TERRAIN AND LAND USE/LANDCOVER ANALYSIS IN BWARI AREA COUNCIL FEDERAL CAPITAL TERRITORY-ABUJA, USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

By

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ABSTRACT

Terrain analysis and land use/cover change using Remote Sensing and Geographic Information System (GIS) is an area of interest that is now attracting attention for land use management. This study focuses on analysis of the terrain and land use change in Bwari Area Council, Federal Capital Territory, Abuja over a 22 year period. The study made use of topographical indicators (elevation and slope gradient) extracted from a digital elevation model and satellite imageries of 1987, 1999 and 2009 acquired from LandSat and Nigeria Sat-1 respectively. Chi-Square statistical analysis was adopted to test for the significant changes in the pattern of land use/land cover of the three times period studied. The results showed that the major LULC changes that occurred from 1987 – 2009 was an increase in built-up area and arable land at an average expansion rate of 0.42% and 1.37% per annum respectively and a decrease in savannah vegetation and rock outcrop at a decline rate of 0.98% and 0.85% per annum respectively. The results also showed that about 82% of the land use in Bwari Area Council is influenced by the landform characteristics as the topography pose severe constraints to development in most part of the study area. The test at 0.01 significant levels showed a statistically significant change with the X^2 value of 67362.27 between the land use types within the study period while significant relationship were also found between land use types and elevation classes as well as slope gradient. Major recommendations included the production of the master plan of the study area, suggestion of the need for the discouragement of the development and cultivation on vulnerable sloping lands within the study area, and revision of the development control policies guiding building of structures in the study area.

Key words: Terrain, Land use/Land cover, Federal Capital Territory

INTRODUCTION

According to a report from Global Land Project (2005), land cover refers to the physical and biological cover over the surface of land, including water, vegetation, bare soil, and/or artificial structures. Meyer (1995) defined land use as simply referring to the use to which man puts land which could be grazing, agriculture, urban development, logging, and mining among many others. Land use and land cover is dynamic in nature and is an important factor for the comprehension of the interaction and relationship of anthropogenic activities with the environment. Knowledge of the nature of land use and land cover and their characteristics across spatial and temporal scales is consequently indispensable for sustainable environmental management and development (Turner *et al*., 1995).

Terrain is one of the important factors affecting the spatial layout and land use / land cover, and also a prerequisite for land evaluation and land use planning. A good understanding of the relationships between land use types and terrain gradient is essential for land use management.Studies by GITTA (2010) shows that terrain characteristics information products such as elevation, slope, aspect, profile curvature and plan curvature can quite easily be derived from digital terrain models. Sometimes these basic terrain parameters are not sufficient and more complex information is required in order to make well-founded decisions. Topographic attributes have been used to quantitatively describe characteristic of landform and its structure. Their algorithms and extracting methods are the emphasis of geomorphologic research at all times (Dong *et al.,* 2008).

Changes in land cover by land use do not necessarily imply a degradation of the land. However, many shifting land use patterns, driven by a variety of social causes, results in land cover changes that affect biodiversity, water and radiation budgets, trace gas emissions and other processes that cumulatively affect global climate and biosphere (Riebsame et al, 1994). Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest (Ujoh, 2009).Change detection is useful in many applications such as Land Use changes, habitat fragmentation, rate of deforestation, coastal change, urban sprawl, and other cumulative changes through spatial and temporal analysis techniques such as GIS and Remote Sensing (Anavberokhai, 2007; Ozbakir *et al*, 2007).

Remote Sensing and Geographic Information System (GIS) is a powerful tool in the study of changes in Land use and Land cover, as well as terrain analysis. The advantage of Remote Sensing and GIS over previous approaches is in its ability to analyse spatial relationship between land use and terrain features over an area in a single image scene. It can also be used to assess data Information products such as elevation, slope, and aspect which can quite easily be derived from digital terrain models (DTM).Remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research, regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

Igbokwe (2008) opined that Land cover and Land use information should form part of the environmental data, which are kept in the form of inventories/infrastructures in many advanced and emerging economies. Most Land use change factors such as water flooding, air pollution, urban sprawl, soil erosion, deforestation, occur without clear and logical planning which results in serious environmental degradation with notable consequences at local, regional and global level. Bwari is richly endowed with good agricultural land and water resources (FCDA, 2004). It is however the most rugged in terms of landform within the FCT. In many parts of Bwari, human alterations of the environment have accelerated changes in land cover and land use during the past two decades. Unfortunately, these activities have taken place mainly on vulnerable sloping lands, without proper consideration of the capability and suitability of the land. However, no comprehensive effort has been made to analyse the characteristic nature of the terrain in relation to the land cover and land use types. This observed gap obviously provide the basis for this research work.

The study aims at analysing the terrain and land use /land cover of Bwari Area Council, using Remote Sensing and GIS techniques. This aim was achieved by analysing the land use/land cover patterns and changes in the study area in the three past decades (1987 – 2009) using multi-temporal satellite imageries, characterizing the topographic features of the study area and assessing the spatial relationship between the terrain and land use types in the study area.

Arising from the aim and objectives of the study are the following hypotheses:

a. The pattern of land use land cover within the Bwari Area Council did not change significantly between 1987 and 2009.

b. There is no significant relationship between the topography and land use pattern in the area.

STUDY AREA

Bwari Area Council is located between Latitudes $6^{0}45^{'}$ and $7^{0}45^{'}$north, and Longitudes $8^{0}25^{'}$ and $9^{0}35^{'}$ east. It covers a total of about 2,300 square kilometres, and lies in the north – eastern part of the Federal Capital Territory (FCDA, 2004), see fig.1. The Bwari area features an interesting terrain, which combines rounded hills and clusters of rock outcrops dissected by river valleys, as well as gentle rolling plains. It falls within the Abuja hills and dissected zone of the Jema'a Platform. Generally viewing the study area, the hilly areas are found towards the eastern part, posing constraint to physical development while the plains occupy the central and western areas. The study area is the highest part of the FCT with several peaks that are about 760 meters above sea level (Balogun, 2001).

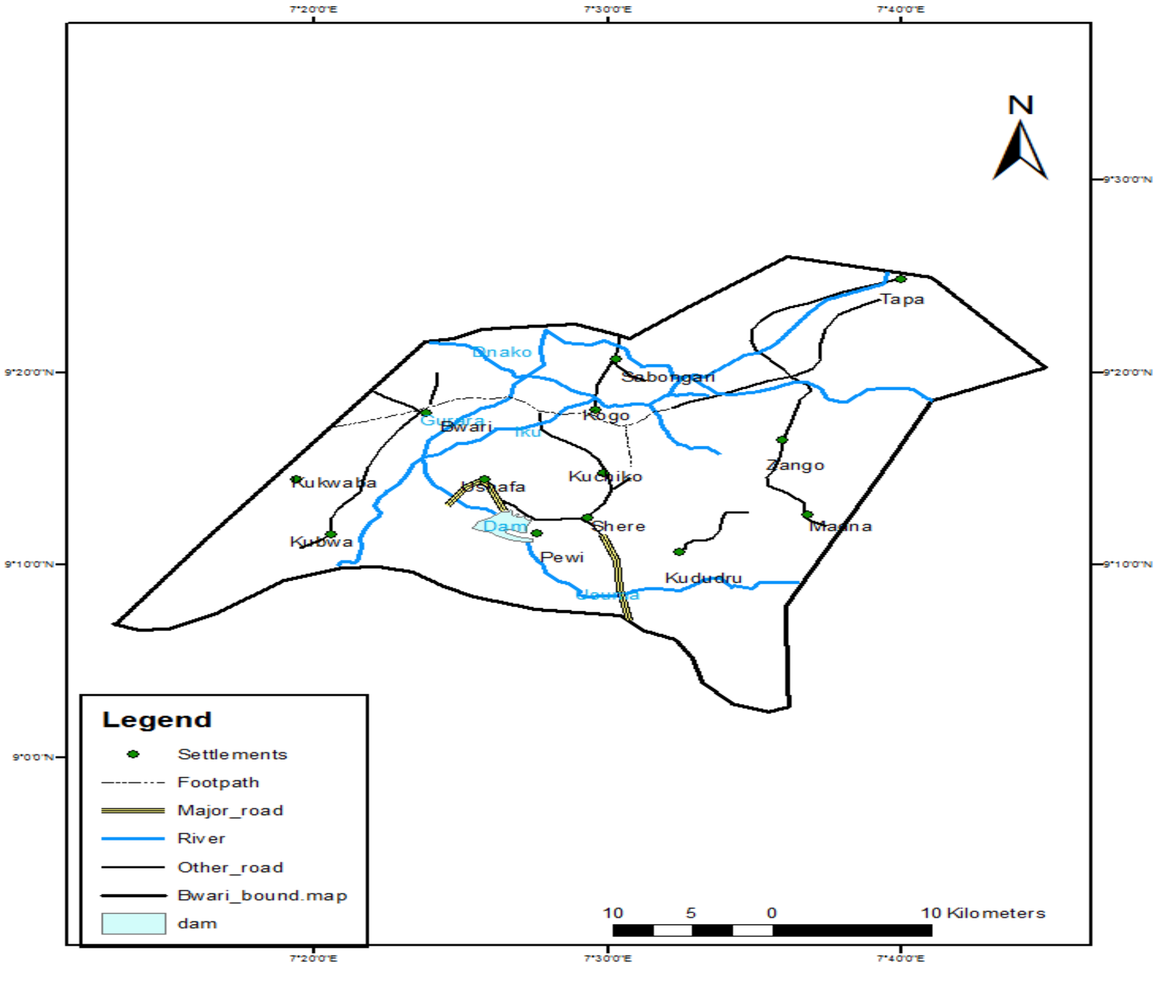


Fig. 1: Bwari Area Council, Federal Capital Territory

Source: Department of Planning and Survey, FCDA Abuja, December, 1992.

The Bwari–Aso hill range, within which the study area is located experiences two weather conditions annually, these include a warm, humid rainy season and a dry season.The rainy season begins from about April and ends in October with an annual total rainfall in the range of 1100 mm to 1600 mm (WMO, 2011).Daytime temperatures range from 28°C to 30°C while night time lows hover around 22°C to 23°C. Relative humidity is higher during the wet season with the average being above 70% (WMO 2011).The vegetation cover of Bwari area is largely secondary in nature. Much of it has been degraded to savannah woodlands, shrub savannahs and parklands (FCDA, 2004).

The population of the communities that comprise the study area is heterogeneous in nature. It comprises of Gbagyi and several other tribes such as Hausa, Gwandara, Nupe, Ibo, and Yoruba etc.Expectedly, this diverse population is engaged in different activities from primary through secondary to tertiary economic activities while agricultureis predominantly the pre-occupation of the indigenes (FCDA, 2004).The population figure of Bwari is given as 227,216 persons based on the 2006 census (NPC, 2007).The main land use types in the study area includebuilt-up, residential, commercial, institutional, administrative, roads and industrial.

MATERIALS AND METHODS

For this study, integration of primary and secondary data was required to achieve expected results. The dataset used in this study includes the Administrative map of FCT showing Bwari Area Council at the scale of 1: 10000 obtained from Federal Capital Development Authority (FCDA) in 2004, digitized contour map of Bwari Area Council at the scale of 1:10obtained from National Space Research and Development Agency (NASDRA) in 2009, Landsat TM satellite image data of Bwari Area Council at 30m resolution of December 1987 obtained from Global Land Cover Facility (GLCF), Landsat ETM satellite image data of Bwari Area Council with 30m spatial resolution of January 1999 obtained from National Centre for Remote Sensing (NCRS) Jos and Nigeria Sat-1 satellite image data of Bwari Area Council at 30m resolution of February, 2009 obtained from National Space Research and Development Agency (NASDRA).

Before the pre-processing and classification of satellite imageries, an extensive and thorough field Survey using Global Positioning System (GPS) was carried out throughout Bwari for ground truthing. The field work wasconducted from 9th – 12th February 2012, this was done to tally with the dry season in which the satellite imageries were obtained, in order to obtain the representative cover type characteristics of the spectral signatures in the area during the period covered.

A sub-set of Bwari Area Council was created using ILWIS 3.7 software for image processing, sampling and classification.For the purpose of this study, the supervised classification technique was employed based on six classes of land use land cover. The maximum likelihood algorithm supervised image classification method was used for the sampled imagery, this is because the Maximum Likelihood algorithm offers the best output in terms of details on Landuse and Landcover (LU/LC) classification as it defined the maximum likelihood between two distinct codes (pixels) (Njike, 2011).

Calculation of the area in hectres of the resulting LULC types for each year and subsequently comparing the results.Thus, the percentage change to determine the pattern of change was calculated by the formular given as:

$$\text{Percentage Change} = \frac{\text{Change} \quad \text{X} \quad 100}{\text{Base year1}}$$

In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of study years 1987 – 1999 (12 years) and 1999 – 2009 (10 years).

An overlay operation of draping the landuse over the DTM was perfomed in ArcScene to visualise and assess the spatial relationship between the land use types and the terrain in 3-D format. The statistics of their relationship was calculated and presented in tables.

Descriptive statistics was used to summarise the results obtained from the analysis of satellite imageries while the inferential statistics was used in the test of hypotheses drawn from the objectives of the study. Chi-Square statistical technique was employed for the hypotheses testing of significant differences in the land use land cover pattern amongst the different time periods and the significant relationship between land use types and terrain characteristics.

RESULTS AND DISCUSSIONS

Land Use Land Cover Pattern and Change

The pattern of change and rate of transformations of land use categories between 1987-1999 and 1999-2009 are presented in figures 2(a, b, c), while table 1 summarizes the statistics**.**

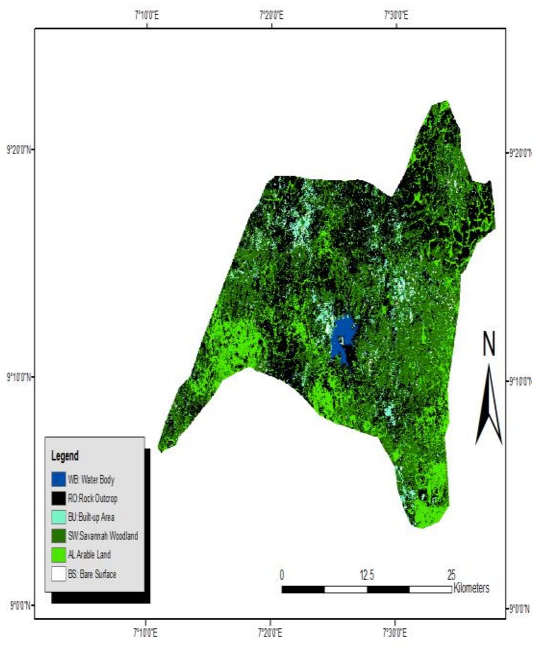


Fig. 2a LULC of Bwari Area Council 1987

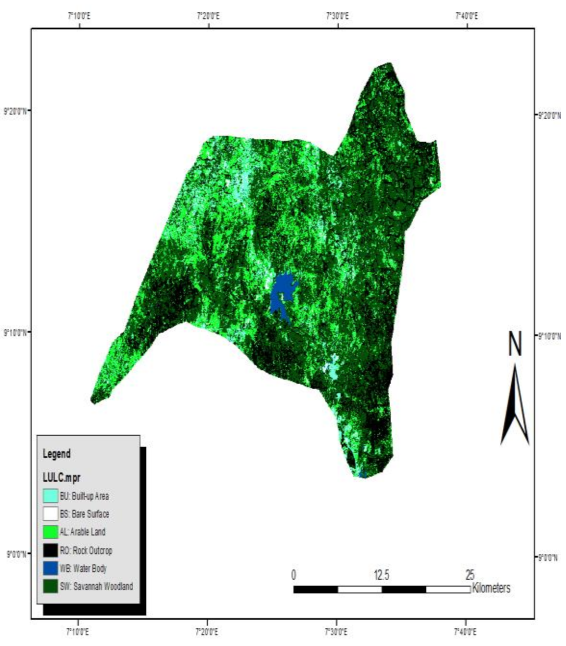


Fig. 2b LULC of Bwari Area Council 1999

From table 1, the savannah woodland constituted the most extensive type of land use/land cover in 1987. It accounted for about 41.2% of the total area. This is followed by the arable land and rock outcrop, occupying 30.2% and 23.8% of the total area, respectively. The built up area, bare surfaces and water body covered 2.8%, 0.8%, and 1.2% of the areas, respectively.

By the 1999 period, the savannah woodland has reduced to 39.5%, but still constituted the most extensive LULC type within the period of study. This is followed by arable land and rock outcrop which, accounted for 38.5% and 14.1% of the total area, respectively. Also, within this period, there was an increase in the built up area, bare surfaces and water body,

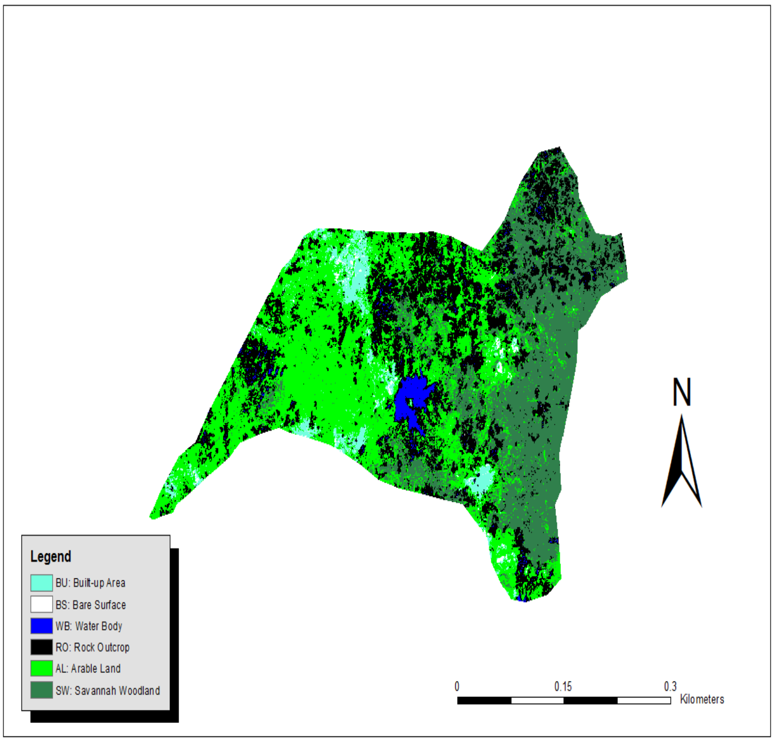


Fig. 2c LULC of Bwari Area Council 2009

covering 5.3%, 1.5% and 1.3 % of the total area, respectively. By 2009, the savannah woodland decreased marginally to 33.9%. There is also an increase in the arable land by 45.3%. The rock outcrop and built up area occupied about 14.0% and 6.3% respectively, while the remaining area was covered by water body 1.3% and bare surfaces 2.0%. When the LULC pattern was subjected to Chi-Square analysis the result obtained showed significant differences (χ^2 value of 67362.27).

Table 1: Land Use/Land Cover Pattern of Bwari Area Council (1987, 1999 and 2009).

LULC TYPE	1987 AREA (ha)	%	1999 AREA (ha)	%	2009 AREA (ha)	%
Bare surfaces	5356.8	0.8	9702.9	1.5	13167.9	2
Built up area	18360.9	2.8	35585	5.3	42115.2	6.3
Arable land	201519	30.2	256929.4	38.5	302206.5	45.3
Savannah woodland	275093	41.2	261786.9	39.5	207087.1	31.1
Rock outcrop	158435.5	23.8	93880.8	14.1	93621.5	14
Water body	8021.7	1.2	8901.9	1.3	8588.7	1.3
TOTAL AREA	666786.9	100	666786.9	100	666786.9	100

Source: Author's Analysis

Land Use /Land Cover Change

The pattern of change and rate of transformations of land use categories between 1987-1999 and 1999-2009 are presented in figures 3a and b while table 2 summarizes the statistics.

The results from figure 3a and table 2 showed the LULC changes that occurred from 1987-1999. The area under arable land, built-up area and bare surfaces registered a net gain of 93.8, 81.1 and 27.5% respectively. Rock outcrop and savannah woodland on the other hand declined by 40.7% and 4.8% respectively. The results show that the areas covered with arable land, built-up area and bare surfaces were expanding at an average rate of 0.69%, 0.22% and 0.07% per annum, respectively, while savannah woodland and rock outcrop were receding at rates of 0.16% and 0.81% per annum over the 12 years period.This is most likely due to the fact that people are encroaching into the rocky/undulating areas for purposes such as buildings, road constructions, quarry, blasting and mining. These changes are consequent upon the various construction projects that were embarked upon in line with the master plan of the FCT.

However, figure 3band table 2 showed that between the periods 1999 – 2009 negative changes occurred in LULC by 26.4%, 0.27% and 3.64% in area under savannah woodland, rock outcrop and water body respectively suggesting an annual decline rate of 0.82%, 0.04 and 0.05% while arable land, built-up area and bare surfaces had increased by 14.9, 15.5 and 26.3% respectively at an expansion rate of 0.68, 0.2 and 0.05% per annum over 10 years period.Within a period of ten years a total of 137821.8 ha (56.5%) of savannah vegetal cover has reduced for other LULC by 2009 showing an annual decrease rate of 0.82%.

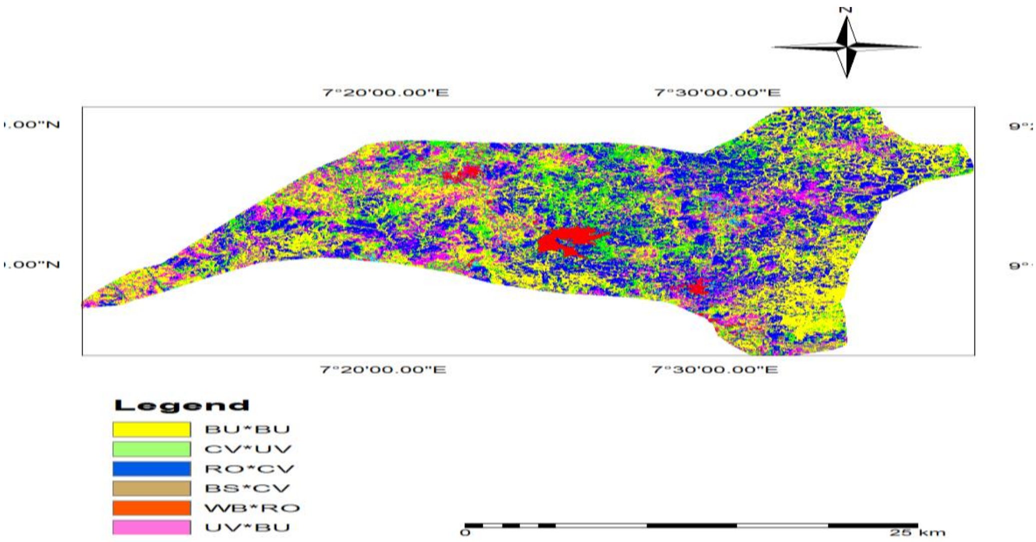


Fig. 3a: LULC Change between 1987 and 1999

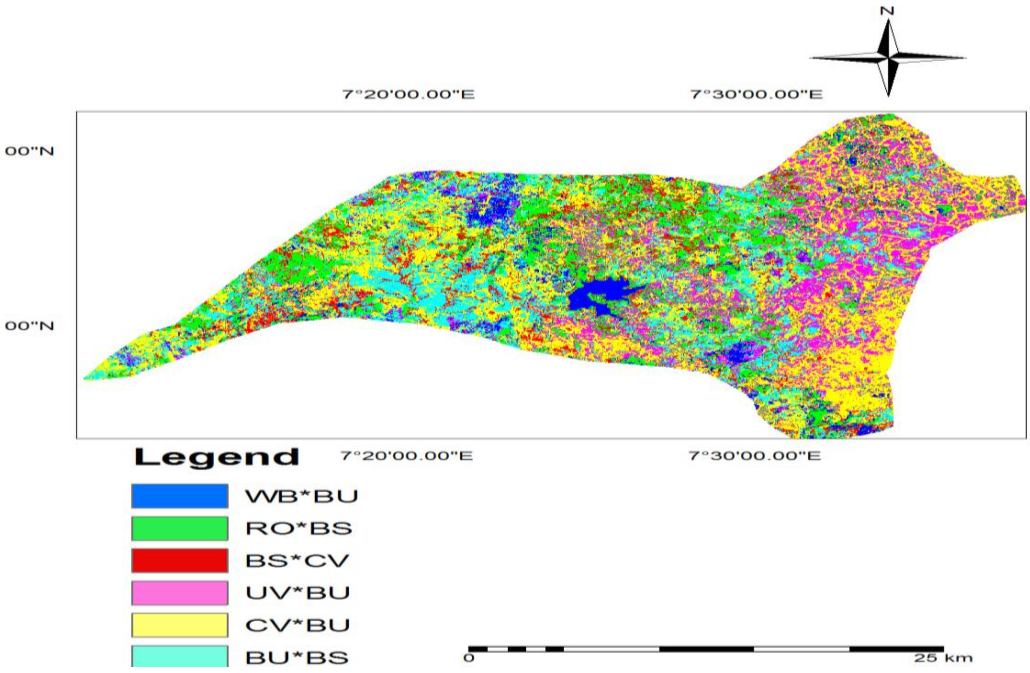


Fig. 3b: LULC Change between 1999 and 2009

Note (BU- Built Up Area; WB- Water Body; BS- Bare Surfaces; AL- Arable Land; SV- Savannah Woodland; RO- Rocky Outcrop)

Table 2: Trend and Rates of Change in LULC of Bwari Area Council between 1987 and 2009

LULC TYPES	Change between 1987and 1999 (ha)	%change (trend)	Change between 1999and 2009 (ha)	%change (trend)	Rate of change (ha/yr) 1987-1999	%	Rate of change (ha/yr) 1999-2009	%
Bare Surfaces	4346.1	81.1	3465	26.3	362.2	0.07	346.05	0.05
Built Up Area	17224.1	93.8	6530.2	15.5	1435.3	0.22	653.02	0.2
Arable Land	55410.4	27.5	45277.1	14.9	4617.5	0.69	4527.71	0.68
Savannah Woodland	-13306.1	-4.8	-54699.8	-26.4	-1108.8	-0.16	-5469.98	-0.82
Rocky Outcrop	-64554.7	-40.7	-259.3	-0.27	-5379.5	-0.81	-25.93	-0.04
Water Body	880.2	10.9	-313.2	-3.64	73.4	0.08	-31.32	-0.05

Note: Decrease carries negative sign while increase carries positive sign.
Source: Author's Analysis

Land use/land cover change has far reaching ecological consequences. According to Olaniran (2002), in Nigeria, deforestation has been seen to cause erosion that is affecting reservoirs, decreasing the aquatic populations, reducing the navigability of canals and also the quality of soil. He also noted that the problem of desertification and environmental degradation caused by land use/ land cover change threatens the country. The finding that the area covered by bare surfaces also increased noticeably between 1987-1999 but the rate of increase declined again by 1999-2009, is in line with Ujoh et al. (2010) for the whole of FCT between the period of 2001-2006 which was attributed to increased tempo of human activities as a result of increase in population

Topographic Characteristics of Bwari Area Council

The result of the topographic analysis, consisting of the elevation and slope of the study area, are given in Table 3 while Figures 4(a, b and c) depicts the Slope analysis, Relief and Digital Terrain Model (DTM). Most part of the study area is characterized by rugged topography (figure 4.c). Slope analysis of the study area showed that the slopes are variable with steep slopes, although there are areas with gentler slopes. Table 3 shows that altitude ranges from 408 to 838.1 metres, with the highest elevation of 750.5 -838.1 metres occupying 14.3% of the study area. Also about 42.9% of the area falls within an altitude range of 518-618 meters, while low altitudes occupied 7.9% (fig 4.b). Although, slope-range varies from 0.5 to 25 degrees, steep slope are found within slope range of 15 - 25^0 while plain surfaces occupies only 0.7 % of the area and about 50% of the area falls within the slope range of 5.0 - 15^0 (Figure 4.d and e)

Table 3: Topographic Analysis of Bwari Area Council

ELEVATION (m)	%	SLOPE	%
408.5-474.2	7.9	0.5 -3.2	0.7
474.3-518.0	8.9	3.3-5.0	2.8
518.1-556.8	9.6	5.1-6.7	5.5
556.9-600.6	10.1	6.8-9.4	8.3
600.7-646.1	11.2	9.5-12.1	11.1
646.2-681.4	12	12.2-15.0	14
681.5-713.4	12.4	15.1-18.3	6.6
713.5-750.5	13.2	18.4-22.6	9.4
750.6-838.1	14.3	22.7-25.0	21.5

Source: Author's Analysis

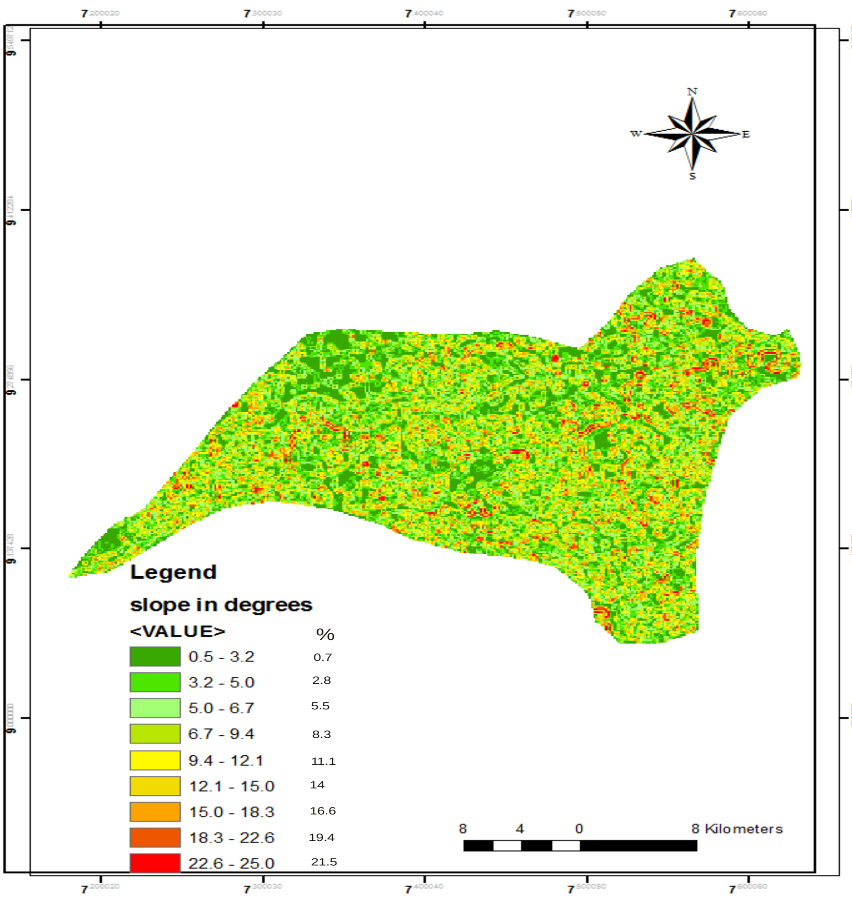


Fig. 4.a: Slope gradient of the study area

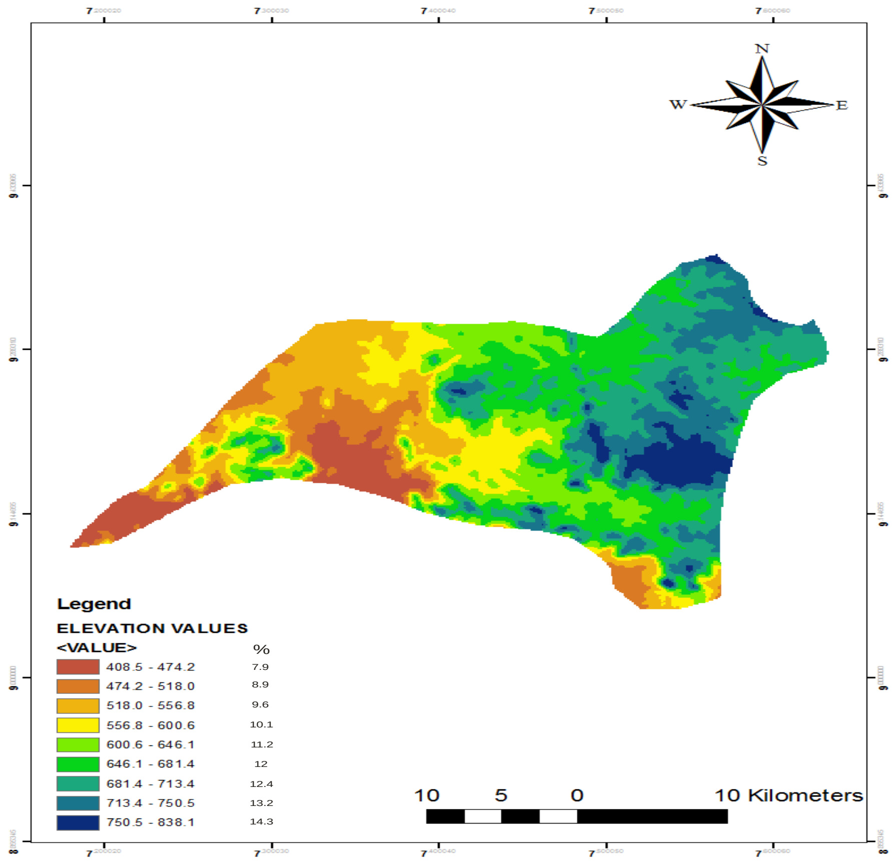


Fig. 4.b: Relief of study area

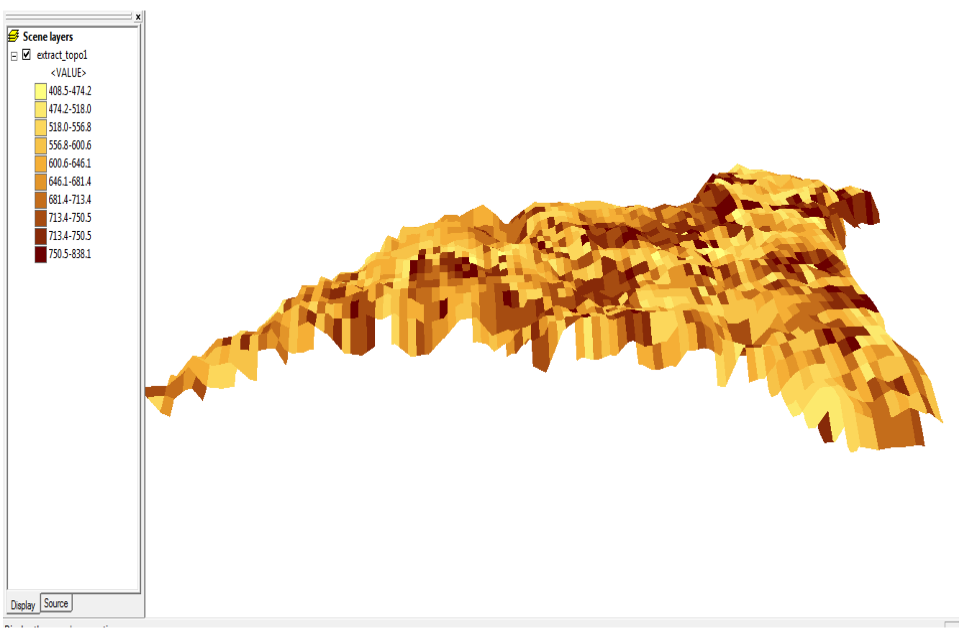
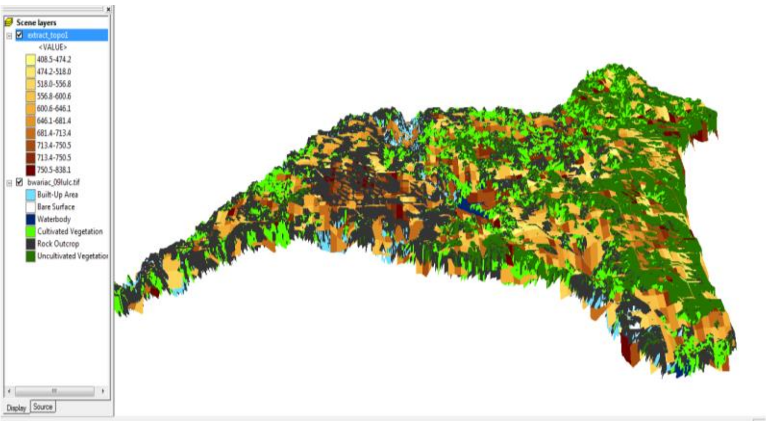


Fig. 4.c: Digital Terrain Model (DTM) of the study area

With respect to terrain characteristics, the study shows that the area was mainly covered with rock outcrop and undulating surfaces with elevation as high as 750 6- 838.1 meters above sea level occupying 14.3% and very steep slope gradient above 22^0 covering about 21.5% of the total area. The areas with slopes < 9.5^0accounted for 17.3% while elevations between 408.5- 600.6 occupied 36.5% of the entire area. It is worthy to note that these are area where the dominant land uses such as built-up area, bare-surface, arable land and savannah woodland are mostly located. Below the rock hills are forest vegetation between pockets of rock and soil cover. The inter-fluvial slopes were covered by savannah vegetation. The lower slopes and valley bottom fringes were dominated by riparian vegetation. The land form therefore includes rock outcrops, rock hills, hill slopes, inter fluvial slopes, and lower bottom fringes. Different land uses occupied the terrain categories.

The Spatial Relationship between Topography and Land Use/Land Cover

The statistics results of the relationship between topographic characteristics (elevation and slope) and land use/ land cover of the study area are summarised in table 4 and 5 while the overlay showing their spatial relationships are given in Figures. 4d & e.



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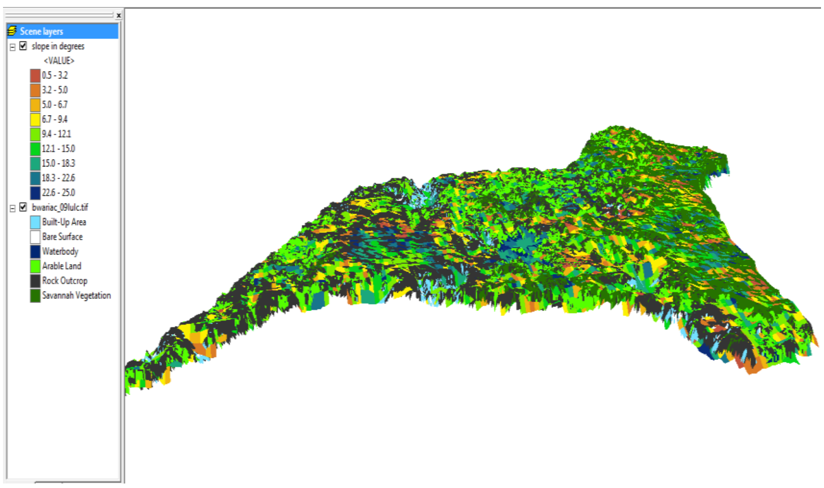

(e)

Fig. 4(d & e) Overlay of the Land Use/Land Cover on DTM (elevation and slope) of the Study Area

Table 4: Relationship between Elevation and Land Use/Land Cover

	ELEVATION IN METERS (above sea level)									
LULC	**408.5-474.2m (%)**	**473.3-518.0m (%)**	**518.1-556.8m (%)**	**556.9-600.6m (%)**	**600.7-646.1m (%)**	**646.2-681.4m (%)**	**681.5-713.4m (%)**	**713.5-750.4m (%)**	**750.5-838.1m (%)**	**TOTAL**
Water body	0.31	0.18	0.17	0.14	0.13	0.12	0.11	0.1	0.04	**1.3**
Bare Surface	0.32	0.29	0.27	0.25	0.22	0.19	0.17	0.15	0.14	**2**
Built-up Area	1.8	1.7	0.9	0.42	0.36	0.12	0.6	0.34	0.06	**6.3**
Arable Land	7.93	7.72	6.84	5.78	5.52	4.26	3.8	3.42	0.03	**45.3**
Savannah Woodland	5.73	4.52	4.16	3.86	3.09	2.59	2.5	2.39	2.26	**31.1**
Rock Outcrop	2.8	2.57	1.53	1.36	1.27	1.19	1.17	1.1	1.01	**14**
TOTAL	18.79	17.08	13.87	11.81	10.59	8.47	8.35	7.5	3.54	**100**
CHI-SQUARE										**109333.3**

Source: Author's Analysis

Table 5: Relationship between Slope Gradient and Land Use/Land Cover

	SLOPE IN DEGREES									
LULC	**0.5-3.2 (%)**	**3.3-5.0 (%)**	**5.1-6.7 (%)**	**6.8-9.4 (%)**	**9.5-12.1 (%)**	**12.2-15.0 (%)**	**15.1-18.3 (%)**	**18.4-22.6 (%)**	**22.7-25.0 (%)**	**TOTAL**
Bare Surface	0.72	0.27	0.23	0.21	0.2	0.15	0.11	0.1	0.01	**2**
Built-up Area	1.5	1.6	1.13	0.72	0.52	0.39	0.3	0.14	0	**6.3**
Arable Land	18.2	9.2	5.09	4.72	4.4	2.51	0.8	0.35	0.03	**45.3**
Savannah Woodland	7.27	6.57	5.35	3.45	3.05	2.21	1.6	1.51	0.09	**31.1**
Rock Outcrop	5.8	3.09	2.2	1.3	1.07	0.19	0.17	0.12	0.06	**14**
Water body	0.49	0.2	0.16	0.14	0.11	0.1	0.05	0.03	0.02	**1.3**
TOTAL	33.98	20.93	14.16	10.54	9.35	5.55	3.03	2.25	0.21	**100**
CHI SQUARE										**11424.04**

Source: Author's Analysis

From the relationship between terrain and land use / land cover it becomes clearer that in Bwari Area Council different land uses occupied the terrain categories. Each terrain category was characterized by different land cover which made correlation of DEM and land use land cover estimation possible. About 51.6% of the total area was under built-up and arable land and another 31.1% was savannah woodland. However, it was observed that 4.4 % of the built up area were found on lower altitude between 408.4-474.2 meters above sea level while 22.9% of the arable land was also found on this altitude (table 4).

It is interesting to note that no form of human interference such as built-up area was found on slope gradient range of 22.7-25.0 degrees while a negligible 0.03% of arable land was also found within this slope range, this is due to the cost prohibitive and rugged nature of the terrain.

Land slope gradient in the North-West region of the study area is moderately steep to steep, relief is moderate, and the hazards are less severe (table 5). Although some areas are already brought under the human use, the major chunk is still under savannah woodland. However, the density of the savannah vegetation in many cases is not high enough to ensure protection of soil loss hazards especially in open and scrub vegetation.

The Chi-Square analysis used to test for the relationship between the land use and topography (elevation and slope) of the study area, showed a significant relationship between the three variables tested (table 4) i.e land use versus elevation and land use versus slope at 0.01 significant levels gave a X^2 value of 109333.3 for the significant relationship between land use/elevation and 11424.04 for the significant relationship between land use/slope characteristics, therefore, the null hypothesis is rejected.

From this result analysis we can conclude that a strong relationship exist between the land use and terrain of the study area. An analysis of terrain characteristic and land use components is useful to delineate suitable areas for production and the GIS combination has potentiality to provide a rational, objective and non-biased approach for making decisions in land use planning (Ceballos-Silva and Lopez-Blanco 2003).

CONCLUSION

This research was on terrain and land use analysis of Bwari Area Council of FCT using remote sensing and GIS. Attempt was made to identify as accurate as possible six land use/ land cover classes as they change through time, result of findings showed the pattern of land use land cover, changes that occurred, trend and rate of conversion of the LULC between 1987 and 2009. The topographic characteristics of the study area was also analysed in order to assess the spatial relationship with the land use types. The data used for this research include a 10m contour data of the study area, the Landsat Imageries of 1987 and 1999 and Nigeria Sat-1 Imagery of 2009.

The result obtained in the land use land cover pattern is one of an increase in the built-up areas, bare surfaces and arable landby 1.28, 4.6 and 15.1% respectively at an expansion rate of 0.12, 0.24 and 1.37% per annum with a corresponding decline in the savannah vegetation and rocky outcrop by 10.2 and 9.74% respectively between 1987 and 2009. It was also observed that a strong relationship exists between the terrain and land use pattern in the study area. The built-up area, arable land, water body and bare surfaces are found mostly at an elevation of 408.5 – 600.6 meters and slope of 0.5-9.4 degrees, while savannah vegetation and rocky outcrop are located on higher elevation between 600.6 and 838.1 meters and over moderate to steep slope gradient of mostly 9.4-25.0^0. This implies that over the study area, settlements and farmlands are expanding on vulnerable sloping lands with tendencies that may lead to land degradation and poor agricultural productivities.

In light of the foregoing analysis, it is recommended that

i. The Bwari Master Plan which was produced for Bwari town should be revised to cover the entire Bwari Area Council as built-up area expansion, agricultural activities and deforestation are the major factors behind land use land cover changes in the study area.
ii. Development and cultivation on vulnerable sloping lands should be discouraged within the study area as this can increase land degradation.
iii. Development control policies guiding the building of structures in Bwari Area Council should be revised to encourage high rising structures in order to maximise the available lands for other use.

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