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GIS Analysis of Peri-Urban Agricultural Land Encroachment in (FCT), Nigeria

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Abstract Population explosion, globalization of the economy and the technological advancement of man are responsible for major modern-day transformations in the nature and flow of the Earth ecology, which has a very broad historical background that dates back to ancient times. Presently, the fast urban growth in Nigeria has affected approximately 400,000 hectares of vegetative cover. In the Kuje area council, the increases in urbanization and sprawling pattern of development in Abuja have culminated into the quick disappearance or total transformation of fertile agricultural sites into peri-urban development. This study use questionnaire administration in the ten wards of the area council and multitemporal images of Landsat TM and Nigeria Sat-1 over a period of 35 years (1975–2010) to assess the level of urban encroachment on agricultural lands and displacement of farmers in Kuje area council. The study reveals that urban encroachment into agricultural lands is alarming at the rate of 15.7 Km^2 annually, and a total of 509 Km^2 of agricultural land have been lost to urbanization within the 35 years under review. It is therefore recommended among other things that land management in the area council should be incorporated into the existing Abuja Geographical information System (AGIS) for effective sustainable human development.

Keywords *Agricultural Land, Encroachment, GIS, Peri-Urban, Remote Sensing and Urbanization*

1. Introduction

The activities of man and not the forces of nature are responsible for major modern-day transformations in the nature and flow of the Earth, which has a very broad historical background that dates back to ancient times (Yang and Lo, 2003). This situation has also been aggravated by population explosion, globalization of the socio-economic sector and the technological advancements. Comprehending all the activities and social actions that move them is critical to modeling, forecasting and understanding of universal, regional and local changes in the environment and likewise for the management and response to these changes (Turner and Williams, 1994).

Settlements refer to the occupation of land for man's modification of the natural surroundings through myriad developmental activities. The United Nations (2008) once predicted that by the year 2000, approximately 24 million hectares of cropland globally would be changed to metropolitan purpose. Projections by the United Nations suggested that global population of cities would increase exceeding one billion populace between the years 2010 to 2025, whereas the population of local areas would scarcely increase, see Figure 1.

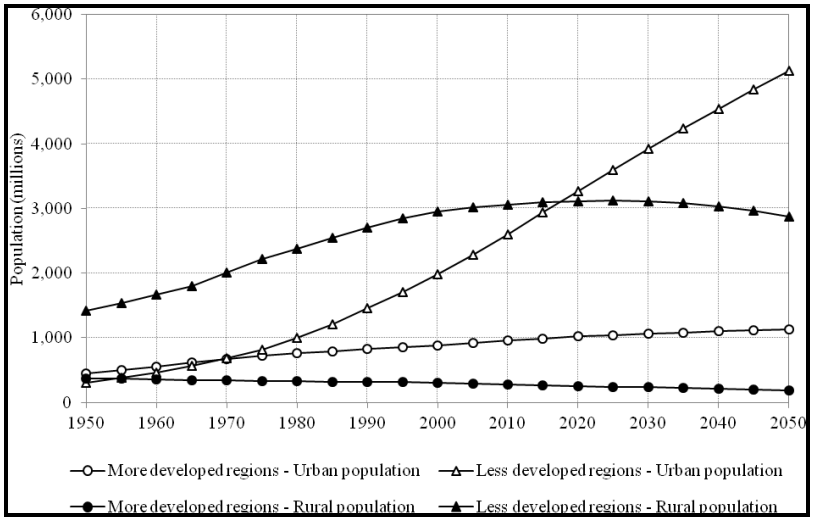

Figure 1: *Urban and Rural Populations by Development Group, 1950-2050*
Source: World Urbanization Prospects; the 2011 Revision

There exist some elements of land use management adaptations from agricultural to none-agricultural uses, the set of laws that are intended to control this are most times shunned by decision makers and property developers (Hardoy *et al.,* 2001). In the Kuje area council, the increases in urbanization and sprawling pattern of development from Abuja have culminated into the quick disappearance or total transformation of fertile agricultural sites to peri-urban development. Although urbanization contributes to national socioeconomic development, the rate of change makes it impossible for government at all levels to meet the needs of basic urban life like food and housing; hence the encroachment on major agricultural lands, (Ekpeyong, 2006). This is particularly visible in Kuje Area Council of the FCT, where agricultural land is disappearing each year, as a result of urbanization occasioned by the growth of the Federal Capital Territory (FCT).

1.1. Review of Literatures

More than fifty percent of land surface free from ice have been translated or considerably altered by the activities of man for the past 10,000 years (Population Reference Bureau, 2001; Mittermerier *et al.,* 2003). This is as a result of the natural and pressure from diverse anthropogenic actions like urbanization and urban sprawl, deforestation, mineral exploitation, intensive agriculture etc. (FAO, 2003; Sarma *et al.,* 2008; Njomo, 2008).

By the year 1900, 14% of the population of the earth were residing in metropolitan areas (UNCHS, 1996) and this percentage of people is rapidly on the increase and presently more than 60% of the people are residing in metropolitan areas (Ifatimehin and Musa, 2008). The continent of Africa is experiencing the fastest pace of urban growth at a pace of approximately 67% in comparison with developing and developed nations (Cohen, 2004).

Presently, the fast urban growth in Nigeria is affecting approximately 400,000 hectares of vegetative cover every year (Adesina, 2005). (Kramer *et al.,* 2008) and (Heimlich and Anderson, 2001) have

both observed that urban growth encourages sprawl blueprint, which most of the time possess negative effects on the ecology of the region, particularly in vegetative and hydro-geomorphology. Food security according to FAO (2006) 'exist when every human, whatever the time, possess both economic and physical access to adequate, secured and wholesome food to meet up the standard dietary requirements and choice of food they prefer for a vibrant and vigorous living'. The transformation of agricultural lands to other land uses is a threat to food security, for instance, in one of the Chilean city, about 1,734 hectares of wetlands and 1,417 hectares of agricultural land were transformed into residential areas between the years 1975 to 2000 (Kwasi, 2004). While in Accra (Ghana), it is estimated that 2,600 hectares of agricultural land are converted every year and similar patterns were observed in China and Indonesia (Lambin *et al.,* 2003). Alabama, Arkansas, Illinois, Mississippi, New York and California are at the top among the states in USA that have lost most proportion of their prime arable lands over the past five years, (Ralph, 2008). Approximately 400,000 hectares of arable land have been taken over by Urban sprawl annually, (Jiang *et al.*, 2007).

In modern day land management, satellite sensors like the Advanced Very High Resolution Radiometer (AVHRR), the French Spot System and Landsat Thematic Mapper (TM) have been used efficiently for the measurement of biomass burning, deforestation and other land use transformation, (Tucker *et al.,* 1991; Skole and Tucker, 1993; Sellers *et al.,* 1995). For instance, one approach adopted by the US Defence Meteorological Satellite Programs Operational Line Scan System (DMS/OLS), is the use of night-time satellite data sets as a procedure for the detection of metropolitan land use encroachment and integrating these data sets together with maps of soils to approximate the impending effect of urban growth on fundamental soil resources, (Elvidge, *et al.,* 1997; Kramer, 1994).

In Nigeria also, since Abuja became the country's Federal Capital Territory in 1976, series of studies have been carried out to determine the rate and extent of urbanization. (Ujoh *et al*., 2010), specifically used Remote Sensing data, Geographical Information Systems (GIS) techniques, and ground data to estimate annual rate of urban sprawl in Abuja. The data set from Landsat TM, Landsat ETM and Nigeriasat-1 satellite data for 1987, 2001 and 2006, respectively, revealed that the annual rate of urban sprawl was 10.6 km^2 over a 19-year period (1987 and 2006). According to them, this resulted into land degradation that includes widespread alteration in the land use/land cover of Abuja environment. Similar results were reported by (Riebsame *et al*., 1994; Twumasi *et al*., 2004; Kelarestaghi *et al*., 2006; Ifatimehin, 2006, 2008). The extent and rate of LU/LC changes of the Abuja city poses a significant regional threat to the national environment sustainability. Other studies in urban encroachment on vegetation/agricultural land include: El-shakhs and Amirahmadi, 1993; Brockherhoff, 2000; UN, 2004; Cariboni, 2002; and Bojle, 2005.

1.2. Aim and Objectives of Study

This study is aimed at assessing the level of Abuja's urban encroachment on agricultural land in Kuje Area Council of FCT in view of the food security challenges in the country. The Specific Objectives are:

i. To analyze and map the landuse/landcover of the area over a period of 35 years,
ii. Determine the rate, nature and direction of encroachment in the area,
iii. Estimate the land use changes and its effect on agriculture land during the time period.

2. Methodological Approach

In this study primary and secondary data were used to ascertain the level of urban encroachment on agricultural land and productivity. The primary data include the use of two sets of questionnaire administered to the professionals in Land Administration in FCT and the residents within the wards of the Area Council, while oral interviews was conducted on the 10 Ward heads. A total of Seven

hundred and eighty-three (783) questionnaires were administered constituting 0.2% of the total population of Kuje Area Council as projected from the census figures of National Population Commission of 2006 as indicated in Table 1.

Table 1: *Questionnaire Distribution in Per Ward Kuje Area Council*

Ward	No of Respondents
Kuje Central	250
Gaube	100
Rubochi	85
Chibiri	75
Kujekwa	60
Kwaku	47
Gwadubada	43
Yenche	43
Gudukeria	40
Kabi	40
Total	783

Source: Author's Field Work, 2012

2.1. Secondary Data

Secondary data were also used for the change detection in land uses, these are basically satellite imageries and maps obtained from relevant agencies as displayed in Table 2.

Table 2: *Imagery Data Types and Sources*

Data	Year	Resolution	Acquisition Source
Landsat TM (Multispectral)	1975, 1980, 1985	30 meters	National Centre for Remote Sensing (NCRS), Jos.
Landsat ETM+ (Multispectral)	1990,1995,2000	30 meters	National Centre for Remote Sensing (NCRS), Jos.
Nigeria – Sat 1	2005,2010	32 meters	National Space Research and Development Agency (NARSDA) Abuja.
Topo. Maps	1972	1 :50,000 Sheet 18-22	Federal Surveys Unit, Kaduna. FCDA, Abuja

For the data analysis, ArcGIS 9.2 was used to carry out on-screen digitizing, editing of the various layers. Colour composites were carried out to enhance major land uses before the map overlay operations to identify and detect the increase or decrease in landuse classes.

3. Background of the Study Area

Abuja, the capital city of Nigeria is located in the centre of the country, within the Federal Capital Territory (FCT). As a planned city, it officially became Nigeria's capital on 12 December 1991, replacing Lagos which is similar to Brazil building its capital Brasília. At the 2006 census, the city of Abuja had a population of 776,298, (NPC, 2007). See Figure 2 for the geographical location of the city within the country. Abuja and the FCT have experienced a huge population growth; it has been reported that some areas around Abuja have been growing at 20–30% per annum.

Kuje is one of the Area Council in the Federal Capital Territory (FCT), it lies between latitude $8^0$27'43'' to $8^0$56'32'' North and longitude $6^0$58'13'' to $7^0$33'11'' East. The landed area covers 1,800 square kilometers, which is about 22.5% of the FCT total land area. It is bounded by Gwagwalada Area Council to the West, eastward by Municipal Area Council, and Abaji Area Council to the South-West. The major ethnic groups dominating the area are the Bassa, the Gade, the Koro, the Ganagana and the Gwandara; all of which have profound attachment with the kwa speaking people. The major occupation of the original inhabitants of Kuje is subsistence farming and the main farm produce are guinea corn, yam, maize, millet and beans. The council area serves a dual function of absorbing excess population from the city centre of Abuja as well as supporting the FCT agriculturally. The area designated for the development of satellite town covers approximate 93.16 square kilometers, (Kuje Master Plan, 2004). Also, Pegi situated in council to accommodate squatter settlers from Jiwa Chiefdom, while Yangoji situated within Kwali Area Council will take care of squatter settlers from the Airport axis of Chika, Aleita, Piwoyi, Kuchingoro and Karomanjiji (Nnabugwu, 2012).

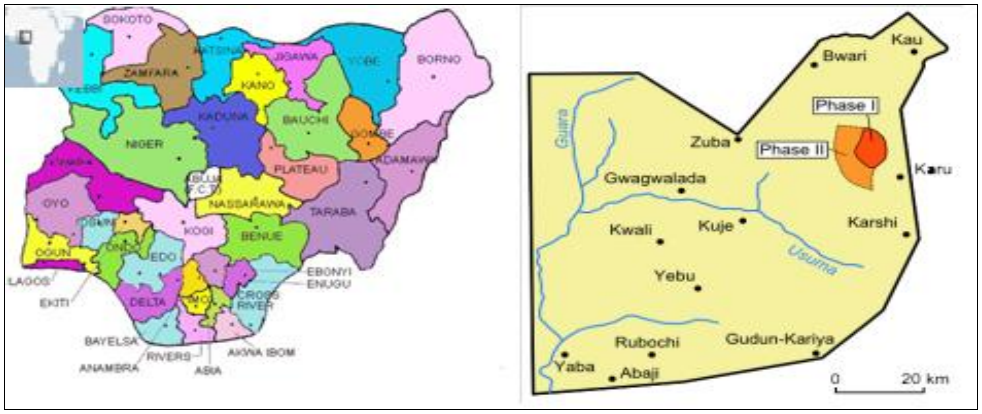

Figure 2: *Kuje -Abuja, Nigeria*

3.1. Data Presentation

One of the socio-economic impacts of Abuja on Kuje is the dramatic occupational mobility as discovered in the field survey. In 1975, the occupational distribution was of the people was predominantly 83% farming, 9% civil service and the organized private sector, 4% engaged business and trading, while 2% were engaged in other forms of occupation. But as at the year 2010, 16% of the surveyed residents are engaged in farming, 38% in the civil service and the organized private sector, 27% are engaged in various forms of businesses and trading, 13% are artisans, while 6% are engaged in other forms of occupation. There is a sharp drop in Farming between the year 1975 and 2010 as revealed in Figure 3.

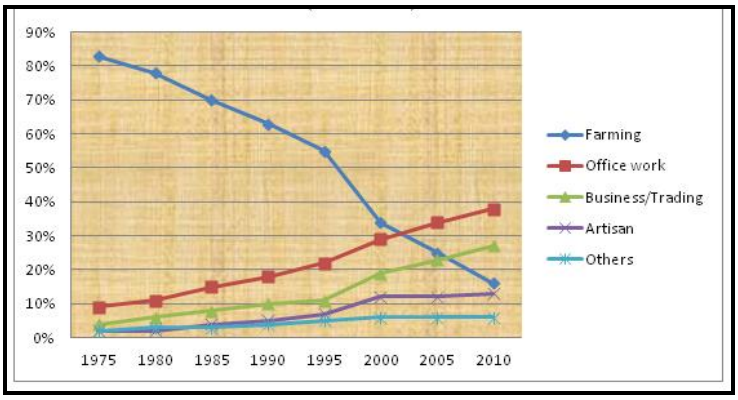

Figure 3: *Occupational Transformation in Kuje Area Council (1975 – 2010)*

An examination of the length of year's resident spent in the area reveals that about 70% (544) of the sampled population moved to Kuje area within the last ten (10) years, and the implication of this is the high loss of agricultural land to built up areas as reveals in Figure 4.

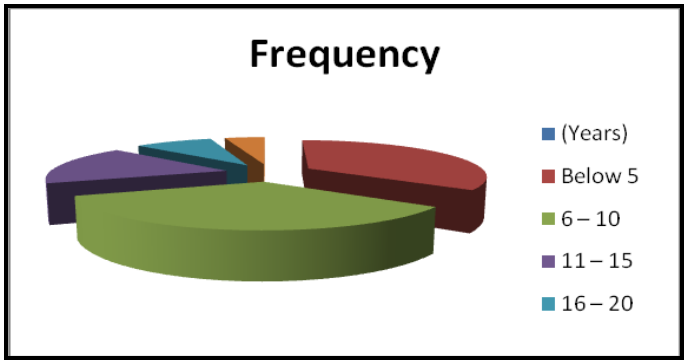

Figure 4: *Length of Residency at Kuje Area Council*

In the area of resident work location, 17% (136 respondents) have their work place or business location within the area council while 83% (647 respondents) work in the other part of the territory. Information on the level of farmer/construction agencies reveals that sizeable numbers of farmers are often displaced for construction activities. In fact, 95% (330) of the farmers interviewed have experienced one form of displacement or the other. See Plate 1 for such construction in the area.

Plate 1: *Road Construction Connecting Kuje to Gwagwalada at Pasali Area*

3.2. Image Analysis

The multitemporal images acquired were analysis at five years interval in the Table and according to subject areas as displayed in the Appendixes, the urban encroachment on arable land, fadama land and forest land were examine separately. The image enhancement of each of the years for proper interpretation is also displayed in Figures A to H in the Appendix.

3.2.1. Changes in Arable Land

The analysis of the Lansat imageries reveals a downward trend in the available arable land from the year 1975 to 2010 as indicated in the bar chart Figures 5 to 8. This is attributed to the continuous increase in developmental activities of migrants from all over the country.

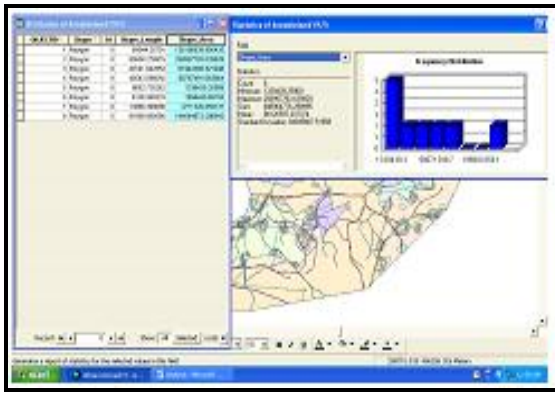

Figure 5: *Statistics of Arable Land in the year 1975*

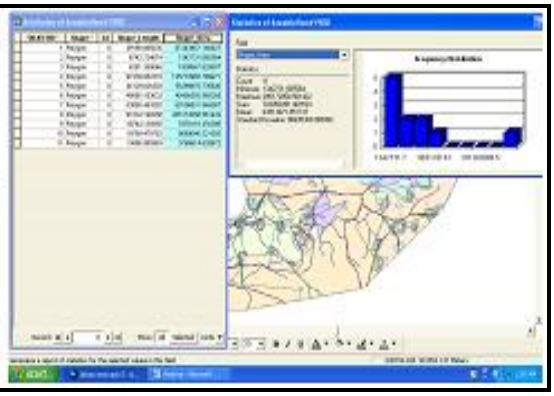

Figure 6: *Statistics of Arable Land in the year 1980*

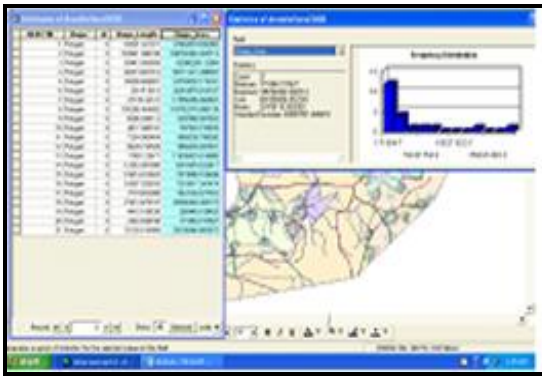

Figure 5: *Statistics of Arable Land in the year 2000*

Figure 6: *Statistics of Arable Land in the year 2010*

The changes between the 2000 to 2010 (10 years) amount the loss of one hundred and seventy square kilometers of arable land about 29.2% of the total land, as indicated in Table 3 and Figure 7. This is very critical in view of the food security challenges in country where mechanized agriculture is still very low.

Table 3: *Change in Arable Land in Km^2 per Year*

Period (Years)	Area(Km^2)	Change(Km^2)	Change% Area
1975	582		
1975 - 1980	576	-6	-1.03
1980 - 1985	566	-10	-1.74
1985 - 1990	551	-15	-2.7
1990 - 1995	547	-4	-0.73
1995 - 2000	533	-14	-2.6
2000 - 2005	480	-53	-9.94
2005 - 2010	412	-68	-14.2
Total		-170	-29.2

Source: Author's image Analysis

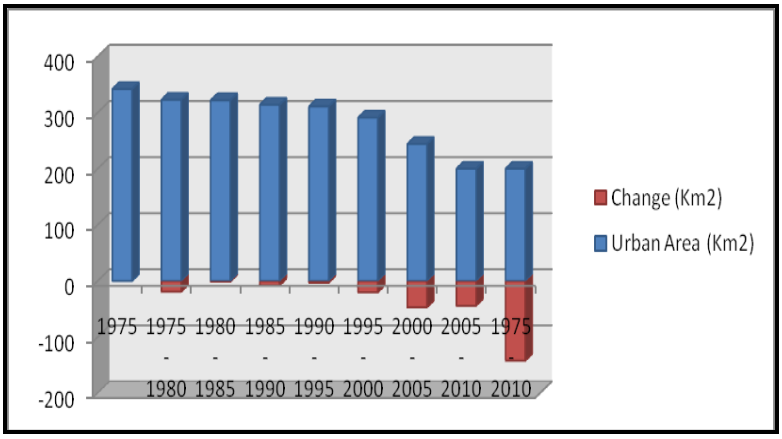

Figure 7: *Change in Arable Land in Km^2 per Year in Kuje Area Council*

3.2.2. Changes in Fadama Land

Fadama farming is a major agricultural area in Nigeria that is now attracting foreign aid to the federal government. In all the northern part of the country, there are various schemes Targ Fadama 1 to Fadama 5. The Fadama scheme is almost like the irrigation scheme in the country that is been used by the government as a way of reducing unemployment problem and at the same time responding to the food security challenges. The result of the image analysis as presented in Table 4 and Figure 8 reveals that there is negative change since 1975 till date. The huge change between the year 1995 and 2005 (10 years) may be attributed to the mass movement of major governmental and none governmental head offices together with their staffs to Abuja.

Table 4: *Change in Fadama land in Km^2 per Year*

Period (Years)	Area (Km^2)	Change (Km^2)	Change % Area
1975	319		
1975 - 1980	310	-9	-2. 8
1980 - 1985	295	-5	-1.6
1985 - 1990	285	-10	-3.4
1990 - 1995	261	-24	-8.4
1995 - 2000	196	-65	-23
2000 - 2005	120	-76	-39
2005 - 2010	112	-8	-6.7

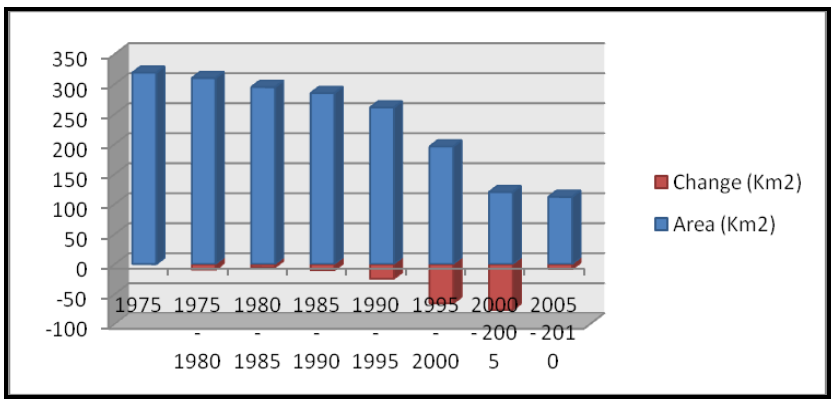

Figure 8: *Change in Fadama land in Km^2 per Year in Kuje Area Council*

4. Findings

Kuje Area Council of the Nigeria FCT is experiencing a lot of socio-economic and political changes that is impacting negatively on the ecological landscape. In the area of agricultural sector as assessed in this study, the following observations are noteworthy:

i. Abuja's Urbanization is taking its toll on Kuje Area Council faster than envisaged by the Master Plan and even the administrators.

ii. The urbanization growth rate of the area is increasing significantly from 12% annually between 1975 and 1980 to 13.4% annually between 2005 and 2010.

iii. Developmental activities are encroaching into the agricultural lands at an alarming rate of 15.7 Km^2 annually. If of this growth rate continues, it implies that by the year 2030, an additional 282.6 square kilometers agricultural land (arable land, fadama land and forest) would have further been lost to urban encroachment.

iv. A total of 509 Km^2 of agricultural land have been lost to urban encroachment within 35 years period under study. Out of this, 170 Km^2 is from arable land; 207 Km^2 from Fadama land; and 142 Km^2 from forest land cover.

v. Road developments were also identified as a major agent of change in the area within the 35 year period. About 200 Km^2 of major roads were constructed between 1975 and 2010.

vi. Lateral development is dominant in the area; in fact, single unit residential housing (bungalows) also known as the "Brazilian housing type" occupy a sizeable portion of the area in the new estates.

5. Conclusion

The invasive nature of urbanization in this area council may be seen as a mark of national development for now, but the continuous compromising of fertile agricultural lands to structural deployments may be a pathway to international slavery in the form of aid dependent or corking a huger gun that may trigger at any time. It must be borne in mind that the food produced at the suburb areas is playing a major complementary role to the food transported from other parts of the country to the Federal Capital Territory.

Recommendation

- There is an agent need to carry out the Master Plan Renewal to secure the agricultural lands, particularly the fadama lands.

- Vertical as a against dominant horizontal development should be encourage from now on to curtail the natural force of demand and supply that will edge out land for agriculture.

- Agricultural programmers that enhances mechanize agriculture, hybrid crops production, and urban agriculture should be vigorously pursued by the government.

- The theories and techniques of Remote Sensing and GIS should be built into the man power development programmers of the relevant environmental agencies in the territory. This will mean that the area council land administration should be incorporated into the Abuja

Geographical Information System (AGIS) to enhance the monitoring and control of developmental activities.

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Appendixes

Table A: *Percentage Change Distribution of Landuse / Landcover in Kuje Area Council*

S. N.	Landuse Land cover	1975 Area Km²	Area (%)	1980 Area Km²	Area (%)	1985 Area Km²	Area (%)	1990 Area Km²	Area (%)	1995 Area Km²	Area (%)	2000 Area Km²	Area (%)	2005 Area Km²	Area (%)	2010 Area Km²	Area (%)
1	Built -up	47	2.6	75	4.2	111	6.2	143	7.9	180	10	302	16.8	462	25.7	596	33.1
2	Road	131	7.3	159	8.8	184	10.2	221	12.3	266	14.8	276	15.3	310	17.1	331	18.4
3	Fadama	319	17.7	310	17.2	295	16.4	285	15.8	261	14.5	196	10.9	120	6.7	112	6.2
4	Arable land	582	32.3	576	32	566	31.4	551	30.6	547	30.4	533	29.6	480	26.7	412	22.9
5	Forest	342	19	323	17.9	322	17.9	314	17.4	311	17.3	291	16.2	244	13.6	200	11.1
6	Hill	228	12.7	218	12.2	201	11.2	198	11	180	10	164	9.1	152	8.4	125	6.9
7	Water body	151	8.4	139	7.7	121	6.7	88	5	55	3	38	2.1	32	1.8	24	1.3
8	Total	1800	100	1800	100	1800	100	1800	100	1800	100	1800	100	1800	100	1800	100

Source: Derived from Landsat and NigeriaSat-1 Imageries for the various Years

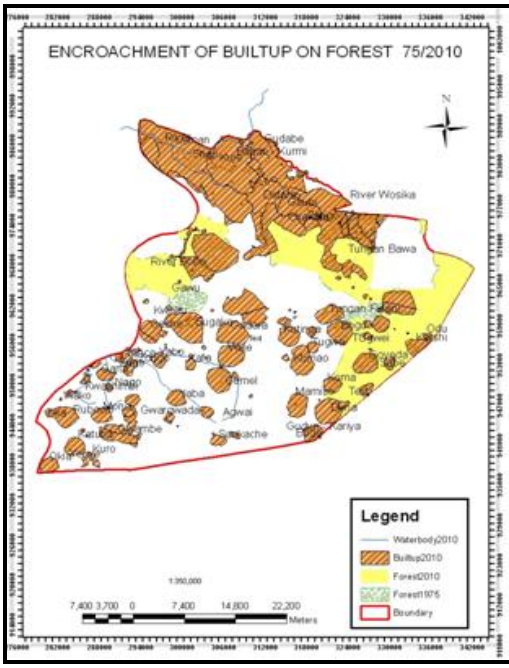

Figure A: *Encroachment of Built–up Areas On Forest Land between 1975 and 2010*

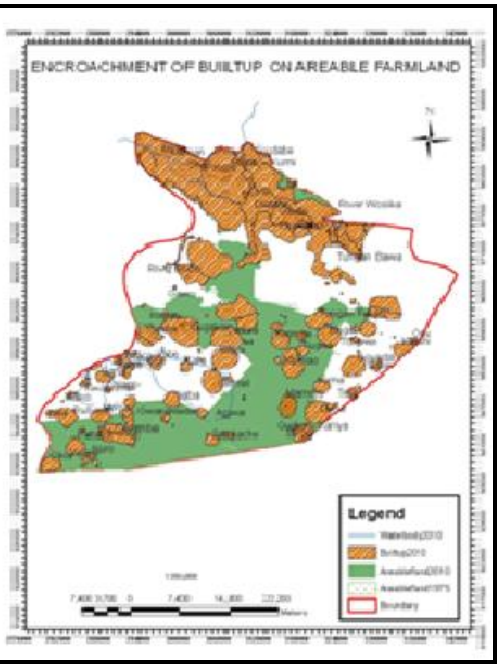

Figure B: *Encroachment of Built-up Areas on arable land between 1975 and 2010*

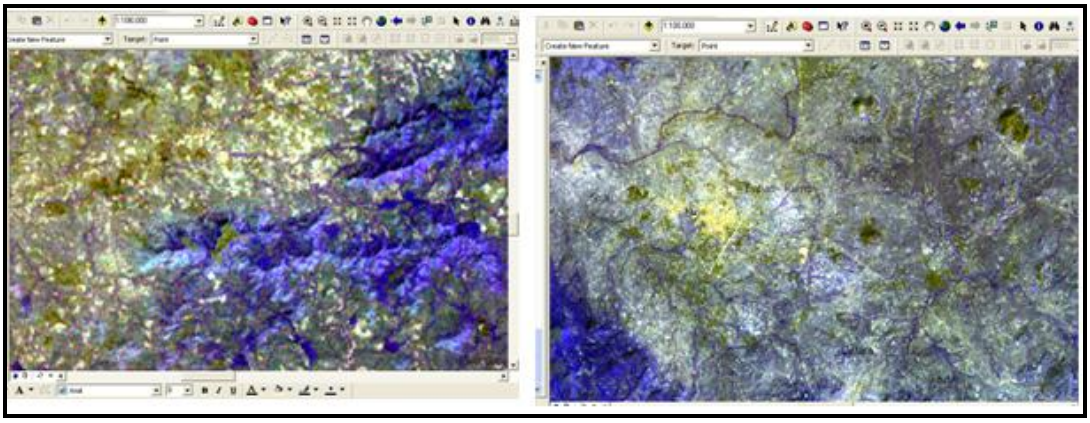

Figure E: *Composite Image of Abuja, 1980*

Figure F: *Composite Image of Abuja, 1990*

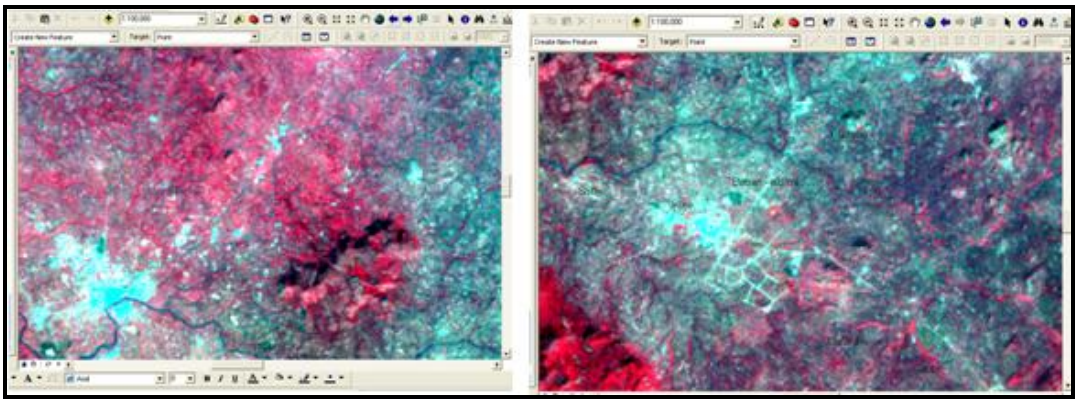

Figure G: *Composite Image of Abuja, 2000*

Figure H: *Composite image of Abuja 2010*