 hectares of vegetation that was lost, 2355 hectares are recoverable (Land where no permanent construction has taken place and land transformation to vacant land and cultivated land) and 1025 hectares are not recoverable (Land where permanent construction had taken place). It is evident too that cultivated land took about 53.2 per cent (2246 hectares) of the area lost to vegetation. And the cultivated land dominates the entire urban landscape of Lokoja with about 59.8 percent (3818 hectares) of the total landscape area.

Lokoja is expanding at about 187.8 hectares annually. This implies that within the study area, the vegetation covers will be completely lost in about 4 – 5 years from now.

The implication of this rapid loss in vegetation cover is the change in thermal properties of built-up land surfaces that would result in more solar energy being stored and converted to sensible heat and the removal of vegetation cover that reduces those natural cooling (effects of
shading and evapotranspiration). The average ambient temperature in urban areas is generally 2 – 3 degrees higher than in non urban area (Nowak et al, 2002), which can cause discomfort and even health risks in the study area as it has in locations such Shanghai in China (Zhou et al, 2004). Indeed, Lokoja is already reported warm (Ogu, 2006). Also, the exposure of the soil to surface run-off would perhaps make erosion to increase steadily (Jimoh, 2003). And very soon cultivated land will start declining as a result of the continuous nature of land transformation through urban expansion in Lokoja.

CONCLUSION

In this study, we have looked at the role which geoinformation (Remote sensing and geographical Information Systems) is playing and could still play in the awakened desire for sustainable development with respect to urban expansion and on the uses of natural resources.

Some of the main findings of the present study are as follows:

i. there has been rapid conversion of vegetation cover to other land uses;

ii. the built-up area has increased in all directions most especially in the southern part of the town;

iii. cultivated land has increased more than any other land uses;

iv. in the study, some 3380 hectares of vegetation cover is lost between 1987 and 2005, of which 2355 hectares are recoverable and 1025 hectares are not;

v. the rapid loss of natural vegetation can be related to the increasing warming nature of Lokoja; and

vi. increase in cultivated land can also be related to urban poverty.

Finally, although urban expansion can not be stopped, with proper management and planning, it can be directed in a desirable and sustainable way, protecting the vegetation cover which always serves as the ecosystem service provider to the urban centres and also policy makers should incorporate afforestation and establishments of green belts and parks into the town planning schemes.

REFERENCES


Ifatimehin, O.O. (2005): Why GIS matters; Our Common Environment; Dept of Geo and Planning, KSU. Anyigba Vol 1 (1) pg 8 – 9

Mather, P.M. (1999): Computer processing of remotely sensed imageries – An introduction; John Wiley and Sons, Toronto
Syed, A and S.M.S. Abdulla (2002): Assessing Desert vegetation cover using remotely sensed data: A case study from the State of Qatar
Zhau, S; Da, L; Tang, Z; Fang, H; Song, K and Fang, J. (2006): Ecological consequences of rapid urban expansion: Shanghai, China; Frontiers in Ecological Environ; The Ecological Society of America, Vol 4(7): 341-346