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Full Length Research Paper

Understanding urban sprawl in the Federal Capital City, Abuja: Towards sustainable urbanization in Nigeria

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In response to the rapid urban sprawling due to the fast rate of urbanization, there is an increasing need for focused research with a view to develop remediation strategies and methodologies for the effective and sustainable environmental planning in Federal Capital City (FCC), Abuja. This paper specifically focuses on an integrated approach of Remote Sensing (RS) data, Geographical Information Systems (GIS) techniques, and ground data collected by the use of Global Positioning Systems (GPS) receiver in facilitating urban planning. 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). In view of the ecological and environmental challenges that accompany such rapid sprawl development, the study recommends measures that would reduce the otherwise rapid rate of urban sprawl in the FCC and to ensure sustainable urbanization.

Key words: Slum settlements, sprawl, ecological and environmental consequences, remote sensing and GIS, sustainability

INTRODUCTION

Man's dependence on the physical environment for his basic needs has generated actions and inaction in various areas and at various times, often translating into land conversion, alteration and modification, much of which degrade and severely damage the abiotic and biotic components of the environment. For instance, since humans have controlled fire and domesticated plants and animals, they have cleared forests to wring higher value from land. Thus, about half of the ice-free land surface has been converted or substantially modified by human activities over the last 10,000 years (Population Reference Bureau, 2001; Mittermeier et al., 2003).

There has been extensive modification of the land-scape at the local, regional and global levels. This is due to natural processes (such as erosion, volcanoes, earthquakes and disasters such as floods, etc.) as well as intense pressure from several anthropogenic activities such as deforestation, urbanization and urban sprawl, intensive agriculture, mineral exploitation, etc (CARPE, 2003; FAO, 2003; Lambin et al., 2003; Njomo, 2008; Sarma et al., 2008). This paper is concerned with urban sprawl as a chief factor that has resulted in intense land use/land cover (LULC) changes in Nigeria (Fashona and Omojola, 2005) and elsewhere, which on the aggregate affects economic and ecological processes (Desanker et al., 1997). Sprawl is simply a direct consequence of urban growth and expansion.

Generally speaking, growth in urban populations worldwide is considered as the factor directly responsible for the unprecedented rate of urban sprawl being witnessed across the world; as the population of an urban centre increases, its need for infrastructure such as transportation, water, sewage, etc. and facilities such as housing, commerce, health, schools, recreation, etc. increases, most often resulting to the phenomenon known as urban sprawl.

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Abbreviations: GIS, Geographical information systems; **FCC,** federal capital city; **GPS,** global positioning systems; **RS,** remote sensing; **LULC,** land use/land cover.

Urbanization and urban sprawl

Settlements represent the most profound human alteration of the natural environment through a spectrum of urban land use activities (Ifatimehin and Musa, 2008) which include, but are not restricted to, transportation, commercial, industrial, residential, institutional, and recreational land uses. The expansion that ensues as a result of increase in the demand for these land uses explains the underlying and fundamental causes of urban sprawl: population increase. Urbanization is the process that refers to the growth both in size and numbers of urban centres. Several studies (UNCHBP, 1974; Lambin et al., 2003; European Environment Agency, 2006; Ifatimehin and Musa, 2008) reveal that the proliferation of urban centres has been phenomenal from the turn of the 20th century.

Urban sprawl is considered synonymous with unplanned, incremental urban development, characterized by a low density mix of land uses on the urban fringe. Urban sprawl is defined as the physical pattern of low-density expansion of large urban areas mainly into the surrounding agricultural areas (European Environment Agency, 2006). Sprawl is commonly used to describe physically expanding urban areas. Such a modified landscape reveals a situation where cities are spreading, thereby minimizing the time and distances between and in-and-out of the cities.

The need for sustainable urbanization in Nigeria

For centuries, nearly every one lived in rural areas. In 1800, only 3% of the world's population lived in urban centres of about 5000 or more and many of these were like large villages in their socio-economic composition (UNCHBP, 1974). By 1900, 14% of the world's population was living in urban centres (UNCHBP, 1974) and this proportion is increasing rapidly and today over 60% of the population are living in urban centres (Ifatimehin and Musa, 2008). However, Lambin et al. (2003) reveals that urban population has been growing more rapidly than rural population worldwide, particularly in developing countries. Furthermore, the United Nations Population Division (2002), asserted that by the year 2000, towns and cities sheltered nearly half of the world's population (over 2.9 billion people), the majority of which are in developing countries. Africa is witnessing the fastest rate of urbanization at about 67% when compared with other developed and developing continents (Cohen, 2004). In Nigeria, the growth and complexity of human settlements and in particular the process of urbanization and urban sprawl have been phenomenal. According to the Thematic Committee (2001), in 1950, less than 15% of the total population of Nigeria was dwelling in urban centres; by 1975 and 2000, it had risen to 23.4% and 43.5%, respectively, and is projected to rise above 50% by 2010. Today, rapid urbanization and sprawl in Nigeria has affects 400,000 hectares of vegetation annually (Adesina, 2005).

Jat et al. (2008) observes that the process of urbanization or its growth drives sprawl pattern, which most often also have adverse impacts on ecology of the area, especially hydro-geomorphology and vegetation. Furthermore, Heimlich and Anderson (2001) believe that while urban centres are growing in population and sprawl (extent), the peri-urban areas are undergoing rapid transformation: with land coming under increasingly intense pressure through construction to provide space for an array of urban landuses. Thus, with rapid population increase and a finite urban land area therefore, available land per individual shrinks pitilessly. The result is an urgent need for proper geo-management of land and the concomitant availability of a detailed, accurate and up-to-date geo-information (Lemmens, 2002). Most importantly, the sprawling nature of cities is critically potent in providing explanations for the major impacts that are evident in increased energy, land and soil consumption. This is because these impacts threaten both the natural and rural environments, raising greenhouse gas emissions that cause climate change and elevated air and noise pollution levels which often exceed the agreed human safety limits. Thus, urban sprawl produces many adverse impacts that have direct effects on the quality of life of people living in cities (European Environment Agency, 2006).

The study area

Abuja is found on latitude 8° 25" and 9° 25" North of the Equator and longitude 6° 45" and 7° 45" East of the Greenwich. It is bordered to the North by Kaduna state, to the east by Nassarawa state, to the west by Niger state and to the south by Kogi state (Figure 1). The Federal Capital City (FCC) is located on the north-eastern part of the FCT. According to Mabogunje et al. (1976), the area is considered the most ideal and conducive for human habitation and settlement develop-ment within the FCT. The area is characterized by a hilly, dissected terrain and is the highest part of the FCT with several peaks that are 760 m above sea level (Balogun, 2001). The geology of the area is underlain by basement complex rocks. The annual rainfall is highest within the FCC and its environs which is about 1,631.7 mm. The annual mean temperature ranges between 25.8 and 30.2°C (Adakayi, 2000; Balogun, 2001). The soils of the study area are basically Alluvial and Luvisols. The FCC is rich in infrastructure such as expanding road network, drainage and sewage systems, and piped water.

MATERIALS AND METHODS

The study utilized multi-temporal satellite data acquired from Landsat TM (1987), Landsat ETM+ (2001) and Nigeriasat-1 (2006). The 3 images were already corrected for geometrical and

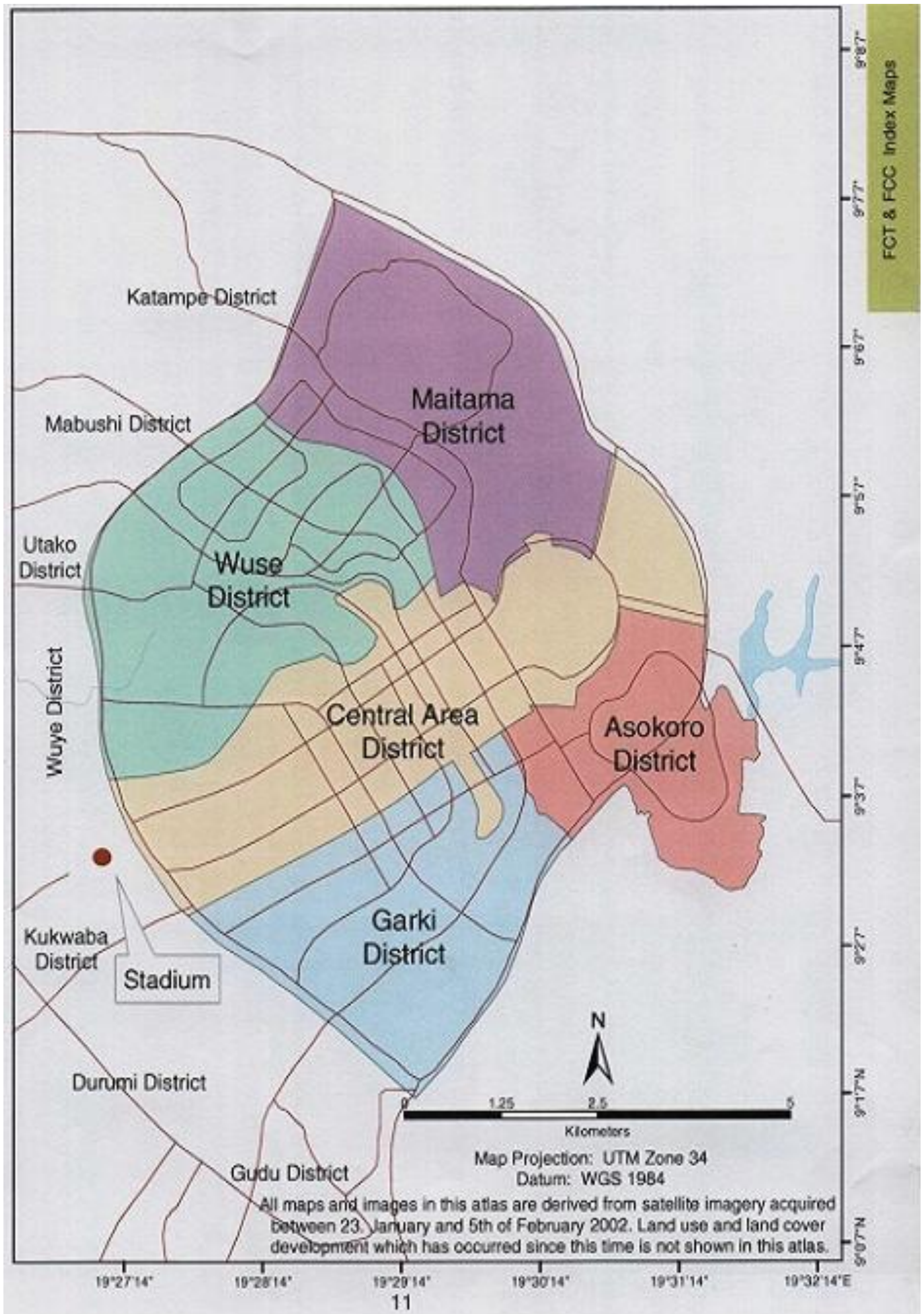

Figure 1. Map of the FCC, Abuja.

radiometric errors. A hand held Garmin III GPS was used in the ground truthing exercise to ensure that features on ground are in their correct planimetric position on the images. A classification scheme was developed using a combination of data collected from field survey and 14 years knowledge of the study area. Five land use classes were found occurring within the study area. Using the Integrated Land and Water Image Software (ILWIS 3.2), the maximum likelihood classifier algorithm was employed in the classification of the satellite images. Statistics generated from the classified images were analyzed to estimate the rate, extent and pattern of urban sprawl within the FCC.

RESULTS AND DISCUSSION

Landuse/landcover change distribution of the study area

The classification and quantification of the images of the study area was necessary in the detection of changes in the various landuse/landcover observed within the study area and over the study period. Thus, the static LULC

Table 1. LULC distribution of the FCC in 1987, 2001 and 2006

Code	LULC categories	1987		2001		2006	
		Area (km^2)	Area (%)	Area (Km^2)	Area (%)	Area (km^2)	Area (%)
CL	Cultivated land	212.43	25.48	187.08	22.44	94.40	11.44
BUA	Built-up area	33.60	4.03	154.40	18.52	235.04	28.18
BS	Bare surface	436.45	52.35	275.37	33.03	362.50	43.48
VG	Vegetation	78.62	9.43	175.10	21.00	61.61	7.39
WV	Wetland Vegetation	72.61	8.71	41.68	5.00	79.29	9.51
Total		833.71	100	833.71	100	833.71	100

Source: Derived from classified satellite images (1987, 2001 and 2006) of the FCC.

Table 2. Gain in built-up area of the study area between 1987 and 2001.

Year	Built-up area (Km^2)	Gain in built-up area (Km^2)		Time in years	Arithmetic mean gain (per year)
		Km^2	%		
1987	33.60			14	14.39
2001	235.04	201.44	699.52		

Source: Classified satellite imagery of FCC for 1987 and 2001.

Table 3. Gain in built-up area of the FCC between 2001 and 2006.

Year	Built-up area (km^2)	Gain in built-up area (km^2)		Time in years	Arithmetic mean gain (per year)
		Km^2	%		
2001	154.40			5	16.13
2006	235.04	80.64	65.69		

Source: Classified satellite imagery of FCC for 2001 and 2006.

distributions for each study year (Table 1) were derived over the three study years (1987, 2001; 2006). The table reveals that as at 1987, bare surface and cultivated land constituted the largest land use categories in FCC collectively occupying an area of 648.88 km^2 (representing 77.83%) of the total land cover of the study area, with built-up area being the least land cover type (33.60 km^2) found occurring in the study area. Statistics for the year 2001 (Table 1 and Figure 4) indicate that there is a significant gain in built-up area as it increased from 33.6 km^2 in 1987 to 154.4 km^2 in 2001. All other landcover types (except for vegetation) experienced significant loss between 1987 and 2001. Within this period also, built-up area is the landcover category with the highest rate of expansion (from 154.4 km^2 in 2001 to 235.04 km^2 in 2006). Conversely, every other landcover category lost in area with the exception of vegetation land cover.

Consequently, the annual rate of gain in built-up area between 1987 and 2001 was 14.39 km^2, while the total built-up area gained within the same period (14 years) was 201.44 km^2 (Table 2). This is an indication of the rate of urban sprawl resulting from the expansion in built-up area which includes residential and official buildings, shopping malls and plazas, infrastructure and facilities such as schools, hospitals, recreational parks and gardens, roads and other paved surfaces. A visual interpretation of the Nigeriasat-1 satellite image of the study area for the year 2006 (Figure 5) reveals that built-up area gained more in land cover and expanded during the period 2001 to 2006. The details of statistics presented on Table 1 and Figure 4 show that built-up area also gained most increasing from 154.4 km^2 in 2001 to 235.04 km^2 in 2006 (Table 3). The false colour composite (classified satellite images) of the study area for the years 1987, 2001 and 2006 are shown in Figures 2, 3 and 5, respectively. These provide a visual appreciation of changes occurring in the LULC of the study area over the 19-year period of study. The built-up area (red coloured) landcover category is seen to have expanded significantly. This indicates rapid sprawl within the FCC.

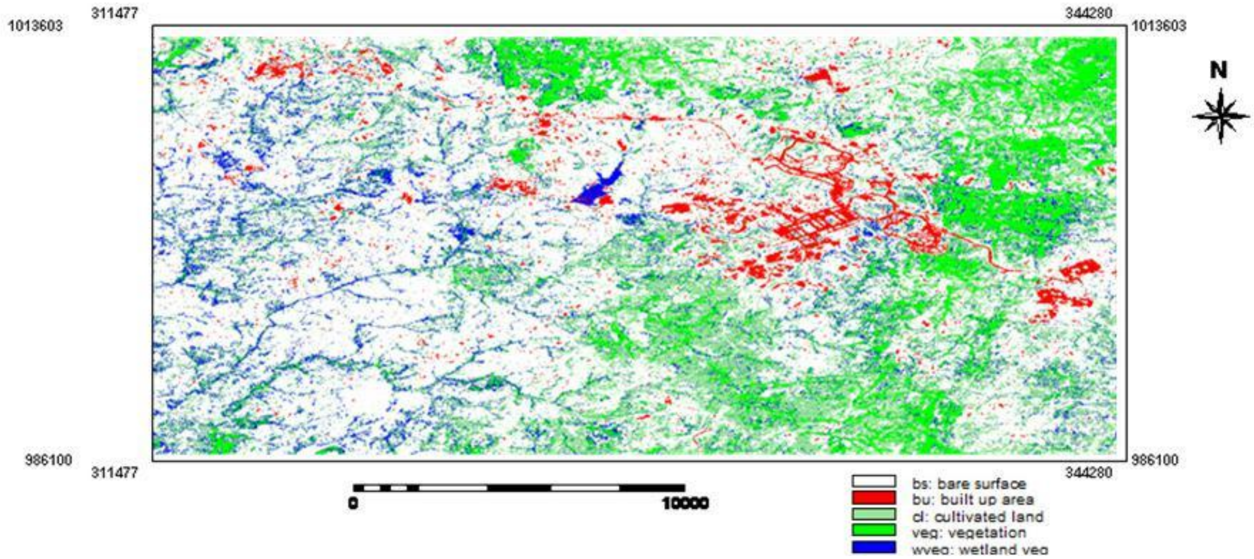

Figure 2. Landuse/landcover map of study area in 1987.

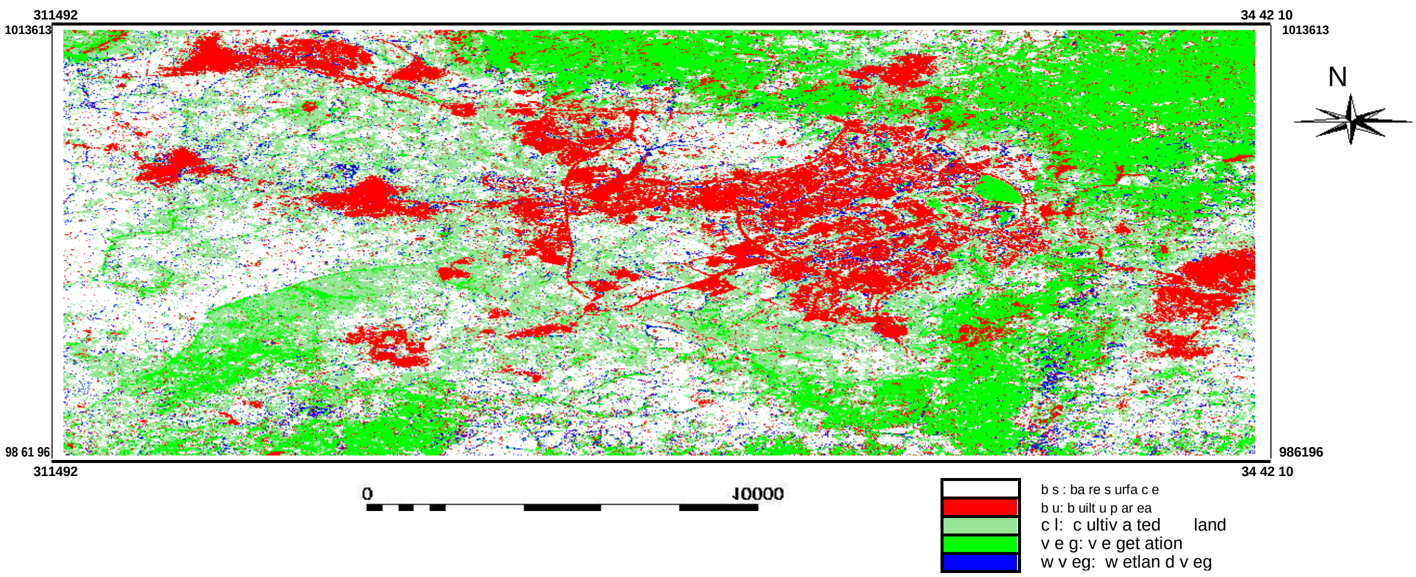

Figure 3. Landuse/landcover map of FCC in 2001.

DISCUSSIONS

The results and statistics derived from the classified satellite images of the study area indicate various changes in the LULC of the FCC. However, the attention of this study is focused on the extent of sprawl within the FCC which is directly expressed in terms of expansion in built-up area. Generally speaking, FCC has expanded from a city with a few developed districts such as Garki, Wuse, Asokoro and Maitama districts to include such districts as Utako, Jabi, Guzape, Mabushi, Gwarimpa, Asokoro Extention, Gishiri, Katamkpe, Gudu and Apo districts. This sprawl has occurred over a period of less than 20 years (1991 to 2006). This period coincides with the time when the Federal Government issued a directive requesting all government ministries and extra-ministerial bodies, departments and parastatals to move their head offices from Lagos to Abuja, the new FCT. With this directive came a great influx of population into the FCT which consequently, reflected in the need for and growth/expansion in the infrastructure and facilities of the study area to cater for the increasing population (compare Figures 2, 3 and 5). The rate of sprawl in the Abuja Municipal Area Council (AMAC) within which the

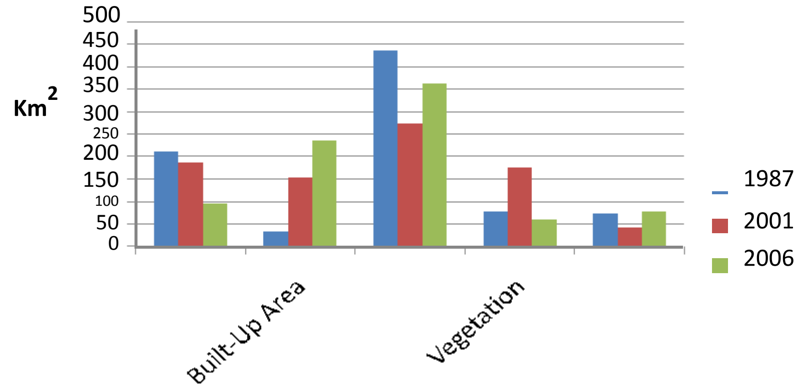

Figure 4. Distribution of LULC in FOC, 1987, 2001 and 2006.

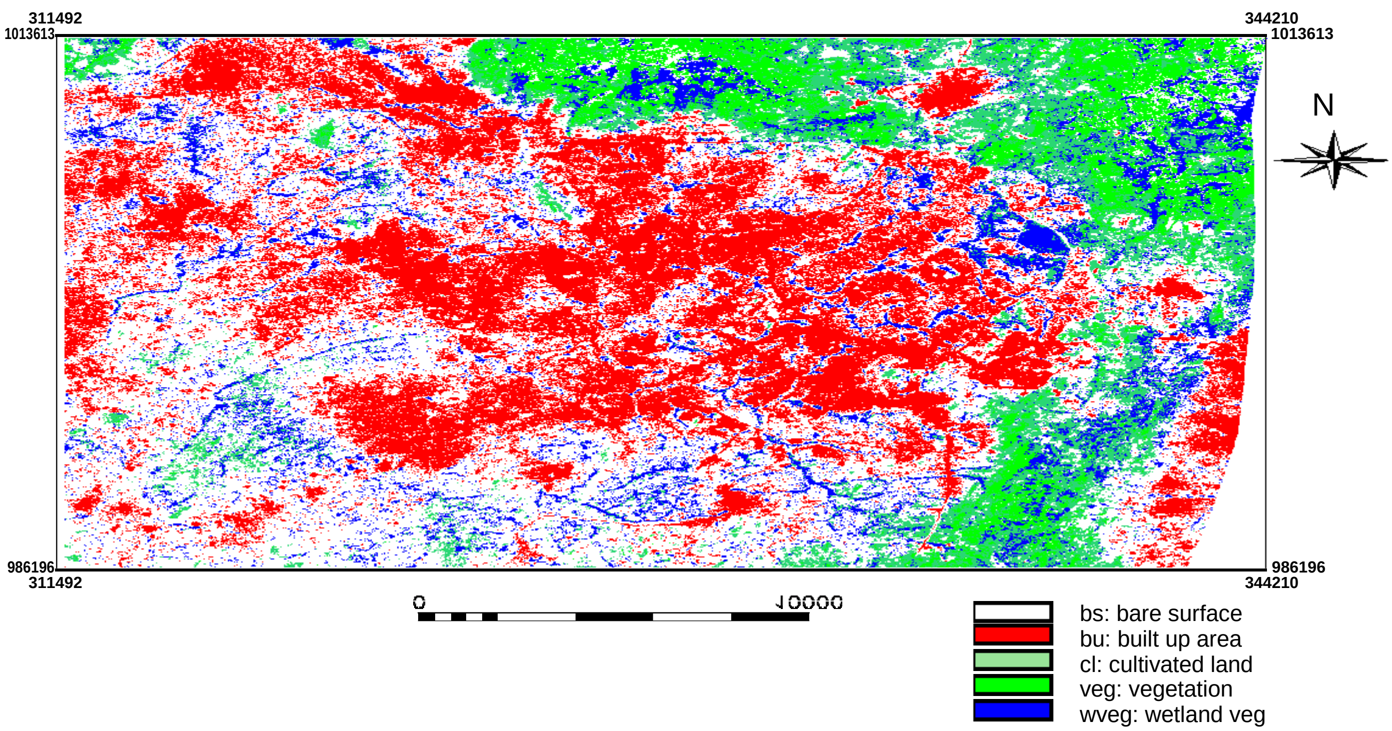

Figure 5. Landuse/landcover map of FCC in 2006.

FCC is located, is also found occurring in the satellite towns such as Nyanya, Karu, Kubwa, Lugbe, Gwarimpa and others. The increasing population of the FCC creates pressure on natural resources such that land is being rapidly loss and converted into built-up areas, the effects of which have been identified at several times by different research works (Adesina, 2005; Ifatimehin and Ufuah, 2006; European Environment Agency, 2006; Ifatimehin and Musa, 2008; Ujoh et al., 2008) to include loss of biodiversity, loss of vegetation, loss of prime agricultural land, alteration of the micro-climate, land degradation, etc. as well as several other effects on economic and ecological processes (Desanker et al., 1997). These effects are now being experienced in the FCC as clearly shown by Mashi and Alhassan (2004) as well as by mere observations. Finally, there appears to be an anomally in the distribution of bare surfaces over the study period as this land use/cover category decreased between 1987 and 2001 while it also increased between the period 2001 and 2006. While this may not necessarily mean increase in built-up area, it could imply various anthropogenic activities associated with the increase in population and expansion in settlement and built-up area within the study area.

CONCLUSION AND RECOMMENDATION

This essay sought to stimulate research in the area of urban sprawl, a phenomena that is rapidly engulfing our urban centres in Nigeria. It is the hope of this work that attention would be paid to the so many effects that urban sprawl brings to bear on the physical, economic and social environments of urban centres. Because Nigeria's rate of urbanization (and consequently, urban sprawl) is among the fastest in the world (Cohen, 2004), it has become imperative to carry out studies that reveal the rate, extent and consequences of urban sprawl in our rapidly expanding urban centres. This is to ensure that urbanization in Nigeria is managed in a sustainable manner such that the damage that urban sprawl brings to bear on the environment is minimized substantially.

In light of the foregoing discoveries, the study recommends the following:

i. Satellite towns should be developed in all 6 Area Councils of the FCT to ensure that population is not concentrated within the FCC (AMAC).

ii. Some key government Agencies, Ministries and departments should be moved to other area councils such as Abaji, Kuje, Bwari, Kwali and Gwagwalada to reduce the pressure and need to live in or around the FCC.

iii. Where development cannot be avoided over a wide area, provision for buffer zones should be made and natural drainages (such as streams) should be preserved.

iv. The policies guiding the development of structures within the FCC should be revised with a view to encouraging the development of high-rise apartments (as much as 50 floors) to reduce the rate of land consumption for construction of buildings.

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