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# URBAN SPRAWL, PATTERN AND MEASUREMENT IN LOKOJA, NIGERIA

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**Abstract**
Lokoja have been experiencing a large influx of population from its surrounding regions, which had led to rapid growth and expansion that had left profound changes on the landscape in terms of land use and land cover. This study uses the GIS techniques and the application of Shannon's entropy theory to measure the behavior of sprawl which is based on the notion that landscape entropy or disorganization increases with sprawl, analysis was carried out based on the integration of remote sensing and GIS, the measurement of entropy is devised based on the town location factors, distance from roads, to reveal and capture spatial patterns of urban sprawl. Then Entropy value for each zone revealed a high value, especially areas outside the core city area; like Felele, with the entropy of 0.3, Adankolo, 0.2 and Lokongoma, 0.2. These areas are evenly dispersed settlement, as one move away from the city core. Study shows a correlation of population densities and entropy values of 1987 and 2007, for areas like Felele ,Adankolo, and Lokongoma , which is indicative of spread over space , an evidence of sprawl. But as we go down the table the entropy values seem to tend towards zero. This study provides quantitative data for effective planning and decision making in projecting the town growth and in planning the direction of growth.
**Keywords**: urban sprawl, patterns of sprawl, entropy theory

## 1. Introduction

Urban sprawl may be defined as the scattering of new development on isolated tracts, separated from other areas by vacant land (Lata, et al. 2001). It has also been described as leapfrog development (Jothimani, 1977; Torrens and Albert, 2000). The need for monitoring urban development has become imperative to help curb the problems of this type of growth.

Monitoring urban development is mainly to find the type, amount and the location of land conversion for future planning (Shekhar, 2001). Urban sprawl varies in degrees between the developed and the developing world and subsequently they have differing consequences.

In a developing country such as Nigeria, development in urban areas and miscellaneous landuse types are isolated in the fringe areas followed by gradual filling of intervening spaces with similar uses, this is mainly due to rapid growth in population size which is usually uncontrolled.

The rapid rate of urbanization being experienced in Lokoja, Kogi State Nigeria, has created serious environmental problems noticeable along the Lokoja metropolis there is the unguided and uncontrolled

expansion without due consideration to interrelated factors such as transport, employment, health and other livable factors. The city is experiencing expansion in all directions resulting in large scale urban sprawl and changes in urban landuse. This is noticed in the on the city fringes, this have increase the built up area and changes in land use patterns which had led to loss in valuable agricultural lands, natural forest cover and anthropogenic encroachment on fadama areas, and loss of surface water bodies and biodiversity .There is therefore a need to monitor such changes and to understand the processes, so as to be able to measure and plan so as to direct growth for healthy development.

## 2. Pattern of Sprawl in Lokoja

The fringe areas of the town of the Lokoja area, Felele, Ganaja area characterized by Random, sporadic and fragmented urban growth which had hindered development towards optimum units in the promotion of local public utility and services. Discontinuous urban growth is also posing the problem of land speculation.

Studies have shown that in areas of sprawl, of the study areas, like Lokongoma only 22% is connected to National Electricity Power Supply, subsequently 7% for Ganaja area and 7.1% for Otokiti area (Alabi and Ufuah, 2007).

The direction of expansion has been observed to tend towards the Okene-Kabba road and the Lokoja-Ajaokuta roads in a ribbon spread pattern. Land adjacent to these roads is developed but those without direct access remain in the rural uses/covers. The city is experiencing 'leapfrog' development due to lack of proper planning.

Remote sensing has been used to monitor this urban development, similar research have been carried out elsewhere by Howarth (1986), Fung and LeDew (1987), Li and Yeh (1998) and various techniques have been developed for land growth detection efficiency, including image differencing (Toll et al, 1980), Image rationing (Nelson, 1983), Masking Method (Pilon et al, 1988) and principal component analysis (Fung and LeDew, 1987; Li and Yeh, 1998).

## 3. Aim and Objective of Study

The aim of this research is to study the pattern and measure sprawl, this is to be carried out by using the Entropy (E) Method, which is based on two location factors, distances from the town centre and distance from roads to show and capture spatial pattern of sprawl.

## 4. Study Area

The study area, Lokoja lies between latitudes $7^0$45'N and longitude $6^0$45'E. Lokoja is the administrative headquarters of Kogi State in Nigeria. It is well connected and accessible through state and federal highways. It is also located close to confluence of the River Niger and Benue; the area is sandwiched between a water body and a hill i.e. River Niger and Mount Patti respectively which had streamlined the settlement to a linear one and has a modifying effect on the climate.

The climate is characterized by wet and dry season. AW type of climate as classified by Koppen's and situated in Guinea Savanna Region. The annual rainfall is between 1016mm and 1524mm with the mean annual temperature of $27^0$7"C.

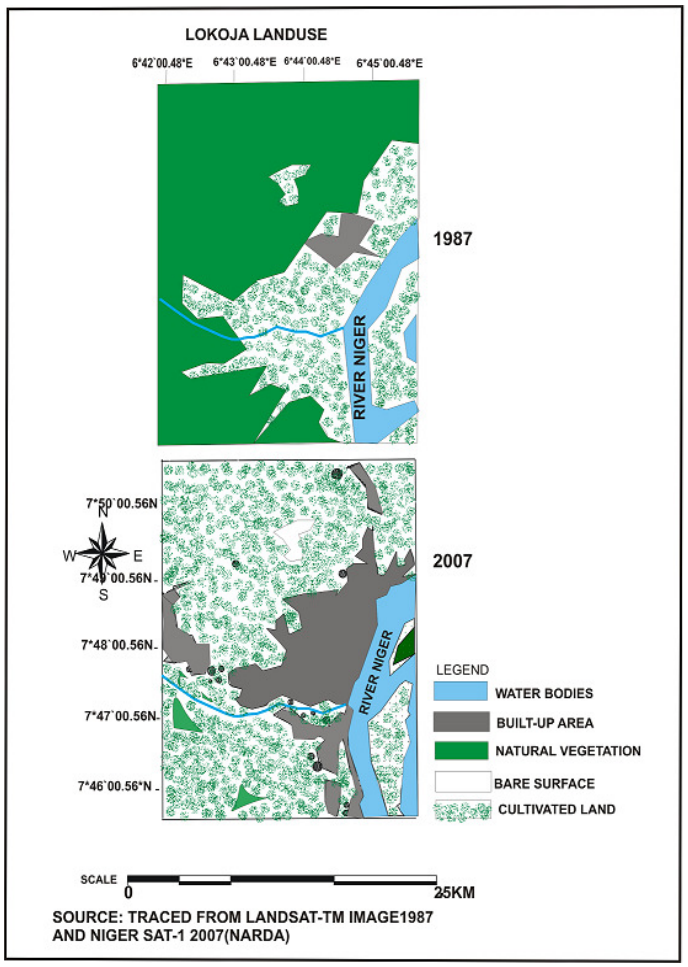


FIGURE -1 SHOWING LANDUSE IN LOKOJA IN 1987 AND 2007.
ARROW SHOWING DIRECTION OF SPRAWL.



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## 5. Data Sets and Methodology

In the present study a processed geo-referenced remote sensed data was used as a base for image registration. Images were traced from Landsat Tm, 1987 and Nigersat-[1]; 2007. The traced image characterized can be seen on fig.1.

Landuse/land cover estimates of the previous years were obtained from the local records for the period 1987-2007.

Six zones of the town were selected, which serves as growth poles. It was however a bit difficult to separate various landuses i.e. the Residential from the commercial, the six growth points where characterized by mixed landuses. The area selected includes the Felele, Adankolo, Lokongoma, Sarkin Noma, Ganaja and Otokiti areas.

## 6. Measuring Urban Sprawl

Urban sprawl was determined by computing the area from the digitized topo sheets and comparing it with the area obtained from Landsat Tm and Nigeria Sat 1-image.

Shannon's entropy was then used to measure the degree of spatial concentration and dispersion exhibited by geographical variable (Theil, 1967; Thomas, 1981; Shekher, 2001).

This measure is based on the notion that landscape entropy or disorganization increases with sprawl. Urban landuses are viewed as interrupting and fragmenting previously homogenous rural environment thereby disorganizing the landscape. In the analysis the six selected zones and their boundaries digitized from scanned map, two types of thematic layers were used for the calculation of densities of land development in each zone, here the point boundaries formed one layer and the built up area formed the other layer. The density of the built up area was calculated from dividing the built up area of each area by the total area. Consideration was given to locational factors such as distance from urban centres, and roads, buffer zones where then created from cores, and highways.

The buffer zones were created in the Arc view GIS and overlayed on Image built up area theme, and the density for each zone was calculated and the entropy values were found for the zones.

TABLE 1 – POPULATION OF LOKOJA (BY SELECTED GROWTH POINTS)

| Name of Area | % Built up area | Population 2006 | Projected Population 2007 | Total Area Km² | Built up area Km² | Population density 1987 | Population density 2007 |
|---|---|---|---|---|---|---|---|
| Felele | 7.1 | 8060 | 9028 | 19.0 | 1.35 | 47515.7 | 66923.96 |
| Adankolo | 26.5 | 22906 | 24046 | 37.0 | 9.81 | 65124.3 | 24569.1 |
| Lokongoma | 18.1 | 18820 | 22260 | 27.9 | 5.01 | 79784.9 | 44080.5 |
| Sarkin Noma | 79 | 6026 | 8092 | 14.7 | 1.2 | 55047.6 | 69605.3 |
| Ganaja | 13.2 | 25896 | 28230 | 24.0 | 3.2 | 71665.3 | 54433.7 |
| Otokiti | 7.8 | 7092 | 12220 | 16.5 | 1.3 | 74060.6 | 94949.9 |

Source: Survey 2008

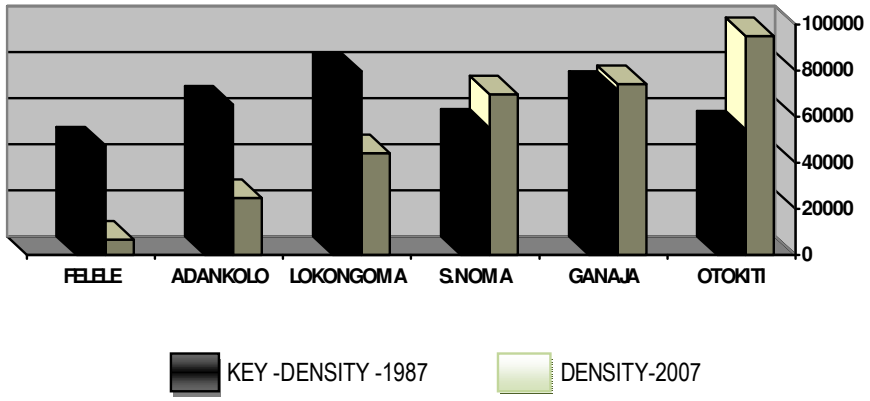


FIGURE -2 SHOWING DEGREE OF SPATIAL CONCENTRATION AMONG ZONES FROM 1987AND 2007.

Entropy (E) can be calculated using the formula $\sum = E\ P\ DEN_i\ Log\ (1/PDN_i)/Log\ (n)\ i$

Where DEN is the density of Land development, which is equal to the amount of land development (i.e. Built up area) divided by the total amount of land in the $i^{th}$ zone in a total of n zones. Since entropy can be used to measure the distribution of a spatial phenomenon, the difference on entropy between two different periods of time can also be used to indicate the change in the degree of land development or urban sprawl.

TABLE 2 – SHOWING ENTROPY OF SELECTED ZONES

| Name of Area | Total Area Rm² | Built up Area Km² | Density of land (PDEN) | Log ( 1/PE/Log(n)) | Entropy |
|---|---|---|---|---|---|
| Felele | 19.0 | 13.5 | 0.7 | 0.4 | 0.3 |
| Adankolo | 37.0 | 9.81 | 0.3 | 0.7 | 0.2 |
| Lokongoma | 27.9 | 5.01 | 0.2 | 0.9 | 0.2 |
| Sarkin Noma | 14.7 | 1.2 | 0.1 | 1.2 | 0.1 |
| Ganaja | 24.0 | 3.2 | 0.1 | 1.2 | 0.1 |
| Okotokiti | 16.5 | 1.3 | 0.1 | 1.2 | 0.1 |
| Total | 139.1 | 34.0 | 1.5 | 17.3 | 1.0 |

Source: survey 2008

This can be done using the table 2. From this table the total entropy value is one i. e

$$E = \sum_{i}^{n} PDE\ N \quad Log\ (1/PDEN\ /Log\ (n) = 1.\ 0$$

## 7. Discussion

From the table 2 above, it is evident that there is pressure on land, considering the increase in population, over study period.

Then Entropy value for each zone revealed a high value, especially areas outside the core city area; like Felele, with the entropy of 0.3 and Adankolo, 0.2. These areas are evenly dispersed settlement, as one moves away from the city core. This shows a correlation with figures of population densities on the figure 2, where the chart shows a reduction in density of population from 1987 to 2007, for areas like Felele and Adankolo, which is indicative of spread over space , an evidence of sprawl.

But as we go down the table the entropy values seem to tend towards zero; example areas like Sarkin-Noma, shows entropy of 0.1.

Ganaja, 0.1 and also Otokiti, 0.1, this can also be correlated with chart on figure -2, which indicates increase in density and compaction, which is indicative of an evenly dispersed distribution across space; this area also shows a maximum concentration of settlements away from the city core, this can be corroborated from the traced satellite images on figure-1, which shows how this areas have leaped forged from the core to form a concentrated settlement outside the main core zones. It therefore possible to analyze the spatial pattern of sprawl over different time periods and systematically mapped , monitored and accurately assessed from remotely sensed data in conjunction with conventional ground data, the increase population has continue to exert pressure on available land in the town and the town limits had been pushed towards fringes.

By applying also the entropy formula, the value of 0.8220, for the road buffer zones was obtained; it revealed that the city has a high degree of sprawl along the highway, this is mainly because of the presence of Natural features which had posed constraint to the physical development of the town, especially towards the northwestern part which is restricted by the Patti ridge. In the south western part development is also it is constrained by the presence of the Meme stream and its various tributaries transversing the land mass, making some part of the area liable to flood. There is also the presence of the River Niger on the entire eastern side of the town.

## 8. Conclusion

The study shows that Lokoja is experiencing growth along the major highways transversing the city. New development areas are concentrated along the workers village, tapering along the Kabba-Okene road ,that also, another area of recent expansion is towards the Ganaja – Ajaokuta road where several government estates had sprung up and some privately owned estates. The total entropy value of the town indicates a value -1, which is an indication of the occurrence of sprawl.

These finally indicates that entropy is a good way of measuring and monitoring spatial distribution of urban phenomena, the result of which will help planners to monitor, identify areas of the city which needs immediate attention , especially where sprawl takes place and to understand the intensity , degree of sprawl and to direct growth in managing the city.

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