# EXPLORATION OF MUNICIPAL EXPANSION AND LAND-USE TERRESTRIAL COVER CHANGE: A STUDY OF LOKOJA, NIGERIA.

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**Abstract:** Lokoja, like many African cities, has been experiencing rapid population growth in recent decades due to mass immigration and economic growth. However, the growth is taking place in an unplanned manner creating sprawling low-density development and uneconomic use of land and environmental resources with adverse effects on the environment. This paper analyses urban expansion and its implications on the environment with a view to improving planning and management of urban growth. The study uses remote sensing and geographic information system techniques to map and quantify land use/land cover changes, measure the rate of urban expansion and examine the pattern of development between 1991 and 2014. Supervised classification of Landsat imageries of 1991, 2001 and 2014 was used to classify land use/ land cover types. The built-up area doubled in size between 1991 and 2001 and almost doubled by 2014 while the city was expanding at 1.2Km²per annum between 1991 and 2014.The major changes in land use land cover were in the forest and shrub/vegetation areas which decreased by 53% and 11.6% respectively. The results indicate widespread degradation of the environment. The study also provides an additional insight on the pattern of residential development. The characteristic leap frog nature of development results in excessive consumption of land which exerts important consequences on the environment and creates conditions that make it difficult to achieve sustainability. The paper concludes by recommending for a physical development plan and stringent implementation of development control to guide the growth of the town.

**Keywords:** Urban Expansion, Land Use/ Land Cover Change, Remote Sensing, Geographic Information System



## 1 .Introduction

More than half of the world's population live in urban areas (UNCHS, 2001; Bloom, Canning&Fink, 2008), generating about 80% of economic growth. In Africa and other developing countries, urban growth is taking place at a rapid rate and forecasts show that practically the majority of the future population will be concentrated in cities (Badiane, 2006; Grandos & Bocco, 2002). The Urban land expansion is the most easily identifiable characteristic of urbanisation process as it affects land use /land cover (LULC) at both regional and global scales. Urban land expansion according to Liu,Zhan & Deng (2005) is the spreading out of thecity and its suburbs toward non-builtup areas at the periphery of an urban area. This process involves the conversion of other land use categories into built-up developed land over time. In developing countries, the growth is taking place in an unplanned manner creating sprawling low-density development and uneconomic use of environmental resources. This fact has led to concern about the impact of urbanisation on the environment, including urban consumption patterns and the environmental footprint of cities (UNCHS, 2001; Rakodi, 1997). The various

types of environmental and socioeconomic problems linked to urbanisation raise the question of whether urbanisation is sustainable. Understanding the growth and change brought on by urbanisation is critical to environmental scientists, urban planners and managers who need to design policies to address the changing environment.

Urban growth causes high density in settlements on one hand, while on the other hand, the dispersal characteristics of growth extend the urban area beyond the fringe to create built-up communities that are isolated from the city by areas of undeveloped land and which increases costs of infrastructural provision. The periphery (suburb, rural-urban fringe, peri-urban) becomes a zone of interaction where urban and rural forces meet and competition for land and other natural resources between newcomers and old communities arises. Land use change can play an important role in environmental changes and contribute to global change and biodiversity loss (Chen, Wang & Qui, 2001).The fringe zone is frequently associated with theconversion of prime agricultural land, vegetation and open spaces, and widespread development of marginal land. It is also the zone where migrant population finds suitable abode perhaps due mainly to economic reasons (Adesina, 2007), lacking in access to basic sanitation and poor housing conditions with severe consequences that potentially affect millions of people (Sanchez-Rodriguez, 2002). Also, the fringe zone is characterised by mixed land uses, where rural activities and mode of life are in rapid retreat and many forms of urban land use are being established. This pattern of development exerts important consequences on ecologically sensitive and risk prone areas through their impacts on soil and water quality and climatic systems (Chen *et al.,* 2001), resulting in serious environmental problems from local to global level. Understanding of land use changes is essential for sustainable management of the environment and urban areas.



Unhindered urban growth and expansion increasingly call for detailed inventories of its components, the changes that took place in the past and the consequences on the environment. This is particularly important in areas undergoing fast unplanned changes such as Lokoja where development control has not been effective. Even though Lokoja has a long history of urban planning dating back to the colonial era, the Master Plan has long been overdue for review since 2009.

Land use /land cover (LULC) change analysis and projection provide a tool to assess ecosystem change and their environmental implications at various temporal and spatial scales. Despite their relevance, quantitative data describing where, when and how change occurs are incomplete or inexact and the conventional manual tools for the mapping and analysis of urban expansion are slow, tedious and expensive, and widely criticised by researchers as being subjective. However, Remote Sensing and Geographic Information System (RS &GIS) provide a cost effective and sound tool and are increasingly being used to provide useful sources of information to run different urban change models desirable in urban planning and management to support decision making (Clarke & Gaydos, 1998). RS & GIS technique are very useful to urban planners and has been used increasingly in urban, rural and regional studies (Lee, 1990; Chen, 1992).

This paper focuses on the impact of rapid urbanisation on the land use of the urban fringe of Lokoja and the implications of these changes for the environment. The paper is guided by the following key questions. What are the effects of the rapid physical expansion of the city of Lokoja on land use/ land cover of the urban fringe? How is the physical environment affected by these changes? What are the challenges of these changes for the management of the urban area?

## 2. Methodology

### Study Area

Lokoja is the capital of Kogi State and lies at an altitude of 45-125metres above sea level. It is located at latitude $7^0$ 45'N and $7^0$51'N and longitude $6^0$ 41'E and $6^0$45'E (Fig.1). It lies on the western bank of the River Niger, close to its confluence with River Benue and sandwiched between the River and the mount Patti. The town is characterised by atropical climate that comprises of wet and dry seasons and falls within the Guinea Savannah belt. The annual rainfall is about 1150mm, with mean annual temperature of about $27.7^0$C. The terrain of the region comprises of dissected undulating plains on the one hand and lofty hill masses on the other. Mount Patti is the dominant physical feature of the town coupled with a number of intermittent valleys and streams crisscrossing the breadth of the town.

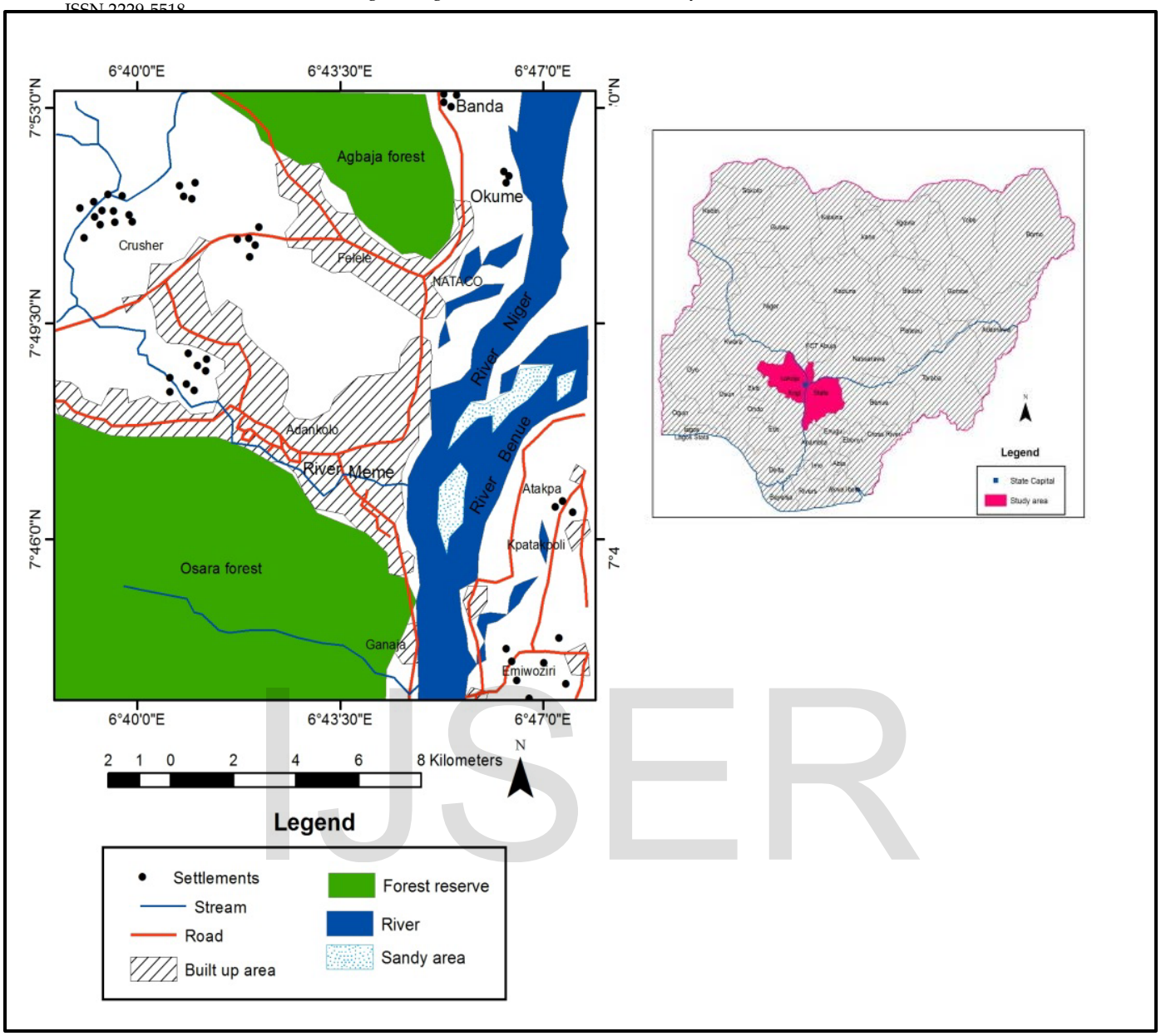


**Figure 1: Lokoja: Study Area**

Source: Adopted and Modified from Lokoja Urban Area, 2013.

## Materials and Methods

The data used in this research were Landsat 5 Thematic Mapper (TM) Satellite imagery of 08.01.1991, Landsat 7 Enhanced Thematic Mapper (ETM) Satellite imagery of 09. 01.2001 and a Landsat 8 Satellite imagery of06. 01.2014, all with a spectral resolution of 30 meters. The images were interpreted with Integrated Land and Water Information System (ILWIS) 3.3 academia and ArcGIS 10.1 to generate the LULC map of Lokoja.

The imageries were imported to a readable format with ArcGIS 10.1. Radiometric enhancements and geo-referencing were not necessary since the images already had these properties at the time of acquisition. The same coordinates were then used to subset the satellite imageries of the study area. The subsets were done in ArcGIS 10.1 environment. Thereafter, the false colour composites of the images were assigned and the thermal and panchromatic bands were excluded. Data set for the study was imported from ArcGIS 10.1 environment to ILWIS 3.3 academic software format where sample set was created for image classification. The images were used to classify land use types. The various visible to near infra-red (NIR) bands of the imageries were merged, subset and geo-synchronised for precision and classified using the maximum likelihood algorithm and supervised classification techniques were employed in the analyses of the different features on the images. The image data were classified into various themes or classes based on the land use/ land cover scheme. These classes were generated based on the reconnaissance survey of the study area. The information collected during the field surveys was used to assess the accuracy of the classification. This exercise resulted in a successful classification into eight land cover classes, namely; Bare surface, Built-up area, Forests, Residual hills, Scattered cultivation, Shrub/vegetation, Water bodies, Wetland/fadama. The digitised images show the changes that have occurred in the study area over the period 1991 to 2014 (Fig. 2).

Change detection and change analysis were performed to detect the spatial growth (lateral expansion) and to analyse the dynamics of the changes respectively. Classified images of the different years were over laid to create a new change image to detect the changes in LULC over the period. The over lay entailed placing the new classified image over the old one in a GIS environment to generate change matrix to show all the changes that have occurred in the study area over the study period.



## 3. Results and Discussion

### Changes in land use/land cover in Lokoja between 1991 and 2014

Land use changes between 1991 and 2014 were mapped using classified images. Some of the land use classes recorded significant changes while others remained practically the same (Figures 2a, b, c and Tables 1and 2). The built-up area has increased steadily from 15.73 km² in 1991 to 31.13km² in 2001 and 42.99km² in 2014, constituting a net increase of 27.26km² over the 23 years study period. The percentage of the expansion of the built-up area of Lokoja increased from 5.4percent in 1991 to 14.8% in 2014 based on supervised classification of images. The average annual rate of urban expansion between 1991 and 2014 was 1.2 km². The increase in the built- up area moved hand in hand with population growth (Table 3), suggesting that growth in population and economic activities of the various individuals are responsible for the rise in thedevelopment of structures for various purposes and the urban expansion.

Another major increase was recorded in wetland/fadama use which showed a significant rise leading to 37.93km², indicating anincreasing level of deposition. This is not surprising,

considering that the channel of the river Niger is shrinking. These increases were at the expense of forests and shrub/vegetation cover which declined in size over the period. For example, forest decreased from 16.93km² in 1991 to 9.14km² in 2001 and 7.75km² in 2014, constituting a net decrease of 9.18km² over the study period and shrub/vegetation cover decreased from 152.63km² in 1991 to 134.99km² in 2014, a net decrease of 17.64km². The decline in forest and other vegetation cover are attributable to a number of reasons such as extensive felling of trees in order to create space for development, bush burning and or a change in climatic conditions. At this rate of vegetation decline within the study area, the vegetation cover may be completely lost in a few years if forest and vegetation protection measures are not put in place. The implications of this rapid loss of vegetation cover are aloss of biodiversity and increase in temperature. As has been documented by Nowak, Crane, Stevens & Ibarra(2002) this could cause discomfort and health risks.

Scattered cultivation is another land use that showed asteady pattern of decrease. It decreased from 22.62km² in 1991 to 14.76km² in 2001 and 14.02km² in 2014, representing a decrease of 8.6km² in a period of 23 years. This could be explained by more cultivation on wetland/fadama land following the Kogi state policy on agricultural transformation which focuses on wetland/fadama land in Lokoja. The sizeable level of bare surface and the predominance of residual hills predispose Lokoja to soil erosion and land degradation if development is not carefully controlled.

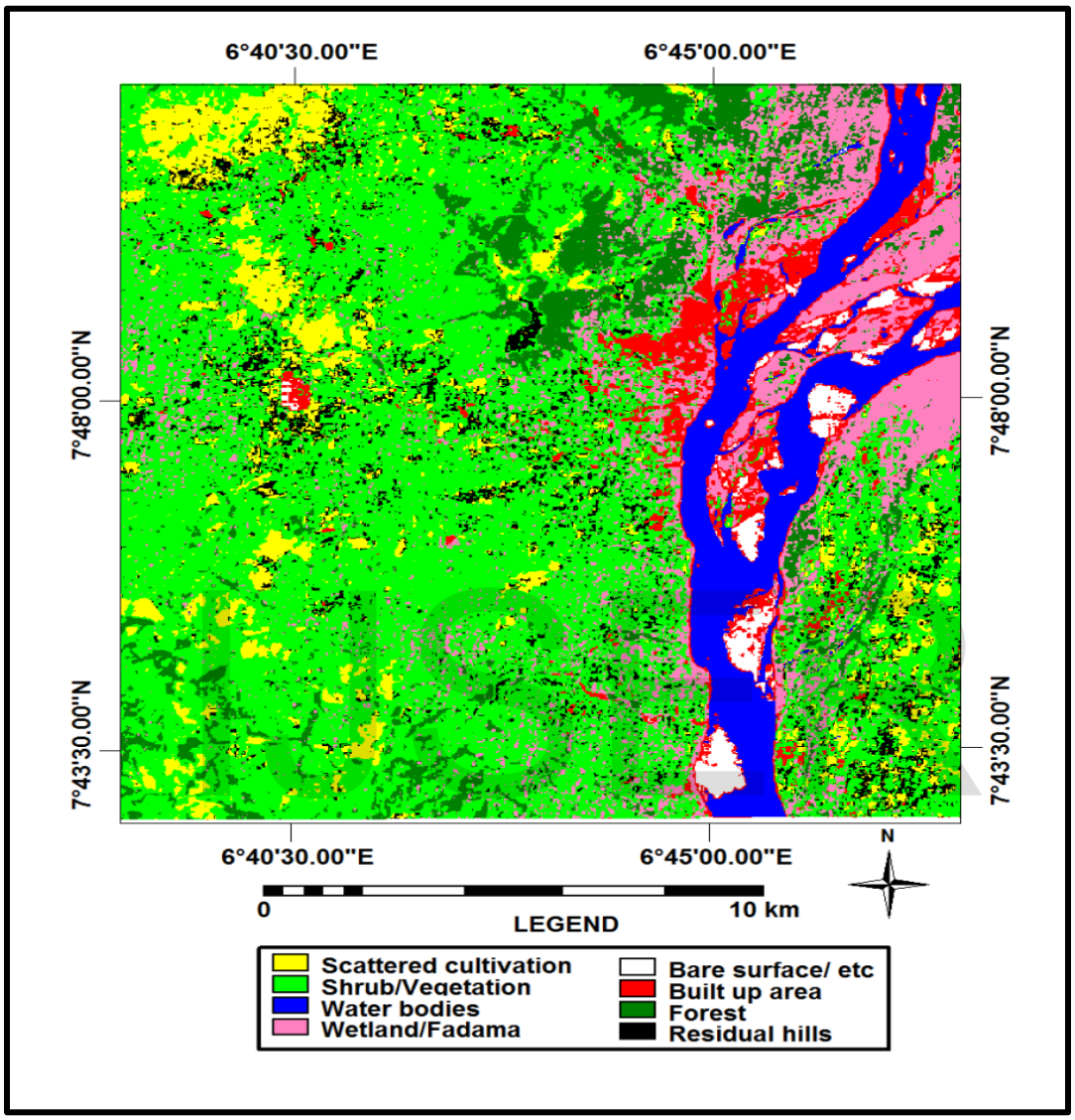


FIG.2 a: CLASSIFIED LANDSAT TM IMAGERY OF 1991

Source: Laboratory analysis, 2014.

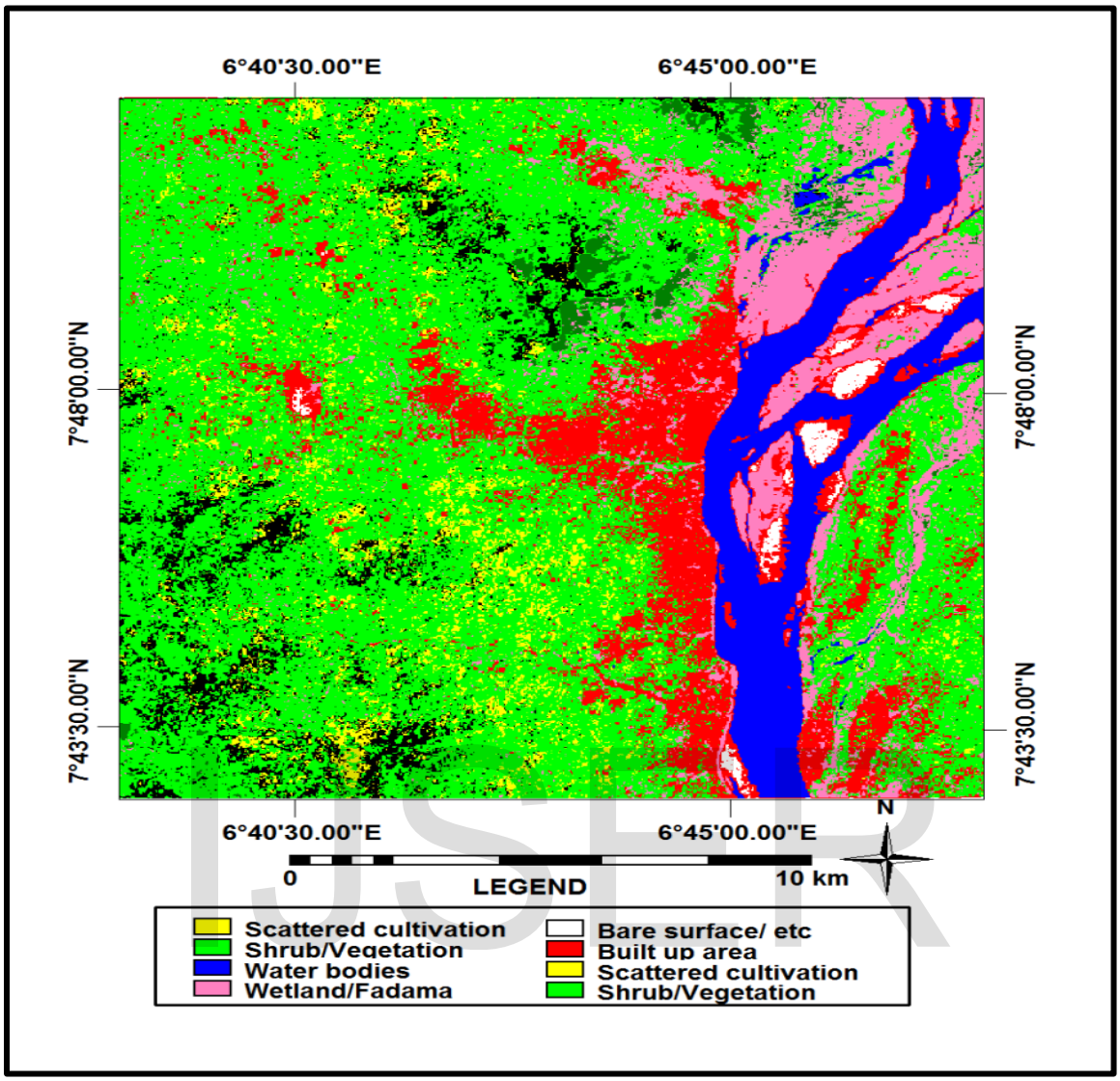


**FIG.2b: CLASSIFIED LANDSAT ETM+IMAGERY OF 2001**

Source: Laboratory analysis, 2014.

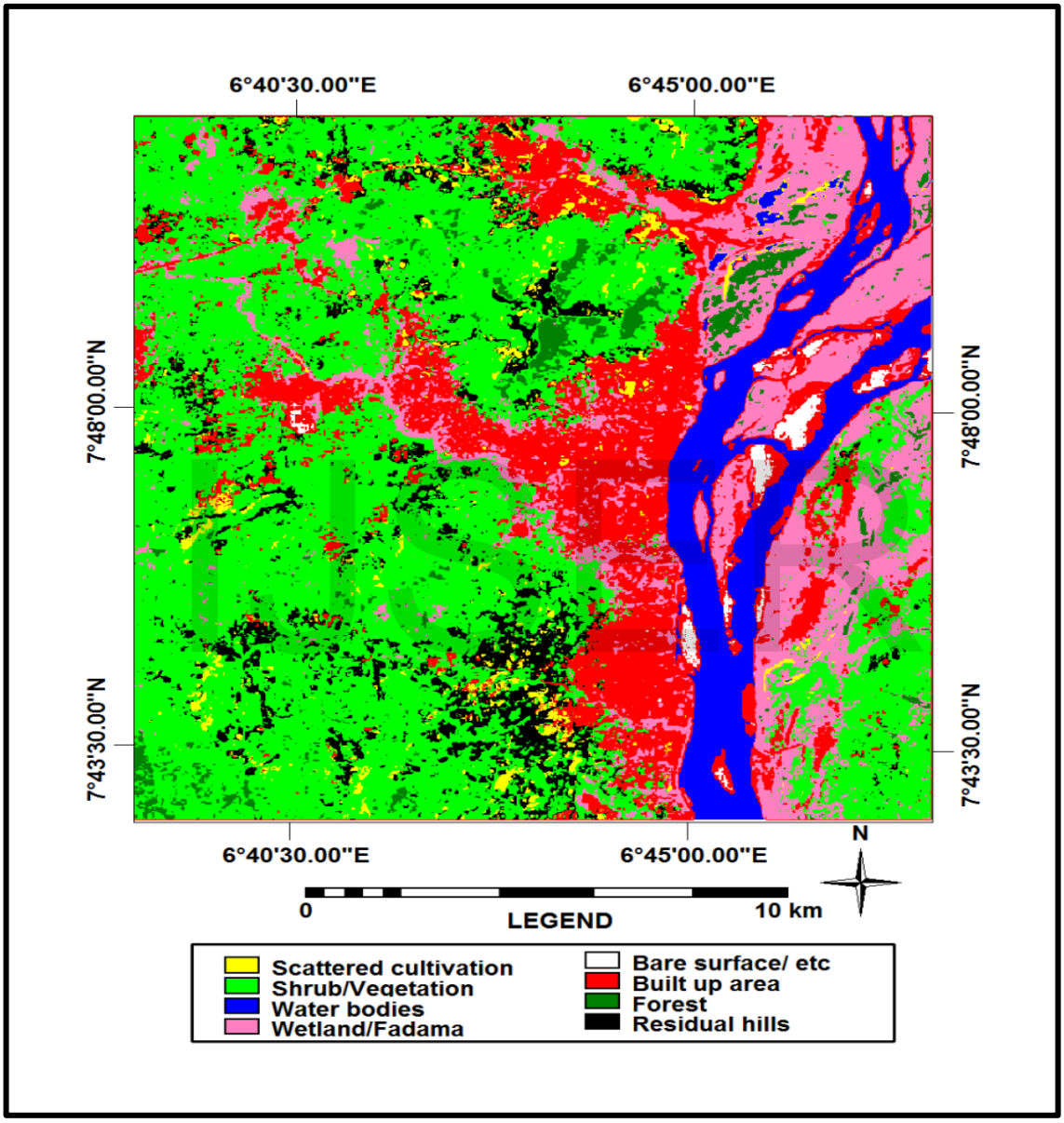


**FIG.2c: CLASSIFIED LANDSAT ETM+IMAGERY OF 2014**

Source: Laboratory analysis, 2014.

**Table 1: Land Use/Land Cover Distribution in Square Kilometres ($KM^2$)**

| LULC | Landsat 1991 | %Area coverage | Landsat 2001 | %Area coverage | Landsat 2014 | %Area coverage |
|---|---|---|---|---|---|---|
| Bare surface | 10.57 | 3.6 | 11.40 | 3.9 | 10.78 | 3.7 |
| Built up area | 15.73 | 5.4 | 31.13 | 10.7 | 42.99 | 14.8 |
| Forest | 16.93 | 5.8 | 9.14 | 3.2 | 7.75 | 2.7 |
| Residual hill | 16.48 | 5.7 | 17.15 | 5.9 | 20.30 | 6.9 |
| Scattered cultivation | 22.62 | 7.8 | 14.76 | 5.1 | 14.02 | 4.8 |
| Shrub / Vegetation | 152.63 | 52.6 | 153.36 | 52.8 | 134.99 | 46.5 |
| Water bodies | 21.42 | 7.4 | 23.74 | 8.2 | 21.64 | 7.5 |
| Wetland / Fadama | 34.02 | 11.7 | 29.72 | 10.2 | 37.93 | 13.1 |
| **Total** | **290.40** | **100** | **290.40** | **100** | **290.40** | **100** |

Source: Laboratory analysis, 2014.

| Land use Category | Percentages | | | Percentage Change 1991-2014 | Areal Change (Km²) 1991-2014 | Rate of Change Percent per year | Area per Year(Km²) |
|---|---|---|---|---|---|---|---|
| | 1991 | 2001 | 2014 | | | | |
| Bare Surface | 3.6 | 3.9 | 3.7 | -0.1 | -0.21 | 0.004 | 0.009 |
| Built-up | 5.4 | 10.7 | 14.8 | +9.4 | +27.26 | 0.408 | 1.185 |
| Forest | 5.8 | 3.2 | 2.7 | -3.1 | - 9.18 | 0.134 | 1.399 |
| Residual Hill | 5.7 | 5.9 | 6.9 | +1.2 | +3.37 | 0.052 | 0.146 |
| Scattered Cultivation | 7.8 | 5.1 | 4.8 | +3.0 | -8.60 | 0.130 | 0.373 |
| Shrub/Vegetation | 52.6 | 52.8 | 46.5 | -6.1 | - 17.64 | 0.265 | 0.766 |
| Water Bodies | 7.4 | 8.2 | 7.5 | +0.1 | -0.22 | 0.004 | 0.009 |
| Wetland/Fadama | 11.7 | 10.2 | 13.1 | +1.4 | +3.91 | 0.060 | 0.170 |

**Table 2: Rate of Land Use Change in Lokoja: 1991, 2001, 2014**

Source: Laboratory analysis, 2014.



**Table 3: Population and Areal Growth of the Built-up Area of Lokoja(1991-2014)**

| Year | Area (km²) | Population | Population density (pop/km²) |
|---|---|---|---|
| 1991 | 15.73 | 82,483 | 5243.67 |
| 2001 | 31.13 | NA | - |
| 2014 | 42.99 | 246,100 | 5724.58 |

Source: Field survey, 2014. FGN, 2007

**Transitionsin land use/ land cover types**

Change detection analysis was undertaken to determine transition among major land use types between 1991, 2001 and 2014 from the satellite imageries (Table 4). From the classification of the imageries for the individual years, a post-classification approach of subtracting the generated percentage cover of each category via the classification maps of 1991-2001 and 2001-2014 was applied to provide change information. This is the common approach to change detection and has been successfully used by Yang, Xian, Klaver & Deal (2003) to detect land changes in Atlanta, Georgia area. The major changes are in built-up, forest, shrub/vegetation, and wetland/fadama land uses.

The change detection analysis helps to determine what is actually changing to what. Location of changes can be assessed from the overlay maps (figure 4). From the figure, almost all classes are changing to one another. New settlement use constituted a large part of the change in the study area. Other important areas included forest use which decreased by 9.18km². Major transition of land use type between 1991 and 2001 relates to the conversion of a substantial amount of shrub/vegetation land use to other uses. For example, shrub/vegetation transited to built-up (17.87km²), scattered cultivation (10.63km²), wetland/fadama (5.92km²) and residual hills (11.70km²). Between 2001 and 2014, the trend observed between 1991 and 2001continued. More of shrub/vegetation use was converted to built-up areas (17.60km²), residual hills (14.70km²) and wetland/ fadama (16.69km²).

Some residual hills (12.97km²) were converted to shrub/vegetation and a large amount of scattered cultivation use (9.56km²) was taken over by shrub/vegetation.

**Table 4: Land use- Land Cover Change in Lokoja: 1991, 2001, 2014**

| Land use Category | 1991/2001 | | 2001/2014 | |
|---|---|---|---|---|
| | Difference in Area (Km²) | Difference in Area (%) | Difference in Area (Km²) | Difference in Area (%) |
| Bare Surface | 0.83 | 0.3 | -0.62 | -0.2 |
| Built-up | 15.40 | 5.3 | 11.86 | 4.1 |
| Forest | - 7.79 | -2.6 | - 1.37 | -0.5 |
| Residual Hill | 0.67 | 0.2 | 3.15 | 1.9 |
| Scattered Cultivation | -7.82 | -2.7 | -0.74 | -0.3 |
| Shrub/Vegetation | -0.73 | 0.2 | -18.37 | -6.3 |
| Water Bodies | 2.32 | 0.8 | -2.10 | -0.7 |
| Wetland/Fadama | - 4.30 | -1.5 | 8.21 | +2.9 |

Source: Laboratory analysis, 2014.

The growth of Lokoja is not only related to the population growth, but also to the availability of urban facilities and accessibility to infrastructure. It is clear from figure 2 that the Ganaja-Ajaokuta road generated the greatest urban expansion (south of the city), followed by Okene road (west of the city), and then the north western part. Lokoja has spread further into the neighbouring local government areas of Adavi, Ajaokuta,and Kogi as new residential areas built by both the state government and private individuals are located mainly on the southern fringe along Ajaokuta road and western axis along Okene road. These residential areas have low densities different from the main town and the core of the fringe. Also, unlike the old core area, the new areas are well provided with roads and facilities. These qualities tend to attract further development to the fringes. The concentration of residential areas along Ganaja and Okene roads

has led toincrease in traffic volume expressed on the road. This has implications on the efficiency of workers as valuable time is wasted in traffic hold-ups.

The rural land at the periphery decreased considerably from 1991 to 2014 as the urban area expanded, encompassing the rural settlements located on the urban fringe. At the same time, the leapfrog or scattered development nature of the growth extended the urban area beyond the fringe to create built-up communities that are isolated from the city by areas of undeveloped land. This type of development is highly inefficient in the use of land and requires a greater need to build highways and other infrastructure to service the outlying areas.

The new residential areas in Lokoja rural/urban fringe developed particularly on crossroads, and along highways (figure 4). By and large, the pattern of growth can be attributable mainly to the rough terrain and rock outcrops causing residential buildings to be distributedalong relatively level ground between hills with different sizes. This leads to a haphazard and unplanned patchwork with negative environmental, social and economic effects (Newman and Kenworthy, 1991).The urban growth pattern leads to land use patterns which are unfavourable to sustainable development. This unplanned pattern of growth causes excessive land consumption more than contiguous development; congestion and air pollution due to increase in commuting and the need for anextension of access and facilities over an extensive area. Even though the open tracts of land are usually filled up eventually, leapfrog developments remains an inefficient use of land.

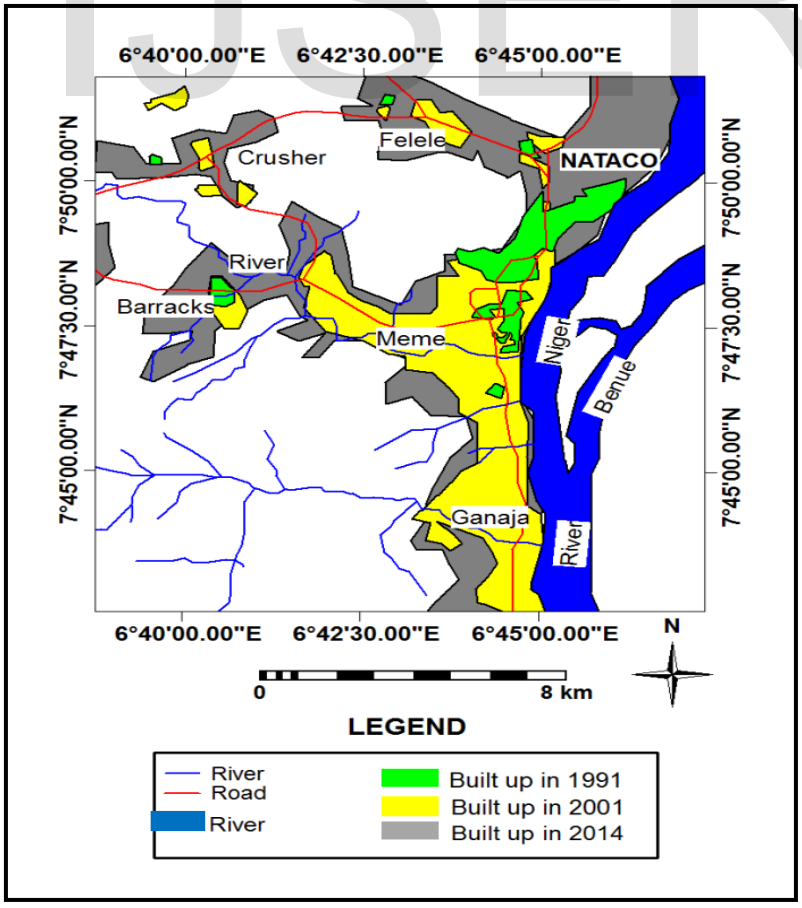

**Figure 4: Pattern of Urban Growth in Lokoja between 1991 and 2014**

Source: Laboratory Analysis, 2014.

## 4. Conclusion and Recommendations

Land use/land cover of Lokoja area has changed dramatically during the past 23 years. With population growth and economic development, Lokoja town has experienced significant expansion between 1991 and 2014. A substantial amount of vegetation cover and available open spaces on the urban fringe and rural land have been replaced with residential use. This paper discovered that the built-up area more than doubled between 1991 and 2014 based on thesupervised classification of imageries. The built-up area was growing at the rate of 1.2Km$^2$ per annum from1991 to 2014. Physical development is springing up along Mount Patti and into marginal and ecologically sensitive areas along water courses. Due to lack of control, urban expansion is haphazard with a tendency towards discontinuity in thelayout. This creates excessive land consumption and adverse implications on the environment that do not favour sustainability. These changes to the environment have resulted in land degradation and frequent flooding during the rainy season. The concerns about these problems are shared among planners, policy makers, environmentalists and people in general. There is now an urgent need to protect the natural environment from further degradation.

Since thedevelopment of the urban and fringe areas have not been planned for, the state government should produce a new Master Plan that reflects the status of Lokoja as a state capital and to guide the development of both the urban and the fringe areas. Pressure on land will continue to increase in the future as urban expansion cannot be stopped, but without a framework to structure the utilisation of land, a balance cannot be struck between the various competing needs for land. Such a plan should ensure that the forest and wetland/fadama land, water courses and sensitive ecosystem, particularly around the residual hills are zoned and reserved to stem urban encroachment and protect them from further destruction.

The development plan should be prepared well ahead of time and implementation of development control should be undertaken aggressively in order to prevent haphazard development that is common in peri-urban areas.

Mount Patti needs to be protected by stringent laws to discourage all forms of development activities on the slope to reduce theoccurrence of erosion and protect the tourism potential of the hill.

The urban planning board, the various communities, and Non- governmental organisations should all help combat environmental destruction by embarking on anawareness campaign on the need to protect the environment.

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