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Landuse and Landcover Change Detection in Kuje Area Council of the Federal Capital Territory (FCT), Abuja, Nigeria

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Abstract: *The paper examined the land use and land cover change in Kuje area council of FCT. Abuja. It identified the land use pattern since 1987 and examined the responsible factors for changes and the effects of these changes on Kuje land area. GISand Remote Sensing Techniques were applied in mapping the landuse/landcoverofKuje between 1973 and 2010 to detect changes that took place in the last thirty seven years (37). Landsat images of 1973, 1987 and 2010 were used for the study. ILWIS 3.3 academic was used for map georeferencing and image classification, while Al-Idrisi 32 was used for area calculation and map analysis. The findings revealed that agriculture/grazing activities have the greatest negative impact in Kuje Area. Extensive agriculture/grazing covered the largest area in 1973 with 102.14km^2 (14.80%) of the land mass which increased to 145.53km^2 (20.86%) in 1987. In 2010, agriculture/grazing increased to 363.35km^2 (52.56%) due to large scale farming and animal rearing activities as well as rapid urbanization in the area. The study further revealed that the impact of settlement on landuse/landcover changes in 2010 has the second largest area cover after agriculture/grazing activities and settlement. Equally, the Woodland areas that was 264.20km^2 (38.26%) in 1973, has also decreased to 115.97km^2 (16.76%) in 2010. The study recommendsthere is a need for embarking on public awareness in the community on sustainable land management. Theauthorities should open up new land for agricultural production; ensure continuous environmental monitoring as well as formation and enforcement of land use policy for future development among others.*

Key Words:*Landuse,Land Cover, Change Detection, Kuje Area*

I. Introduction

Land-use and land-cover change (LULCC);is a general term for the human modification of Earth's terrestrial surface. Changes in land use and land cover date to prehistory and are the direct and indirect consequence of human actions to secure essential resources. This may first have occurred with the burning of areas to enhance the availability of wild game and accelerated dramatically with the birth of agriculture, resulting in the extensive clearing (deforestation) and management of Earth's terrestrial surface that continues today. More recently, industrialization has encouraged the concentration of human populations within urban areas (urbanization) and the depopulation of rural areas, accompanied by the intensification of agriculture in the most productive lands and the abandonment of marginal lands. All of these causes and their consequences are observable simultaneously around the world today(The Encyclopedia of Earth, 2013).Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of LULCC are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air.

Landuse has generally been considered a local environmental issue but with global significance (Cunningham and Cunningham 2007). Landuse patterns are driven by a variety of physical and socioeconomic determinants and principally explain land cover changes. More specific stressors have been identified to be responsible for landcover changes around the world (Nakagoshi and Lubis(2011). These include: agriculture, urbanization, fires, timber and fuelwood extraction grazing, construction of dams and roads, rapid growth rate of population, lack of valuation of ecological services, poverty, ignorance of biologically incompatible technologies, and national economic revolution. Surveying the causes of land degradation in Africa, Enger and Smith (2004) reported that 13 – 46% were due to deforestation, 48% to fuelwood and timber extraction, 25% due to overgrazing and 14% due to agriculture. Udo (2006) reasoned that rural Nigeria with about 60% of the population on 95% of the land area faces environmental crisis in terms of farmland, fuelwood and water supply.

Sustainable land management is therefore a central challenge in the sustainable management of earth systems and resources. Monitoring and mediating the negative consequences of LULCC while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world.Moreover, local alteration of land use and land cover can have global consequences, requiring local and regional solutions to global problems and the cooperation of the world's policymakers, land managers, and other stakeholders in land management at local, regional and global scales.Protection of productive agricultural

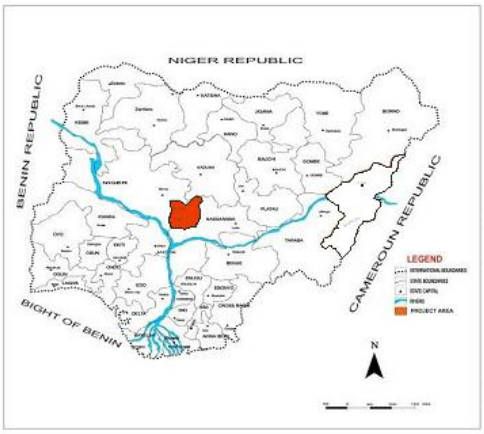
land has thus become a major priority in many regions of the world. Land degradation by overgrazing and intensive agriculture on marginal lands is a major driver of land loss; a number of national and international programs have responded with land reforms and incentive programs to avoid this outcome.

Landcover is therefore an important indicator of environmental change and plays a role in the process of change (Lambin*et al*., 2006 cited in Samuel&Tim, 2013). In Nigeria, land cover data for natural resources management is lacking and where they do exist they are out of date. Thus, because of lack of such data, professionals such as town planners and resource managers often make decisions based on false assumptions (Samuel & Tim, 2013). Presently remote sensing methodologies provide the most current and viable means of obtaining land cover data (Ramankutty*et al.*, 2006). The availability and continuous affordability of satellite data at global, regional and local scale makes the remote sensing method viable and hence the means of assessing changes occurring in the study area.

Kujearea was originally an agricultural settlement but with the creation of the Federal Capital Territory, it has turned to a satellite town.Kuje area was formerly in Niger state, but when the new capital territory came into existence by Decree No 6 of 1976, in November 1987, by President General Ibrahim Babangida it has been moved to the FCT. The problem associated with land use and land cover change is expressed in terms of residential land use development as well as lack of proper development plan implementation based on the master plan. This perhaps led to an unhealthy co-existence in neighborhoods resulting from distortion of the original layout plan and conversion of reserved lands to uses. Today, there are little or no marked boundaries between what is high, medium and low, because of incessant changes and uncontrolled landuse development and management of residential land in Kuje.Within the last decades, in Kuje area, several buildings and shanties have been demolished and converted into more sophisticated commercial properties such as private schools, hotels and banks which havenow brought about land useand land cover change. The tenants have been asked to vacate their residential properties in order to use the whole or part of the building for commercial purposes which have led to the alterationin the land use pattern.Due to the increase in commercial activities and populationgrowth there was increase in traffic flow and lots of noise in the area. This paper therefore examined the landuse and landcover change detection in Kuje Area Council of the Federal Capital Territory (FCT), Abuja, Nigeriausing GIS and remote Sensing Techniques.

II. Study Area

Kuje LGA is located on latitude 8°53′47″N and longitude 7°14′ 24″E north and east of Abuja and south of Abaji area councils (onlinenigeria, 2009) and is about 40 km south west of Abuja, the Capital of Nigeria.Kuje has a total land mass of 1,800sqkrn about (22.5% of FCT) and a population of 97,367 at the 2006 census, due to urban population growth rate of 4.52% (Census,2014. It comprises of two major districts, Kuje central and Rubochi (Figures 1 and 2). The area comprises of different ethnic groups with varying cultural and social backgrounds namely the Egbirakoto, Gade, Gbari, Gbagyi, Bassa, Hausa-fulani and others.The people are predominantly farmers and traders who specialize in agriculture and livestock breeding. However, other economic activities of the people includes trading in pharmaceuticals, provisions, building materials and other essentials such as fruit, vegetables, fresh meat, household goods, fabric, shoes, clothing, smoked fish etc.



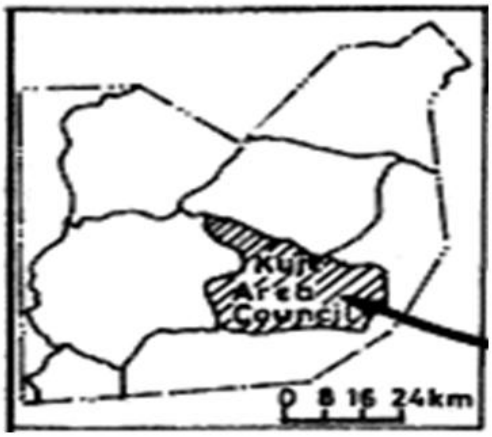


Fig.1: Map of Nigeria showing FCT Abuja.Fig. 2: Map of Abuja showing Kuje Area.

III. Materials and Methods

The research design adopted for this study was the use of satellite images and other methods to generate datafor the paper.Data were obtained inform of satellite images, library materials such as articles, magazines, academic journals, official publications, internet materials and conference proceedings. Data were

also collected from Landsat TM: Earth Science Data Interface 21/11/1973, Landsat MSS: Earth Science Data Interface 19/9/1987, and Nigersat-1: NARSDA 21/11/2010 (Plates 1, 2 and 3).
Maps and measurements of land cover werederived directly from remotely sensed data by a variety of analytical procedures, including statistical methods and human interpretation. Maps of land use and land cover (LULC) are produced from remotely sensed data by inferring land use from land cover (e.g., urban = barren, agriculture = herbaceous vegetation).

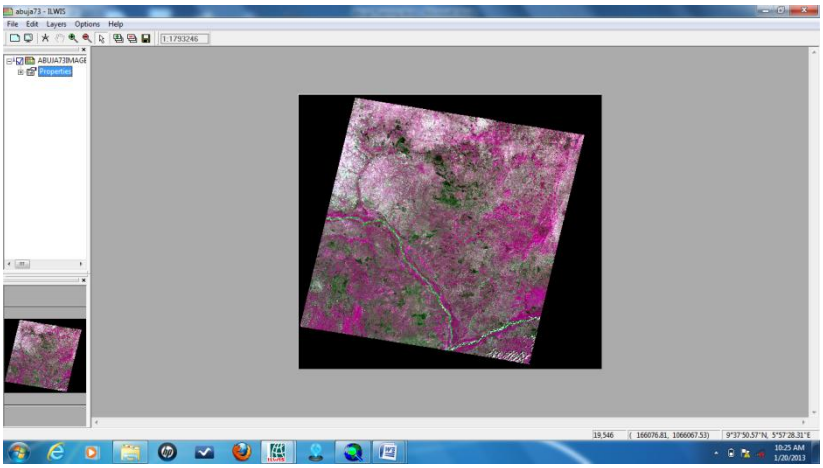


Plate1:1973 Landsat MSS Image; Image of Abuja and Environs.

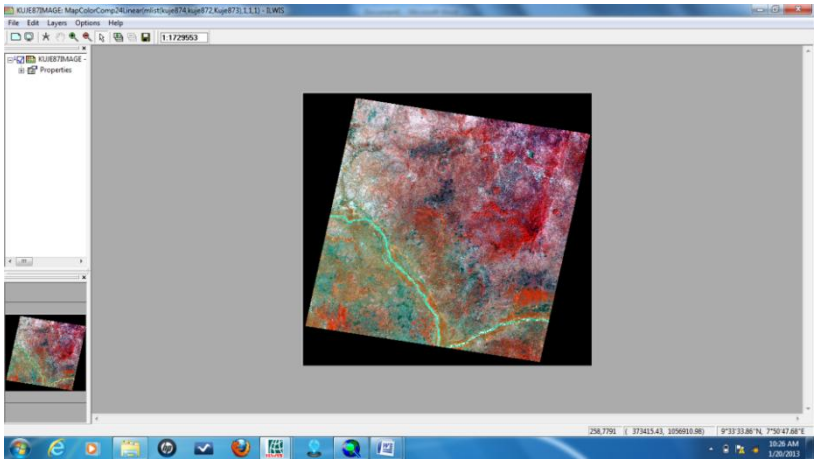


Plate2: 1987 Landsat TM Image; Image of Abuja and Environs.

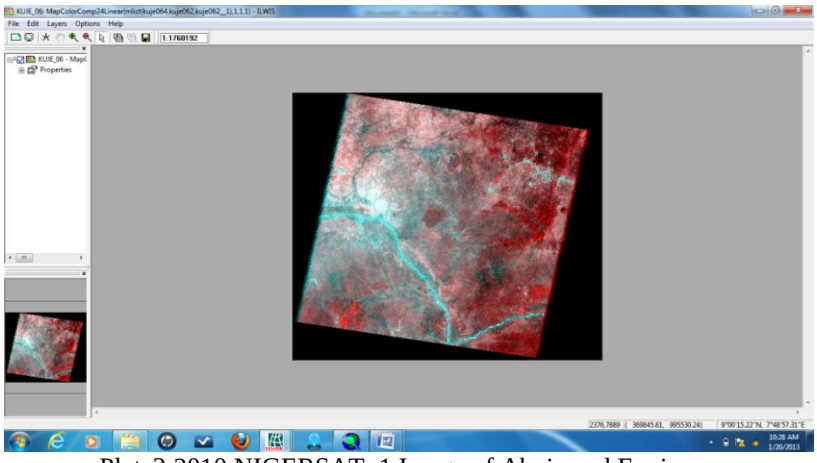


Plate3:2010 NIGERSAT_1 Image of Abuja and Environs

3.1Materials and Equipment

The study utilized three soft wares: ILWIS 3.3 Academic, Arc GIS 9.3. Three Landsat images of FCT Abuja were acquired from different sources. The landsat satellite images include that of 1973, 1987, and 2010. While the 1973, and 1987 were obtained from Earth Science Data Interface. The 2010 image was acquired from the National Space Research Development Agency (NASRDA), Abuja. The Kuje Area Council and its environs were extracted out using the Local Government boundary map and Nigerian administration map.The results are presented inform of maps and statistical tables calculated by dividing the percentage change of each class by 100 and multiplied by the number of the study years (ie 37 years)which is presented in tables2 and 3.

3.1.1 Image Extraction and Classification

The FCT was first extracted and subsequently Kuje Area from the full scene of the acquired images. Image extraction was applied to carve out the actual study area from the entire scene of the image where the area is located. The ArcGIS 9.3 software has an extraction module to carve out the desired part of the images as shown in plates 4 to 6. The Bands 4, 3 and 2 were selected from each of the four imageries for the colour composition operation using ILWIS 3.3 software. This was followed by colour separation which was performed in order to generate 'map list' while the sample set modules of the ILWIS 3.3 was used in creating the 'Domain' that were used for the image classification. The maximum likelihood classification technique of the ILWIS was used to classify each of the three images. The classified images are shown in Plates 6 and 7. The three main change detected methods which have been previously applied by several researchers like Omojola (1999) and Ikusemoran (2009) were employed in this paper.

3.1.2 Change detection by area calculation:- Three major steps were involved in calculating change detection of the area by calculation.

i. The first step was the calculation of the magnitude of change, which was derived by subtracting the observed change of each period of the years from the previous period of years.

ii. The second step was the calculation of the trends that is the percentage change of each of the land use, by subtracting the percentage of the previous land use from land use dividend by the previous land use and multiple by 100.

iii. The third step involved calculating the annual rate of change by dividing the percentage change by 100 and multiplied by the number of the study years, 22 years (1973 – 1995).

3.1.3 Magnitude and Annual Rate of Change proportion

The magnitude of change is the difference between the areas of each land use between the studies periods, which is derived by subtracting the area covered in one year from the previous years. The percentage change is the changes of each class to the overall change, derived by dividing the magnitude of change multiply by 100.

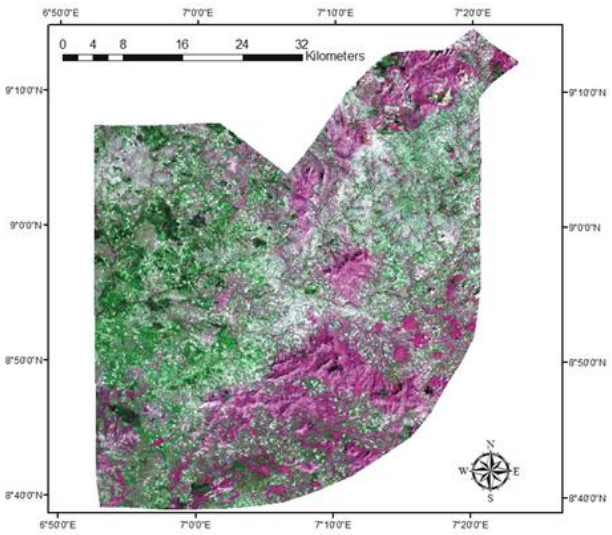


Plate 4:1973 Extracted image of FCT Abuja from the 1973 Landsat Scene.

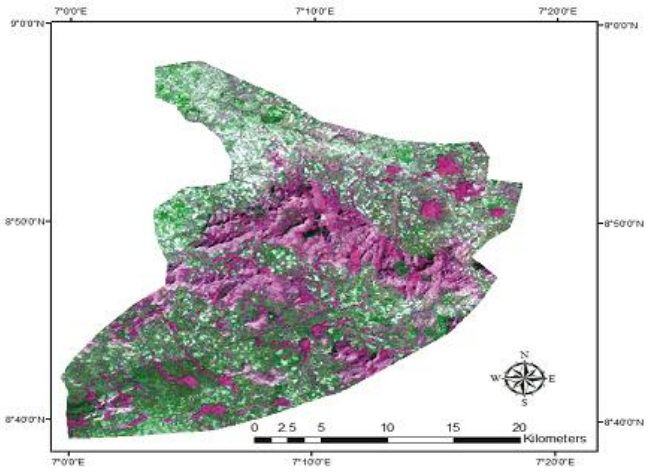


Fig. 5 Extracted image of Kuje Area from the Abuja portion of the 1973 Landsat Scene

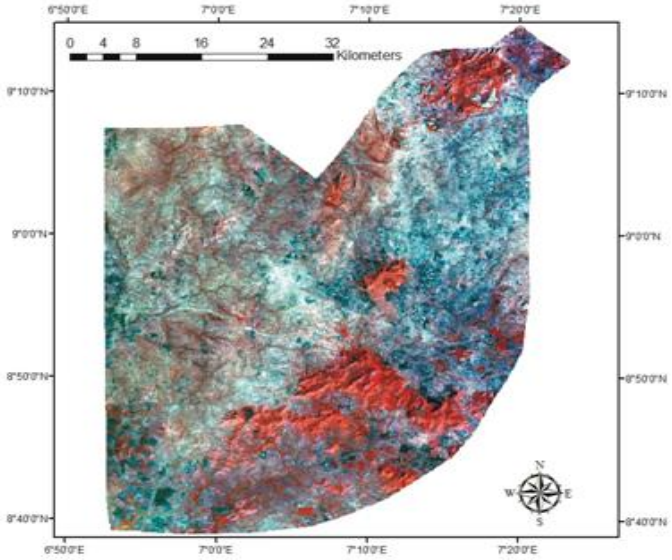


Fig.6: 1987 Extracted image of FCT Abuja from the 1987 Landsat Scene.

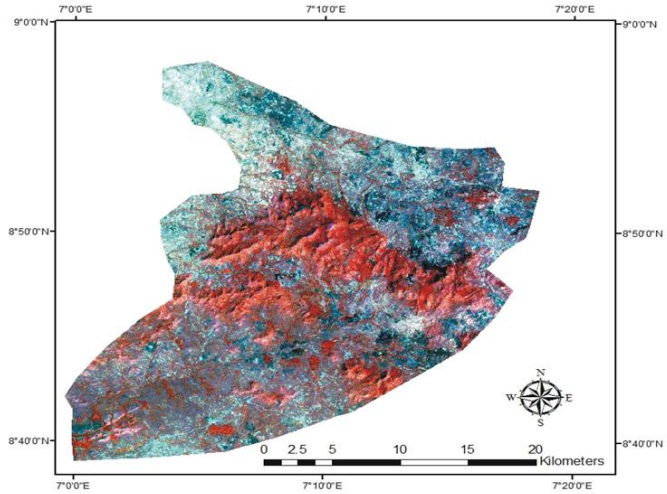


Fig.7: 1987 Extracted image of Kuje from the Abuja portion of the 1987 Landsat Scene.

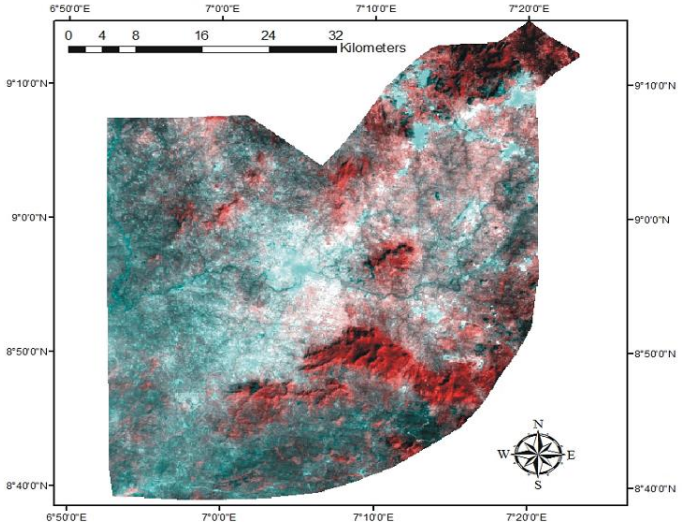


Plate 8: 2010 Extracted image of FCT Abuja from the 2010 NIGERSAT¬_1 Scene.

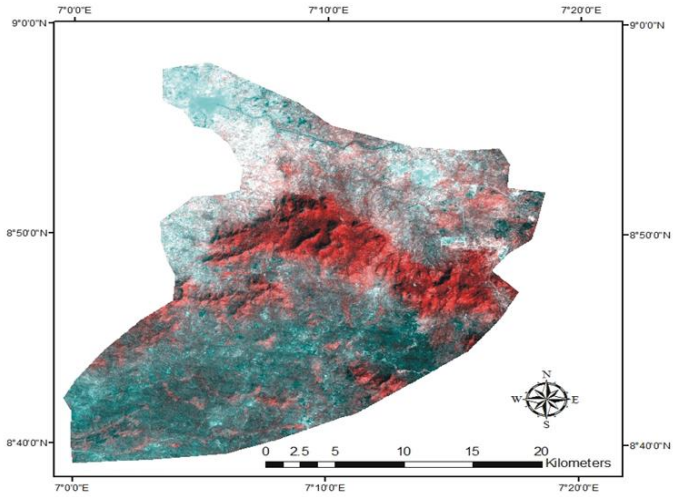


Fig. 9: Extracted image of Kuje Area Council from the Abuja portion of the 2010 NIGERSAT_1 Scene.

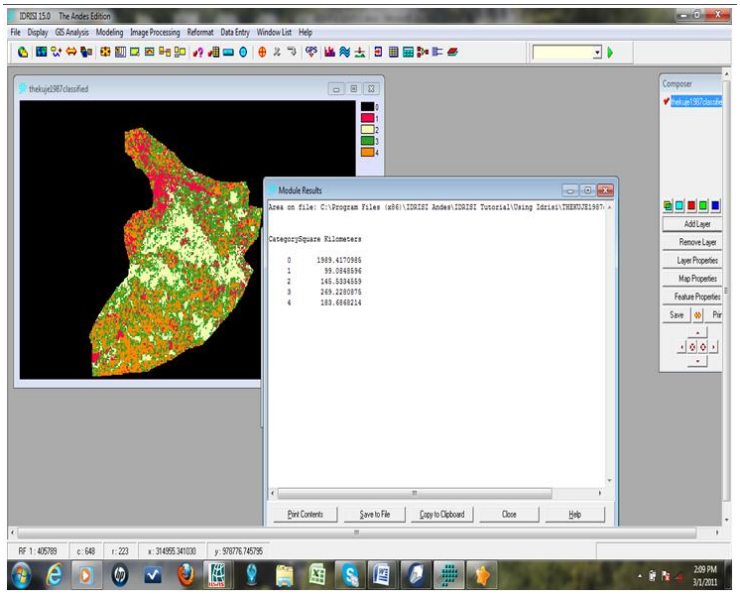


Fig.10:Calculated Area of the 1973 Kuje Area

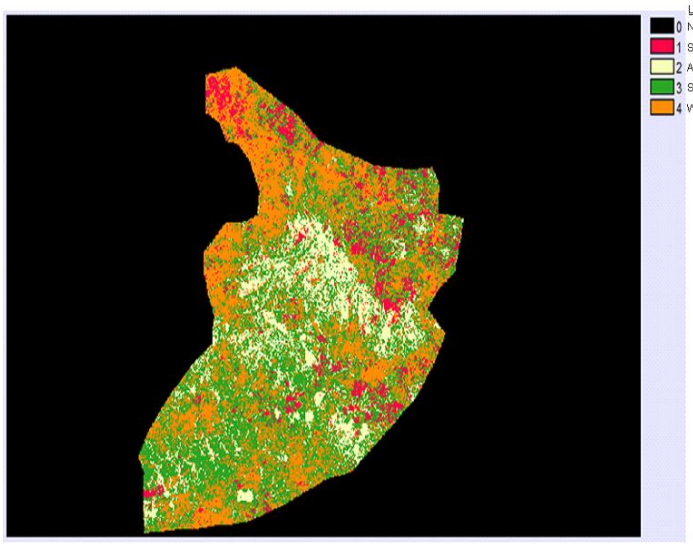


Fig.11:Classified Image of Kuje Area Council in 1973.

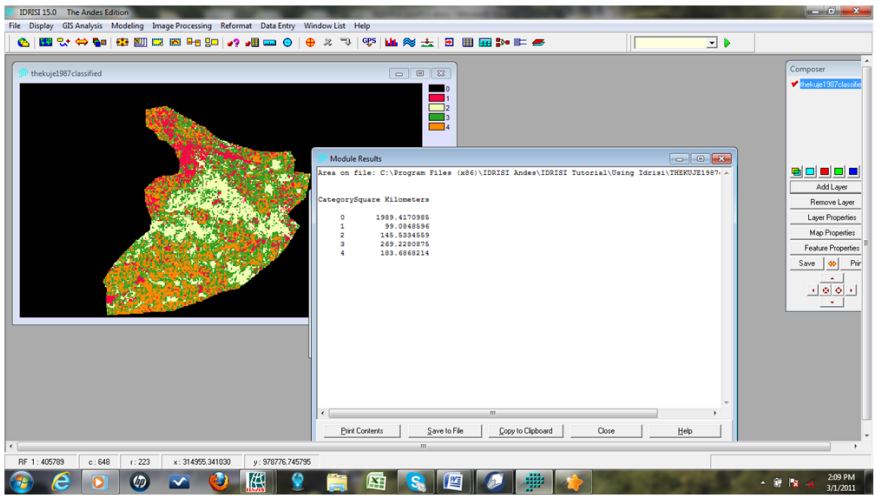


Fig.12:Calculated area of the 1987Kuje Area Council.

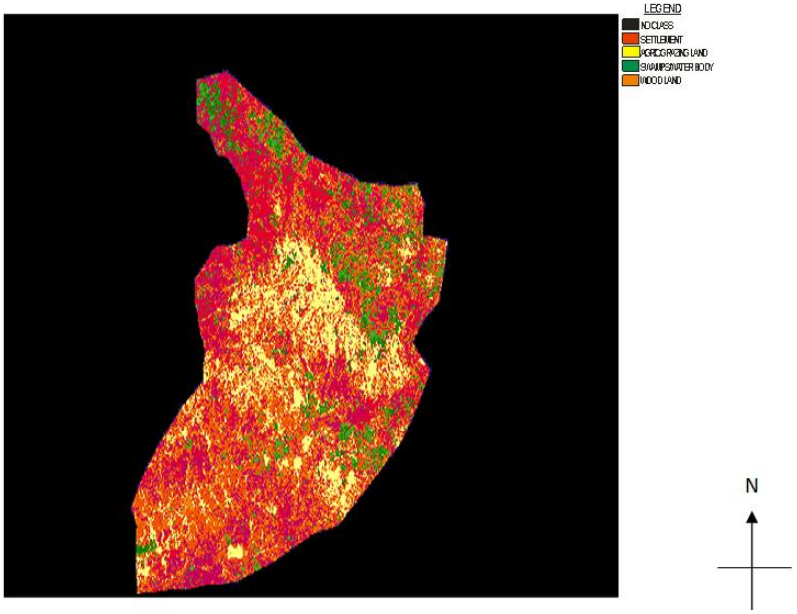


Fig. 13: Classified image of Kuje Area in 1987.

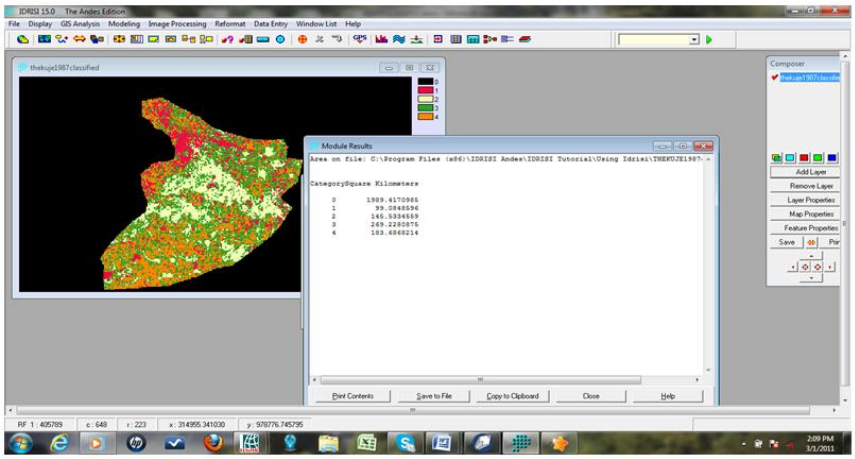


Fig.14: Calculated area of the 2010 Kuje Area

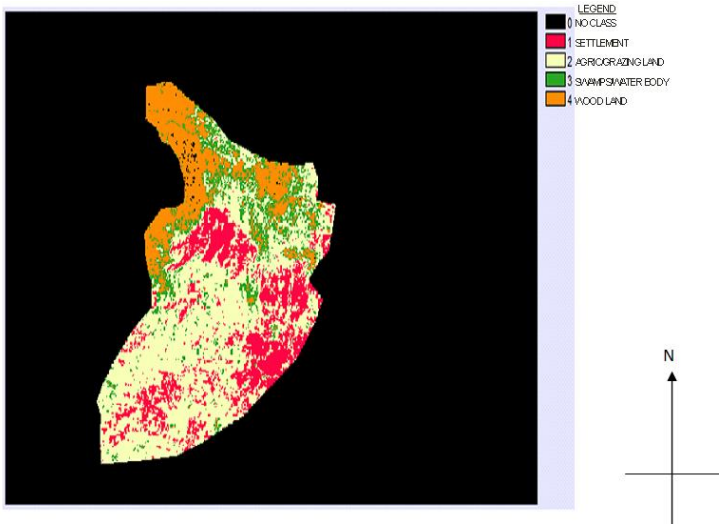


Fig. 15: Classified Image ofKuje Area in 2010

IV. Results and Discussion

Kuje Area Council study area has been subjected to series of changes from 1973 to 2010 (Plates 4-15). Between 1973 and 1987 there is a positive change, resulting into an increment in agriculture/grazing and settlement areas, both increased by 25.84% and 21.09% and swamps/water body is 5.16% while woodland have negative changes that is reduction, which might be due to agricultural activities and settlement expansion. Between 1987 and 2010, there was positive change in many of the land use and land cover types, that is increment in settlement and agriculture/grazing land which all increased by 7.46% and 41.95% respectively, while swamps/water body and woodland have negative changes, reducing by 37.56% and 13.04% respectively. These changes occurred as a result of both human and natural activities.Agriculture/grazing land activities have the greatest negative impact on the Kuje Area as extensive agriculture covered the largest area in 1973 with 102.14km^2 (14.80%) of the area land mass but increased to 145.53km^2 (52.56%), agricultural/grazing still covered the largest land mass area. Settlement was also discovered in 1973 and 1987,as less but suddenly became the second largest area after agriculture/grazing land in 2010. Finally, the impacts of these human activities were revealed to be greatly felt on the swamps/water bodies because it covered 260.56km^2 in 1973 and increased to 269.22km^2 in 1987 and drastically reduced to 10.73km^2 in 2010. Woodland was also discovered to have a negative annual rate of changes of -6.71. This means that wood land is changing annually at a rate of -6.71%.They include the static change and projected land use land cover of each class of area from 1973 to 2010 as derived from the area calculation of the 1973, 1987 and 2010 (Table 1).The static land use land cover distributions for each study year as derived from the maps are presented in the table 1.

Table 1: Trends of Landuse and Landcover Change of Kuje (1973 – 2010).

Landuse/Landcover	**1973**		**1987**		**2010**	
	Area (km^2)	**Area (%)**	**Area (km^2)**	**Area (%)**	**Area (km^2)**	**Area (%)**
Settlement	63.65	9.22	99.08	14.20	137.81	19.93
Agriculture/Grazing Land	102.14	14.80	145.53	20.86	363.35	52.56
Swamps/ Water Bodies	260.56	37.73	269.22	38.60	74.19	10.73
Woodlands	264.20	38.26	183.69	26.33	115.97	16.76
Total	**690.55**	**100.01**	**697.52**	**99.99**	**691.32**	**99.98**

The results in table 1 represent the static area of each land use/land cover for each study year. Settlement covered 63.65km^2; representing 9.22% of the study areas in 1973 have increased to 99.08km^2 representing 14.20% in 1987 which might be as a result of increased in human population of the area when Kuje area council was created by decree no. 6 of 1976. Agriculture / grazing land increased from 102.14km^2 representing 14.80% of the study area in 1973 to 145.53km^2 representing 20.86% in 1987. This could be as a result of anthropogenic activities for example crop production and animal rearing in the study area. The record which shows that between 1987 and 2010 settlement and agricultural/grazing land representing 14.20% and 20.86% of the study area in 1987 increased to 19.93% and 52.56% in 2010 respectively. This could be as a result of anthropogenic activities. Such as crop production and animals rearing in the study area. The record which shows that between 1987 and 2010 settlement and agriculture/grazing land representing 14.20% and 20.86% of the study area in 1987 increase to 19.93% and 52.56% in 2010 respectively. This could be as a result of human population in the communities in Kuje Area Council which most of them are farmers and pastoralist. Furthermore, settlement increased from 14.20% in 1987 to 19.93% in 2010. As a result of increased settlement and agricultural grazing activities in the study area, the woodland area which represents 26.33% of the total area in 1987 decreased to 16.76% in 2010, while swamps/water bodies decreased from 38.60% of the total area in 1987 to 10.73% in 2010.

Magnitude and Annual Rate of Change proportion.

Table 2: The magnitude, percentage and annual rate of change of Kuje (1973-1987)

Land use/land cover	**1973**	**1987**	**Magnitude of Change**	**Percentage Change**	**Annual Rate of Change**
Settlements	63.65	99.08	35.43	21.09	2.95
Agriculture/ Grazing lands	102.14	145.53	43.39	25.84	3.62
Swamps/ Water Bodies	260.56	269.22	8.66	5.16	0.72
Wood land	264.20	183.69	80.51	47.93	- 6.72
Total	**690.55**	**697.52**	**167.99**	**99.9**	**14**

Table 2 shows the Settlement, Agriculture/grazing land and Swamps/water bodies' areas by 21.09%, 25.84% and 5.16% respectively between 1973 and 1987. Woodland has 47.93% is the only one that has negative impact or change in the land which has -6.71%. The decrease in woodland might be as a result of increase in settlement, agriculture/grazing (cropping and animal rearing) in the study area.Assessing the annual rate of change, it was observed that agriculture/grazing land experienced 3.62% increment annually for the period of fourteen (14) years, the percentage of change of settlement, swamps/water body are observed as 2.95% and 0.72% while woodland is -6.71% reductions respectively. A total of 14% of total landues and land cover experienced for the annual rate of change for the period between1973-1987. While other land use types recorded decrease of 2.95%, 3.62% and 0.72% which might be due to increase in agriculture/grazing land (farming and animal (rearing) activities that is, other land use types were converted to agriculture/grazing land or settlements area. The result revealed that agricultural activities for example crop production and animals' rearing is the main human activities that are contributing negative functions or roles on the land degradation in Kuje Area between 1973-2010.

Table 3: The magnitudes, percentage and annual rate of change of Kuje (1987-2010)

Landuse/Landcover	1987	2010	Magnitude of change	Percentage change	Annual rate of change
Settlement	99.08	137.81	38.73	7.46	1.72
Agriculture/Grazing Land	145.53	363.35	217.83	41.95	9.65
Swamps/water bodies	269.22	74.19	195.03	37.56	-8.64
Wood land	183.69	115.97	67.72	13.04	- 3.00
Total	**697.52**	**691.32**	**519.31**	**100.01**	**23.01**

The results in table 3 shows that the annual rate of change of settlement in the study area has reduced to 1.72% as from 1987 and 2010 compared to 1973 to 1987 as against of 2.95%. It may be due to the relocation or resettlement of some inhabitants from F.C.T Abuja land to the three neighboring states like Kogi, Nasarawa and Niger. This is as a result of creation of new federal capital territory (FCT) Abuja in 1976. Some of these inhabitants or villages that are settled in Nasarawa state are New Karu, SabonKarshi, NyanyaGbabyi, NyanyaGwandara, Jikwoyi, Rubochi, Rubatu, Kulo, Tika, Kutumba, Gwargwada, Ukya, Zagabutu, Zokutu and Yewuje. Those villages resettled in Niger state are Wuse Sabo, Maitama, SabonLugbe, Kubwa, Kubabwa and that of Kogi state is Abaji. The resettlement took place around 1982/1983 during AlhajiShehuShagari regime. The annual rate of change indicates that agriculture/grazing land experienced 9.65% increases annually for the period of twenty three (23) years, while the percentage of change of swamps/water body and woodland stood between -8.64% and -3.00% reduction respectively.

A total of 23% increase was experienced for the annual rate of change for the period between 1987 – 2010. However, agriculture/grazing land area also recorded increase between 1987 and 2010 but woodland recorded decrease of -3.00%. Swamps/water body and woodland have negative changes of 37.56% and 13.04% reduction respectively which might be as a result of conversion of agriculture/grazing lands by settlement, which may occurred as a result of human activities and natural activities. Swamps/water body were also affected by the changes in settlement, agriculture/grazing lands, thus, it decrease from 269.22km in 1987 to 74.19km^2 in 2010. Crop production and animal grazing was also discovered to be the principal activities in Kuje for land degradation between 1987 and 2010 with a positive annual rate change of 9.65%.

Woodland has been steady in reduction between 1987 and 2002. It will be in the good side of Kuje Area Council and indeed the nation as a whole if the moderate reduction in woodland observed in between 1987 and 2002 is sustained or maintained. It was observed that man has been playing major roles in the use of land resources of Kuje Area Council within the study years. The increasing human activities such as settlement development, agriculture (farming and grazing) and others have exerted so much stress on the ecosystems and resulted to the loss of great proportion of the land vegetation. Woodland which had a total land mass of 264.20km^2 in 1973 has undergone decrease to 183.69km^2 in 1987.

The woodland vegetation was also discovered to have a negative annual rate of changes of -6.71. This means that woodland is changing annually at rate of 6.71% in Kuje Area Council. This drastic reduction in wood-land vegetation as revealed in this study confirmed the existing structure of the vegetation of FCT. For instance (premium times paper) reported that the Federal Capital Territory Administration (FCTA) in September 13, 2012 constituted a 25 man committee to work out the ways to tackle deforestation in the six Area Councils of the city. It was noted that the effect of deforestation in FCT today was confirmed and witnessed by all residing in the city, as it has increased FCT daily temperature in recent time. For instance, few years ago the highest daily temperature was as low as 27^{o}C, but now it is between 34^{o}C and 37^{o}C in some months of the year.

Over the past years, data from earth sensing satellite has become vital in mapping the earth's feature and infrastructure for managing natural resources and studying environmental change. GIS has made it possible to integrate multi-source and multi-data for the generation of land use and land cover changes and the mapping and evaluation and identifying the land use pattern of the area since 1987 and show how it influence the development of Kuje Area Council.

V. Conclusion

The study reveals that land use and land cover change in Kuje Area Council was due to the increase of population of the area which led to land acquisition for residential, agricultural and grazing purpose. This also shows that too much needs of land caused the land use and land cover change of the area which brings about congestion in the area and reduction of government preserved lands for agricultural/grazing lands, woods land and settlement areas.

VI. Recommendations

The paper recommended that:Remote sensing and GIS techniques should be applied by organizations, legislatures and government for environmental monitoring and formation of land use policy for future development. There is need for public awareness for the inhabitants or communities of the study area on how to manage the land.There should be land use edict, for proper management of land by urban town planners to justify good use of available land resources.With the increase in settlement in Kuje Area Council there is a need for management authorities to open up new land for agricultural production.Government should establish an agency charged with the responsibility for mapping and evaluating land use land cover change in Nigeria.

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