Application of Geospatial Technology in Assessing the Impact of Urbanization on Vegetation Degradation in Kuje Area Council, Abuja Nigeria

Abakpa D. Ibrahim and Sunday P. Ejaro
University of Abuja, Nigeria

Abstract: **The level of Urbanization in Kuje Area Council in the last thirty (30) years has degraded the vegetation cover. This study used geospatial technology to assess the impact of urban growth on the vegetation cover between 1985 and 2015. The images of different epochs (1985, 1999 and 2015) were classified into built-up area, cultivated area, vegetation cover and bare land. This was carried out using ARC GIS 10.1, ILWIS 9.1 and ERDAS softwares for data generation and analysis. The result indicates that built-up area increased by (18.85%) and bare land increased by (10.26%) between 1985 and 2015 while vegetation cover and cultivated land were decreased by (-16.68%) and (12.44%). The study further recommend the urgent need to carry out the Master Plan Review to secure the vegetative land cover, particularly the forest lands which have been greatly encroached by urbanization. The government should encourage environmental sustainable programmes that will foster forest development, urban agriculture and other urban expansion processes in Kuje Area Council.**

Keywords: **Vegetation, Urbanization, degradation, Land use/land Cover, Environmental Sustainability**

I. INTRODUCTION

The increase in number of people in a particular place either through birth or migration has many consequences on the environment. As human population grows, demands for resources such as food, water, timber, energy have increased and therefore posing a high pressure on the landscape (UNEP, 2011). Ejaro (2009) explains that rapid urbanization has raised several challenges for land cover changes in FCT. As the environment offers these services and resources to man it needs to be cared for, and the total conditions, circumstances surrounding man needs to be protected to give maximum resources and services (Ogidiolu and Balogun, 2000).

Vegetation is the total plant cover in a particular location and has been saddled with the responsibility of producing oxygen, carbon sink or sequestration and wind breaking capacity (Ablett *et al.,* 2005). On global scale, vegetation influences climate and the removal of it for developmental purpose constitutes damage to the ecosystem. According to Valerie *et al.,* (2008), there are limits to the number of people that can be adequately housed and catered for in urban areas by the available physical infrastructures. When urban growth out-paces adequate housing provision, water supply capacity, waste disposal facilities and health care services, it is only then the urban environmental problem takes the centre stage. Preparation of land before the cultivation, like clearing and burning of bush destroys the vegetation cover and gradually leads to succession on a particular land. Also, overgrazing of vegetation by animals without any managerial strategy put in place causes destruction to the environment.

In recent time, viewing the earth from space has become necessary to the understanding of human influence on vegetation resources base over time (Ujoh *et al.,* 2010). Observation of the earth from space provides objective information of human utilization of the land surface in situation of rapid and often undocumented land use change. Data from satellite have become vital for studying urban expansion, vegetation cover, managing natural resources and studying environmental change. Remote sensing (RS) and geographic information system are now providing new tools for ecosystem management.

Geospatial Technology Method of Detecting Changes in Vegetation

The use of satellite data offers benefits in the field of vegetation mapping and their change analysis. One major advantage of satellite systems is their capability for repetitive coverage at short interval, and consistent image quality which is necessary for change detection studies (Strvasta and Gupta, 2005).With the availability of multi-sensor satellite data at very high spatial and temporal resolution, it is now possible to prepare up-to-date and accurate vegetation map in less time at lower cost and with better accuracy than traditional ground methods (Srivasta and Gupta, 2005).

The study carried out by Balogun and Salami (2006) on both Borgu and Zuguma sector of the Kainji Lake National park had the classification characteristics as evergreen vegetation, farmland, grassland, open/degraded woodland, settlement/bare surface, woodland/grass land complex and water. The result showed that deforestation still continues.

Adeniyi and Omojola (1999) used aerial photographs, Landsat MSS, SPOTXS/Panchromatic image and topographic map sheets to study changes in the two dams (Sokoto and Guronyo) between 1962 and 1986. The work revealed that land use land cover of both areas was unchanged before the construction while settlement alone covered most part

of the area. However, during the postdam era, land use /land cover classes changed but with settlement still remaining the largest.

Aweda and Adeyewa (2011) conducted a study of the inter-annual variations of vegetation anomaly over Nigeria using the Normalized Difference Vegetation Index (NDVI) derived from the Advanced Very High Resolution Radiometer (AVHRR) data sets using the visible and near-infrared channel 'reflectance. The study covers the period between the year 1982 and 2000.

Ishaya *et al.,* (2008) utilized remote sensing and GIS applications to asses urban expansion and vegetation cover loss in Kaduna State. They utilize Remote sensing and GIS techniques with survey to identify the various land uses, their transformation over a period of 11 year (1990- 2000). The study revealed that vegetation cover declined at a very fast rate of 297.5 hectares annually.

Helen A. (2015) observed the analysis of vegetation change in Gwagwalad Area Council of Abuja using Geo-informatics techniques between the periods of 1987-2007. The study revealed that vegetation cover and water body was decreasing, while farm land and built-up area was increasing

Statement of the Problem

The choice of this study area is because it has been observed that there have been population explosion, massive fuelwood harvesting, and overgrazing, urban expansion, clearing of vast land for cultivation and construction purposes among other activities that degrade vegetation in Kuje Area Council. Since urbanization cannot be stopped, there is the need to monitor the process of urbanization and to understand the dynamics of vegetation in the area for sustainability of the environment. Studies have been carried out on changes on land use/land cover in FCT using multi-temporal satellite data (Ejaro, 2008) and agricultural land loss due to urbanization in the FCT (Abere, 2011) these studies however involves the whole of Abuja. But to be specific, none of these studies have observed the impact of urbanization on the vegetation of Kuje, it is in view of this the study was carried out to observe the vegetation change between 1985 and 2015.

Aim and Objectives

The aim of this study is to assess the effect of urban expansion on vegetation degradation in Kuje Area Council using geo-spatial technology.

The objectives are to:

i. Classify the land cover type in the study area.
ii. Appraise the scale of vegetation change over time (spatio-temporal)
iii. Examine the impact of urbanization on vegetation cover

The Study Area

The area of this study is Kuje Area Council. It lies between latitude $8^0$25'N and $8^0$55'N and longitude $6^0$57'E and $7^0$30'E. Kuje area council is bordered by the Abuja Municipal Area Council to the north and east, Kwali Area Council to the west and Abaji Area Council to the south (Fig1). The area council occupies a land mass of about 1650 square kilometres (22.5per cent of the total land mass of the FCT), it has the highest landmass in the Federal Capital Territory (Kuje Area Council, 2010).

Savannah is the dominating vegetation found in the region this can be classified into grassland savannah, shrub savannah and woodland savannah. The grassland savannah is mostly thick and mostly found along the plain region. According to Adekayi (2000), some of the trees found there include, *Albizia, Zygia, Daniella oliver, Butrospernun paradoxum, Anniellia oliveri*, *Parkia clappertoniana* and other wild plant species. There is a spontaneous increase in human activities over the years as the population continued to increase in the area, the urban renewal exercise witnessed during the former FCT minister, Mallam Nasir el Rufai around 2003 and 2005 has forced many people to settle in the satellite towns such as Kuje, Gwagwalada, Abaji, Kubwa, Zuba among others which is one of the major causes of urbanization in Kuje Area Council.

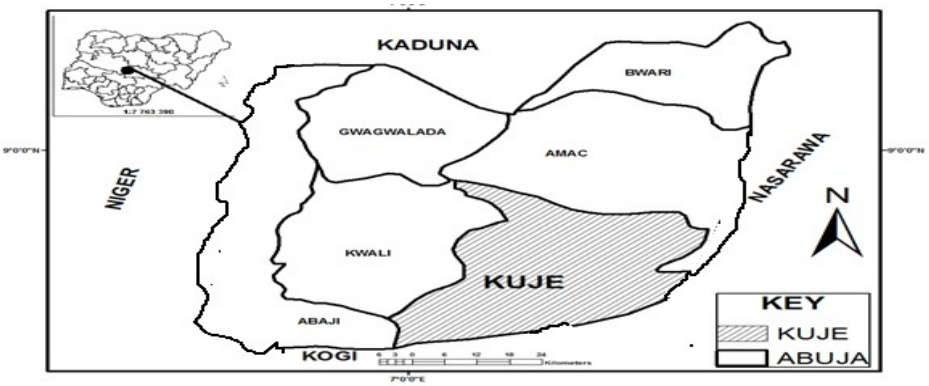

Figure 1:The addministrative map of Nigeria showing Abuja and Kuje Area Council Source: Author, 2017

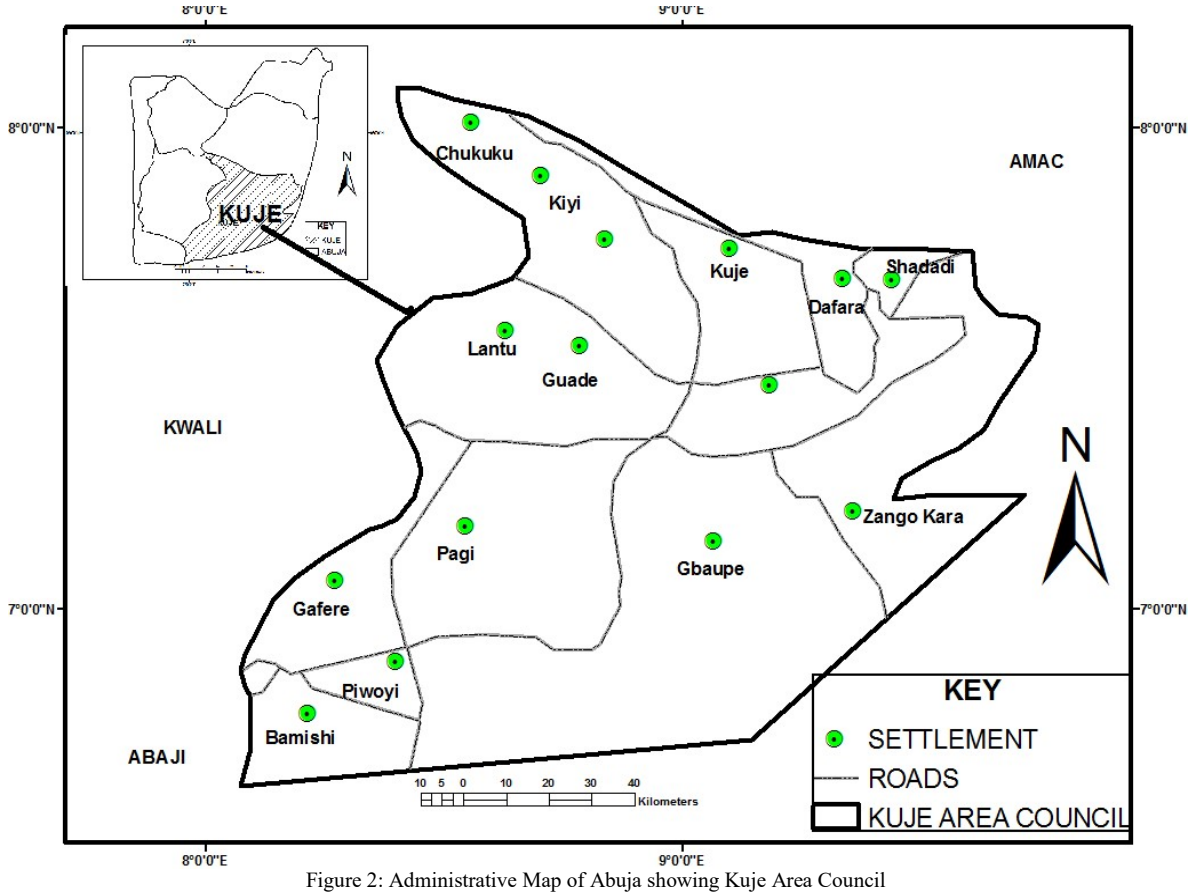

Figure 2: Administrative Map of Abuja showing Kuje Area Council

Source: Author, 2017

II. METHODOLOGY

The data consist of satellite imagery, Administrative map covering Kuje Area Council (KAC) as stated in Tables 1and 2

Table 1: Types of Map

Materials	Date	Source	Scale
Landuse/landcover map	1995	KAC, 2014 secretariat	1:1000000
Administration map of Kuje Area Council	2015	KAC, Secretariat	1:50000

Source: Author 2017

Table 2: Land Sat Images Used

Materials.	Date	Source	Resolution
Land sat-5 TM	1985	NASRDA	30m
Land sat-7 ETM	1999	NASRDA	30m
Land sat-8 ETM+	2015	NASRDA	30m

Source: Author 2017

Stages in the operation

These stages of operation are presented in Fig 3 and they are outlined as follows

A. Acquisition of satellite image covering the research area:

The satellite image was imported into the GIS software so as to make it available for the manipulation.

B. Ground truth

Field checking was conducted to establish trained sites in some locations. A hand held GPS receiver was used to facilitate navigation and identification of some locations (i.e. longitude and latitude).

C. Development of Classification Scheme

With respect to objective one (1), a four category land use/land cover classification scheme was used. These are built-up area, vegetation land, cultivated area and bare land. The classification scheme is based on prior knowledge of the study area and a reconnaissance survey carried out with additional knowledge from other research works.

D. Digitizing of maps in layers of Built – up areas, Vegetation, Cultivated and Bare Land.

E. Geo- referencing:

The transformation of co-ordinates of two surfaces from their different coordinate system to the same coordinate system was carried out to enable enable overlaying or superimposition.

F. Geo–coding

Orienting a geo referenced image to the true North using the system of the project boundary.

G. Change detection Analysis Area coverage analysis was employed. After the classification, change detection analysis was performed on the classified dataset. In this set, area coverage of each of the classification characteristics for different epoch was compared to one another in percentages (%) and square kilometre (km^2).

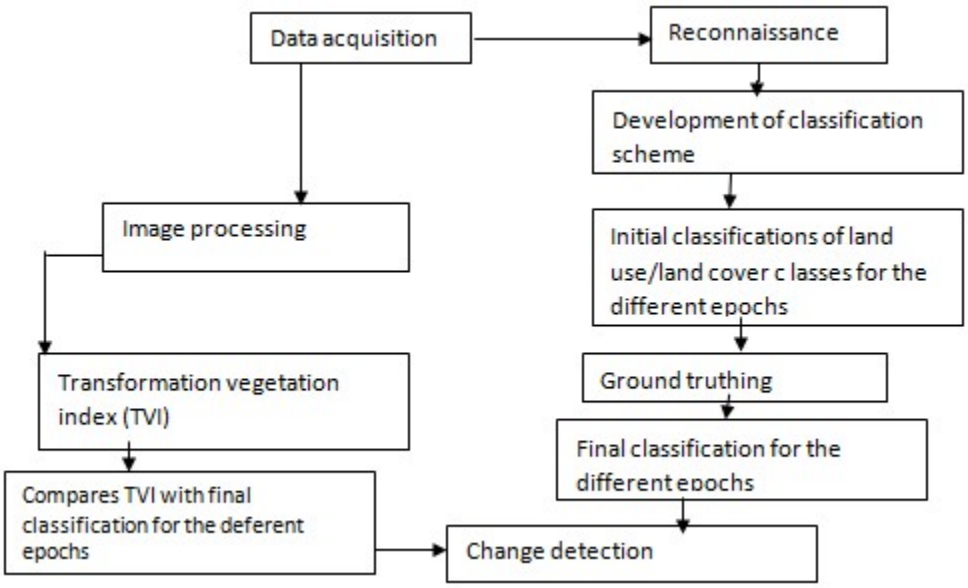

Figure 3: Flow chart showing the major steps in geospatial technology application

III. DATA PRESENTATION AND ANALYSIS

The results are presented in form of maps, statistical tables, plates and charts. The analysis cover land Use/Land Cover distribution of different periods.

Land Use/Land Cover Distribution

The land cover classified is presented in square kilometres and percentage as shown in Table 3

Table 3: Land use/land cover distribution (1985, 1999, and 2015)

Land classification	1985		1999		2015	
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)
Built-up Area	246.48	14.94	399.58	24.22	557.55	33.79
Vegetation Land	765.70	46.41	671.09	40.67	490.57	29.73
Cultivated Area	395.90	23.99	275.19	16.68	190.57	11.55
Bare Land	241.92	14.66	304.13	18.43	411.21	24.92
Total	1650	100	1649.99	100	1649.90	100

Source: Derived from classified imageries.

Landuse/Landcover Distribution in 1985

From Table 3 the vegetation cover dominates the study area with (46.41%) in 1985; it is followed by cultivated area which is occupying (23.99%). The built up area occupies (14.94%) while the bare land is represented by (14.66%). Figure 4.1 shows the spatial distribution of the land use categories derived from classified Landsat-5^{TM} Image of 1985. The vegetation area dominated as a result of low anthropogenic activities, low level of urban growth and few other technological activities needed to converter vegetation land to built-up area for human settlements, commercial and other forms of agricultural land usage.

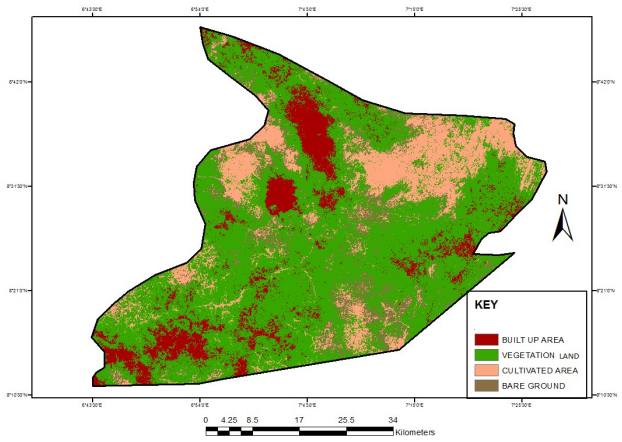

Figure 4: Land use/cover map derived from Landsat- 5 image of Kuje 1985

Landuse/Landcover Distribution in 1999

Table 3 presents vegetation cover to be the largest area in the classification with about (40.67%) in 1999, built-up area category followed with (24.22%), and the bare land is a little lower with (18.43%) while the cultivated land occupied (16.68%). There is no much change observed between 1985 and 1999 images as can be seen in the figure 5. There was a slight increase in built-area which has lead to increase in other forms of human activities in the area. In Figure 5, the vegetation area conversion was not much noticeable as compared to 2015 image, this is due to few number of residents in Kuje Area Council and the level of human activities has no much difference from that observed in the 1985.

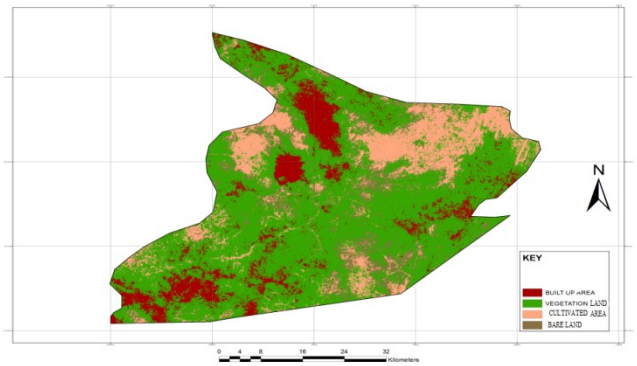

Figure 5: Land use map derived from Landsat – 7 image of Kuje in 1999

Land Use/Land Cover Distribution in 2015

In 2015, the high level of land use conversion can be clearly seen in Figure 6, compared with other previous years and as it has been represented in Table 4.1. Built-up area occupies more space with (33.79%), vegetation land covers (29.73%), bare land occupies (24.92%) and cultivated area is represented by (11.55%). The rapid increase in population has resulted to high level of anthropogenic activities in the area. In 2015, the built-up area occupied the largest area compared to other land uses due to high level of urbanization which has converted most of the vegetative areas to residential, industrial, commercial, recreational and forms of agricultural land use in the area.

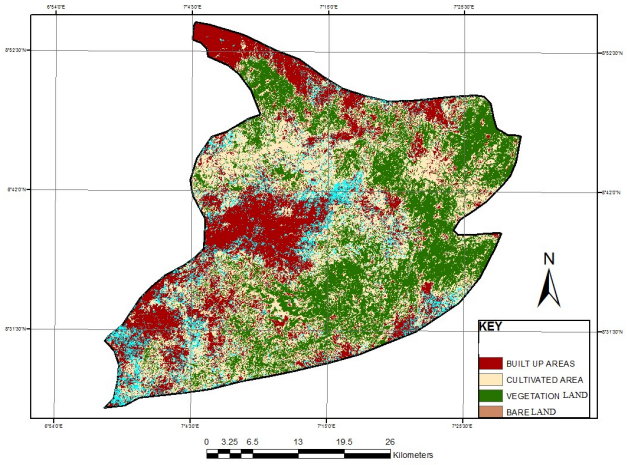

Figure 6: Land use map derived from Landsat-8 image of Kuje in 2015

Land Use/Land Cover change trend of the study area

The land use/Land Cover change compares the changes observed in each of the land classification during the period of study as shown in table 4

Table 4: Land Use/Land Cover Change

Land Classification	Change between 1985-1999		Change between 1999-2015		Change between 1985-2015	
	Area (km^2)	Area (%)	Area (km^2)	Area (%)	Area (km^2)	Area (%)
Built-up Area	153.10	9.28	157.97	9.57	311.07	18.85
Vegetation land	-94.61	-5.74	-180.52	-10.94	-275.13	-16.68
Cultivated Area	-120.71	-7.31	-84.62	-5.13	-205.33	-12.44
Bare Land	62.21	3.77	107.08	6.49	169.29	10.26

Source: Derived from classified imageries

Table 5: Showing change Detection or conversion table of Kuje Area Council between 1985 and 2015 in Km^2

vgetation to bare land	6.43
built-up Area to bare land	10.26
cultivated to bare land	2.18
vegetation to cultivated land	4.24
built-up Area to cultivated land	12.44
bare land to cultivated land	2..18
cultivated land to buit up land	298.63
vegetation to built-up	294.39
bare land to built-up	298.63
cultivated land to vegetation	4.24
bare land to vegetation	6.43
built-up to vegetation	1.06

Source: Derived from the classified imageries

Built-up Area

Plate 1: Conversion of farm land to residential area due to urbanization in Kuje Central

Table 4 presents built-up area as one of the least land use between 1985-1999 with (9.28%). The built-up area increased between 1999 and 2015 with (9.57%), between 1985 and 2015 there was a high increase of about (18.85%) in the built-up area compared with other years. This shows that there is a spontaneous increase in human activities over the years as the population continued to increase in the area. In 2015, the built-up area occupies the highest land use compared with others in the classification and this indicates the high rate of urbanization over the last 30 years in Kuje. Figures 4 and 5 gives the change in Built-up-area to be insignificant due to low human population in the area as compared to Figure 6 and Plate 1 where the built up Area covers the major part of Kuje Central, Gaube, Chubiri and Kujekwa.

Vegetation

Plate 2: Vegetation and Natural Wetland cover In Gaube Kuje Area Council

The change in Vegetation cover between 1985 and 1999 was observed to be (-5.74%) as shown in Table 3, 4 and Plate 2. This is because there was no much population in Kuje. Between 1999 and 2015 the vegetation was further reduced by (-10.94%) as compared to the previous years. The vegetation cover continued to decrease as more people moved into Kuje

Area for settlement. Between 1985 and 2015 vegetation was observed to have lost (-16.68%). This shows the high rate of deforestation activities taking place in the area. Migrants who predominantly settled in Kuje Central, Rubochi and Chubiri together with the indigenous populace have degraded the vegetation through unsustainable farming practices, building of structures, and construction of roads, fuel wood harvesting and overgrazing. As shown in Figure 6, in 2015 vegetation cover has been highly degraded and this process may continue as most of the lands have been commercialized to individuals who have the intention of raising structures around villages like Kwaku, Kabi, Yenche and Gwadubada.

Cultivated Area

Plate 3: Grazing Cattle alonge cultivated rea in Chukuku

The cultivated area reduced in size between 1985 and1999 by (-7.31%), the decrease between 1999 and 2015 was (-5.13%) much compared to the previous years. Much of this decrease was observed between 1985 and 2015 with the value of (-12.44%) as indicated in Table 4. These areas have been converted to residential buildings, commercial buildings, major roads etc. as the built-up area is expanding. Majority of people living in Kuje moved there because of high cost of housing in the central area, but most of them have their occupation outside Kuje This has led to selling of this cultivated land to individuals or groups who use them for other purposes outside cultivation.

Bare Land

Plate 4: Commercial fuel wood on a bare land in Chibri

Source: Field survey, 2017

The bare land increased throughout the study period as shown in Table 4 and Plate4. This was due to high rate of anthropogenic activities taking place in the area. Between 1985 and 1999, the value of bare land was recorded as (3.77%), and in 1999-2015, the area further increased to (6.49%) compared to the previous years. Between 1985 and 2015, it further increased by (10.26%). This indicates poor farming practice, overgrazing by cattle and other deforesting activities taking place around Kabi, Rubochi, Gudukeria and Gaube Village.

Impact of Urbanization on the Vegetation

Kuje Area Council is experiencing a loss of vegetation that is impacting negatively on the ecological landscape. In the area of urban expansion as it affects the vegetation cover, the following implications are noteworthy:

1. Abuja's urbanization is taking its toll on Kuje Area Council faster than envisaged by the Master Plan; This is in line with the views of Ishaya *et al.,* (2014) which says that residential land use has exceeded the expected area in FCT. If the rate continues, it implies that more vegetative land will be converted to other land uses like residential, commercial, industrial and other uses which are not well planned. This process will lead to development of slum in the area rather than the gradual economic and social transformation in the area. Planning projection should be done and appropriate budgetary provision made on continuous and incremental basis.
2. A total of 275.13Km^2 of vegetation cover has been lost to urban encroachment within a period of 30 years under study as shown in Table 4 Out of this are arable land, fadama land, and forest land cover. Developmental activities are encroaching the forest land and agricultural lands at an alarming rate as it is indicated in Plate1. If this growth rate continues, it implies that land (arable land, fadama land and forest) would have further been lost to urban encroachment. This will lead to low food production as the arable land suitable for Agriculture is been converted to other uses. The food security problem will result to more hunger, economic break down which will cause conflict and other social vices among the residents of the area.
3. Road developments were also identified as a major agent of change in the area within the 30years period. About 250 Km^2 of major roads were constructed between 1985 and 2015. This gradual process of removing natural landscape and replacing it with impervious surfaces have changed the micro climate of Kuje. The bare land was observed to increase throughout the study period, this exposes the soil to direct effect of sun's radiation which reduces the microbial activities of the soil which in retune reduces the soil nutrient which is needed for crop production. When the soil is exposed, it is easily washed away by water and wind which also deplete the soil nutrient.
4. Vegetation cover serves as a habitat for different species of animals. Most of them have migrated to other locations while some are extinct as a result of deforestation in Kuje Area Council. This trend has reduced the protein supply and other raw materials gotten from these animals.

IV. CONCLUSION

In conclusion, considering the implication of urbanization on the vegetation resources of the study area, there is a high pressure on these resources due to high level of human activities in the area. The Information on change detection has been able to identify gaps and areas of agreement. Having classified the land use/Land cover of the study area as stated in objective one, it became clear from the findings that the vegetation cover and the cultivated land was decreasing throughout the study period while the built up area and bare land increased throughout the period.

In addition, the land use/Land cover analysis compare the vegetation change of different epochs and it revealed the level of vegetation degradation, Although the change detection covers only the period of thirty (30) years but the aim of the research has been archived as was observed in the result analysis.

V. RECOMMENDATIONS

Urbanization in Kuje Area Council have degraded the vegetation cover, these also constituted land degradation, deforestation, erosion, biodiversity loss and other environmental problems, the following are recommended with a view to ameliorating the conditions of the degraded areas in Kuje

There is an urgent need to carry out the Master Plan Review to secure the vegetative land cover, particularly the forest lands which have been greatly encroached by urbanization, the agricultural activities should be carried out sustainably in order to improve the quality of the soil. Since the grazing activities of cattle can sometimes create land conflict between the herdsmen and farmers, cattle ranches should be provided to resolve this issue. In order to reduce the menace of fuelwood harvesting, household should be encouraged to use cooking gas and gasoline to reduce pressure on the vegetation resources.

The government should encourage environmental sustainable programmes that will foster forest development and urban agriculture and other urban expansion processes. Some of the forest land should be converted to nature reserve area and money generated should be used for community development. Thus, further study need to be carried out to analyse the potential consequences of the soil degradation in the study area.

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