The Growth Of Kaduna Metropolis Between 1973 And 2012: The Physical Planning Implications

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Abstract: This paper examined the growth and development pattern of Kaduna metropolis, Nigeria over a period of 39 years with a view to identifying its physical planning implications. The study employs the use of Remote Sensing data and GIS technology. Data used for the study include; Landsat Imagery of 1973, 1990, and 2001 and NigeriaSat-1 of 2006 and GeoEye image of 2012 and the population data for 1963, 1991 and 2006. The data was used to determine the pattern of growth, rate of growth, land consumption rate and land absorption efficiency of the study area. The study established that Kaduna metropolis have been increasing like most cities of the world of which the highest growth was witnessed between 2006 to 2012 with 13.4% growth rate per annum. It also revealed that the pattern of growths witnessed were along the major routes. The study also revealed that there is a relationship between population growth and urban growth in Kaduna metropolis The study concluded that the need for available data is vital to the understanding of the dynamic of the urban environment. More commitment had to be done on the part of government and research to ensure that the gap is closed.

Key words: Remote Sensing, Geographic Information System, Urban growth.

1.0 INTRODUCTION

The growth of towns and cities are not a new phenomenon in human history, as most of the big cities we have today emanated from a small settlement of few families to agglomeration of settlements and towns. Most of those growths could be attributed to the accumulation of human population over time either as a result of natural population increase or a pull factor which could attraction population from other surrounding town and villages due to concentration of activities in the urban area. Ajala and Olayiwola (2013)[1] described the urban environment as an ecosystem that accommodates multitude of activities and processes thereby attracting continues growth. According various finding, the growth of towns and cities were not only in size but also in numbers. For instance, the studies conducted by (Cohen 2006;[2] UNPD 2009;[3] Van de Voorde Canters, Kwast, Engelen, Binard and Cornet 2009[4]) affirms that more of the global population are gradually becoming urban. It was also discovered that number of cities and mega cities will also increase of which most of the effect will be felt in Africa and Asia. Some of the issue identified by Ajala et al (2013)[1] as threating to the urban system include urban congestion, poor housing, crowded transportation, lack of basic services, decaying infrastructure, increasing crime among others of which if such growth were not monitored, the functionality, aesthetic and the security of a city can be threatened. Quite a number of measures have been adopted both in the developing and countries of the world in an attempt to formulate and effective and more sustainable urban policies for our urban centres.

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However, availability of data has been a major setbacks (National Population Commission 2010)[5]. Some of these policies include the vision 2020, the millennium development goals among other policies. The need for the proper documentation of the trends of growth in our cities becomes paramount. These necessitated the need to understand the trends of growth of our urban cities which can help in proper monitoring and policy formulation. This study therefore examined the growth of Kaduna metropolis from 1973 to 2012 with a view to understanding the pattern and challenges that will guide policy formulation in the effective management of the metropolis.

2.0 LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Studies revealed that the three classical models of urban growth; Concentric, Sector and Multiple Nuclei models remain relevant to the evolution of modern urban structures. Although authors opined that one single model might not be sufficient to defining the structure of a city. The Concentric Zones Model of Burgess (1925) [6] postulated that cities grow in a ring, radiating from a centre to the fringes. This model established that the concentric nature of urban areas was influenced by the residents' social segregation. The model assumed uniformity in the direction of growth. One of the limitations of this model was its inability to describe the pattern of growth in most cities of the world. The Sector analysis Model of Hoyt (1939) [7] and the Multiple Nuclei Model of Harris and Ullman in (1945) [8] were later developed due to the limitations of the Concentric Zone Models of Burgess. Hoyt (1939) [7] propounded that an urban area substantially grow in a sectorial form around major transportation routes. That is, from the city centre towards the outskirt with each sector being segregated according to uses and income/social status. The Multiple Nuclei Model on the other hand was developed on the assumption that an urban area is made of more than one centre. Unlike the concentric and sector models, the model (Multi nuclei) propounded that urban areas were developed around the various activity areas within their neighbourhoods. Afon (2008) [9] observed that most Nigeria cities can be classified into three homogeneous residential zones these are: core, transition and sub-urban residential zones. He attributed the development of these

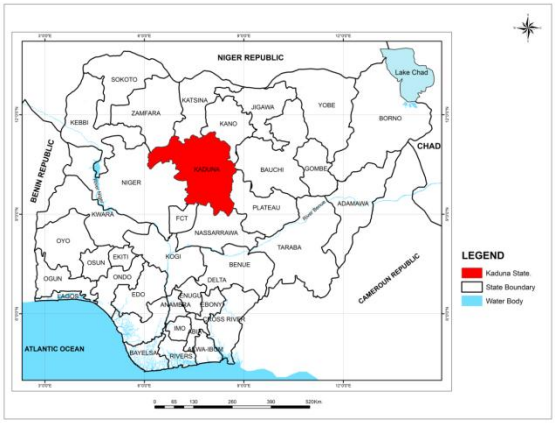
zones to the historical development of the country. These are: the pre-colonial, post-colonial and post independent periods respectively. This implied that the growth of most Nigeria cities is influenced by time and since time cannot be controlled, monitoring of such growth becomes necessary to ensuring a liveable environment. The monitoring of urban growth over the years has been very challenging. This is because the different approaches used before the advent of Remote Sensing (RS) and Geographic Information System (GIS) have been very difficult (Olorunfemi 1983;[10] Zubair 2006 [11]). RS as defined by (NOAA 2014)[12] is the science of obtaining information about objects or areas from a distance. This includes air borne and satellite remote sensing. GIS on the other hand is a technological field that incorporates geographic features with tabular data in order to map, analyse and access real-world problem (Caitlin 2012)[13]. This technique has become very popular since the launch of the first remote sensing satellite (Landsat-1) in 1972 and had proved to be effective in environmental monitoring. The U.S Geological Survey used this technique in 1985 to produce a land cover map of Alaska on the scale of 1:25,000 using Landsat MSS data. The above mentioned projects were attainable due to the synoptic coverage of large area using remotely sensed data. As a result, this reduces the expenses in terms of cost, man power and time compared to conducting ground survey. Generally, the RS data has the ability to provide more frequent data on a regular basis than any other data source that can be used for monitoring of urban growth. A RS device records feature of the earth surface, using electro-magnetic fields. This feature includes both the natural and human distorted cover. These features were interpreted using the element of tone, texture, pattern, shape, size, shadow, site and association to derive information about land cover. Information generated from the RS data could be used to ascertain the changes as they occur over time. This is what scholar named as change detection. Singh (1989)[14] defined change detection as the process of identifying differences in the state of an object or phenomenon by observing it at different times. Change detection is a task in the GIS environment that can be used to identify changes of a location at different times. This technique has being widely adopted in natural resource management and monitoring of urban changes. Zubair (2006)[11] list four aspects of change detection which are important in environmental monitoring. This include:

i. Detecting the changes that have occurred
ii. Identifying the nature of the change
iii. Measuring the areal extent of the change
iv. Assessing the spatial pattern of the change

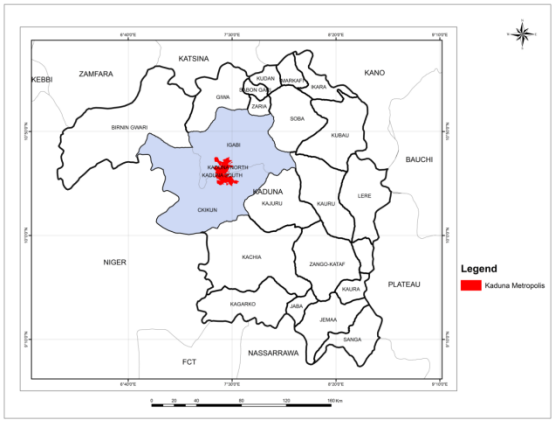
The application of this technique has being adopted widely. This was attributed to the increasing versatility in manipulating digital data and increasing computer power as well as the need to monitor natural resources over time. Therefore data on landuse change is of great importance to physical planners in monitoring the consequences of growth of urban areas over time. This information is prime to urban growth monitoring which involved assessing, and predicting future challenges.

3.0 THE STUDY AREA: AN OVER VIEW

The study covered Kaduna which is presently the administrative capital of Kaduna state, one of the 36 states of Nigeria. The metropolis is located between Longitude 7^0 21'and 7^0 30' East of the Greenwich Meridian and Latitude 10^0 23'and 10^0 36' North of the Equator. It was also the mid-point between Kano the commercial hub of Northern Nigeria and Abuja the Nation's capital. The name Kaduna as the metropolis was called is derived from two perspectives, while others say the name originated from the Gbagi tradition whom were the early settlers mean river with water, other opined that it originated from the word kadduna meaning crocodiles in Hausa because of the predominance of crocodiles in the river which is a major landmark in the metropolis.



Map of Nigeria showing Kaduna State



Map of Kaduna State showing Kaduna Metropolis

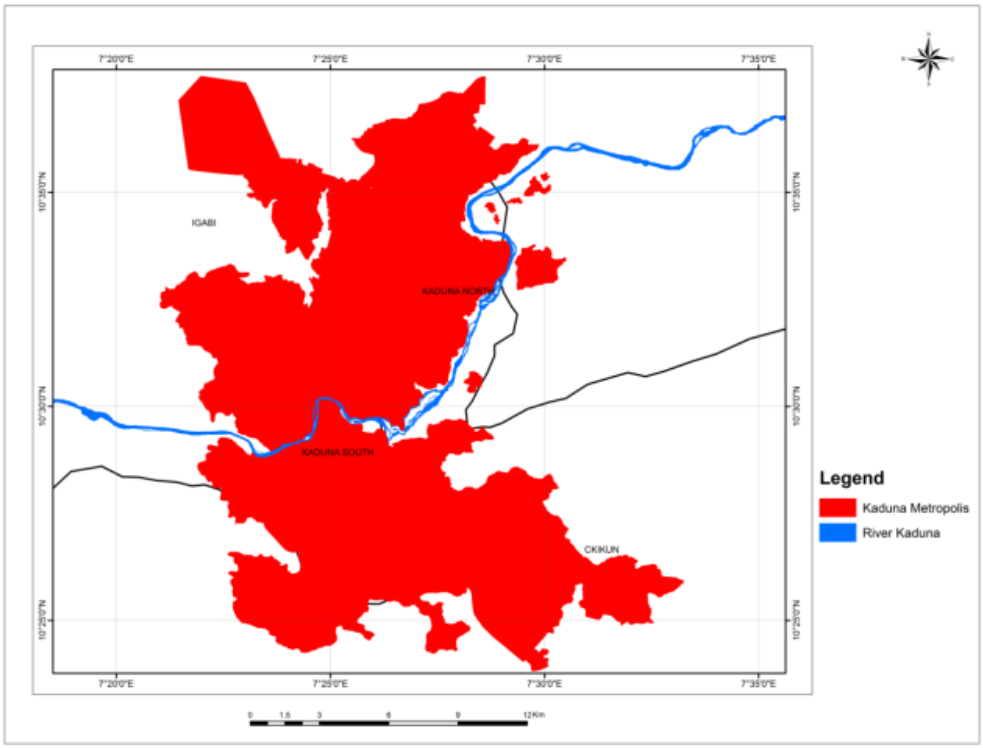


Figure 1: *Map of Kaduna metropolis*

The metropolis was formed as a garrison town in 1912, which transformed to the regional capital of the Northern Protectorate in 1900 and presently the capital of Kaduna state in north western Nigeria. The metropolis was designed by MaxLocks (1964) [15] to accommodate Administrative and Industrial hubs. This makes Kaduna to attract people of different race, religion and culture making it one of the most cosmopolitan city in Nigeria (Mohammed 2013)[16]. The spatial extent of the metropolis covers Kaduna North and Kaduna South Local government and spread into Igabi and Chukun local government areas of the state towards the Northern and Southern direction respectively. However, the metropolis unlike other Nigerian cities had no defined central traditional institution but its function as the capital of the Northern region makes most of the prominent northern traditional rulers have their houses in the metropolis. The metropolis is surrounded by a rural country side of scattered farmsteads with a gentle slope which gives it a room for expansion (See Fig 1).

4.0 METHODOLOGY: DATA COLLECTION

The study employed both primary and secondary data. This includes both spatial and non-spatial data. Multi-temporal Landsat Satellite Imageries (MSS of 1973, TM of 1990 and ETM of 2001); NigeriaSat-1 2006 and Geo-eye image of 2012; and ground truthing were the primary data. The data were selected based on availability due to the limitation of remote sensed data which is often limited by cloud covers. The satellite data for 1973, 1990 and 2001 were sourced from Global Land Cover Facility (GLCF) an Earth Science Data Interface, while the images of 2006 and 2012 were obtained from National Space Research and Development Agency in Abuja (NASRDA) and Google earth respectively (see Table 1). Secondary data were extracted from the administrative maps of the area and population data from National Population Commission (NPC) and other documented source. The data analysis adopted for the study includes; unsupervised classification of built-up areas of the metropolis using the multi-date images overlay of the extracted built-up area and statistical calculations of rate of change over time, Land consumption rate and Land consumption coefficient.

Table 1: Data set used for the study.

S/n	Data type	Data of capture	Resolution	Source
1.	Landsat imagery	25 Dec. 1973	80 m (MSS)	GLCF
2.	Landsat imagery	27 Nov. 1990	30 m (TM)	GLCF
3.	Landsat imagery	24 Oct. 2001	28 m (ETM)	GLCF
4.	Nigeriasat-1 imagery	06 Nov. 2006	32 m	NASRDA
5.	Geo-eye image	12 Nov. 2012	0.6 m	Google earth.

Source: *Author's Field Survey (2015).*

5.0 RESULT AND DISCUSSION.

5.1 Urban Growth.

The growth of a city is the measure of the rate of urbanisation and this measure of urbanization could be influenced by a measure of factors. Those factors include increasing population, political/historical function and socio-economical activities Ajala et al (2013) [1]. Some of the historical features of the metropolis include its serving as the northern political hub, geographical location which enables traveling from the metropolis to other part of the country to be covered within a day. The metropolis was also known to be an area non for its pronounced military presence. This includes the location of the Nigeria Defence Academy (NDA), the Nigeria Air force Base, and the Headquarters of the 1 Division of the Nigeria Army as well as a number of Army formations. Result of the analysis revealed that the areal extent of the built-up area of Kaduna metropolis as extracted from the satellite images of 1973, 1990, 2001, 2006 and 2012 were 35.10 Km^2, 92.39 Km^2, 129.39 Km^2, 149.94 Km^2 and 263.24 Km^2 respectively. This result further buttressed that between 1973 to 1990 the Kaduna metropolis grew physically at the rate of 9.6% per annum. This growth was considered high by urban researchers. This could be attributed to the implementation of the first National Development that led to the construction of most government residential areas and the major ring road (western by-pass) in the metropolis that influenced its growth. This corresponded to the findings of Michael (2005) that opined that provision of social amenities such as road networks do influence people's movement to such areas. The study also revealed that from 1990 to 2001 and 2001 to 2006, the annual growth rate of the metropolis reduced to 3.6% and 2.7% respectively. This indicated a growth stabilization of the metropolis within these years. However, between 2006 and 2012, the metropolis experienced a tremendous growth of about 13.4% within the six years under study (see Table 2). This could be attributed to the ethno-religious crises that engulf the metropolis as well as the high rate of land conversion taking place at the urban core areas of the metropolis leading the redirection of the urban populace towards the urban fringes were land is available and cheaper. This conforms to the inversion and succession of land uses as postulated by the Burgess concentric zone model of 1925 which signifies that homogenous land use within the city centre do invade and succeed the adjoining land use as a way of reacting to expansion. These were the growth trends of the metropolis over the period of 39 years. The overlay of multi-data satellite images of the study areas were presented in Fig. 4, Fig. 5Fig. 6, Fig. 7, Fig. 8 while Fig. 9 illustrates the overlaid of the five images.

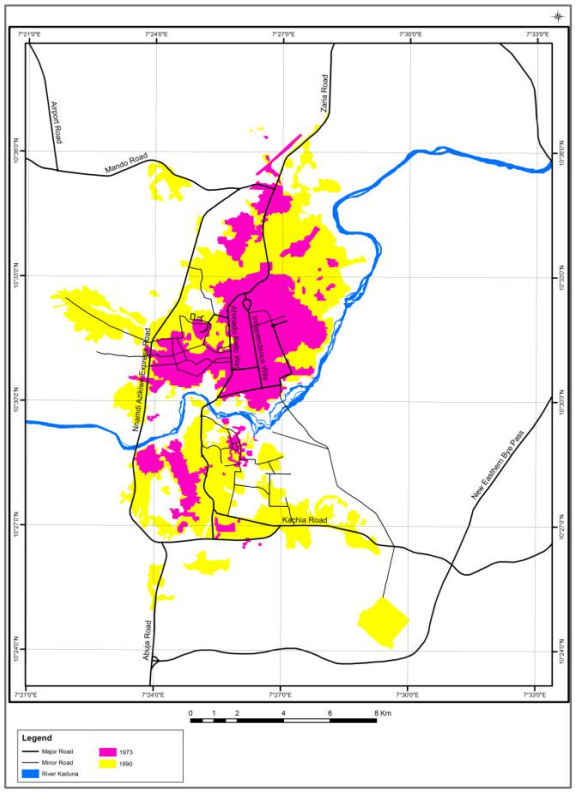


Fig.: 4.5: *The built-up area of Kaduna metropolis for 1973 and 1990.*

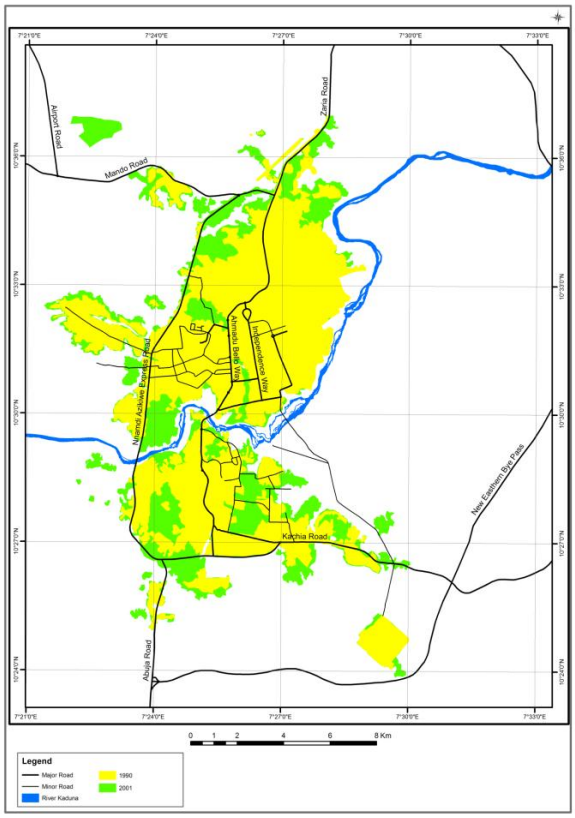


Fig.: 4.6: *The built-up area of Kaduna metropolis for 1990 and 2001*

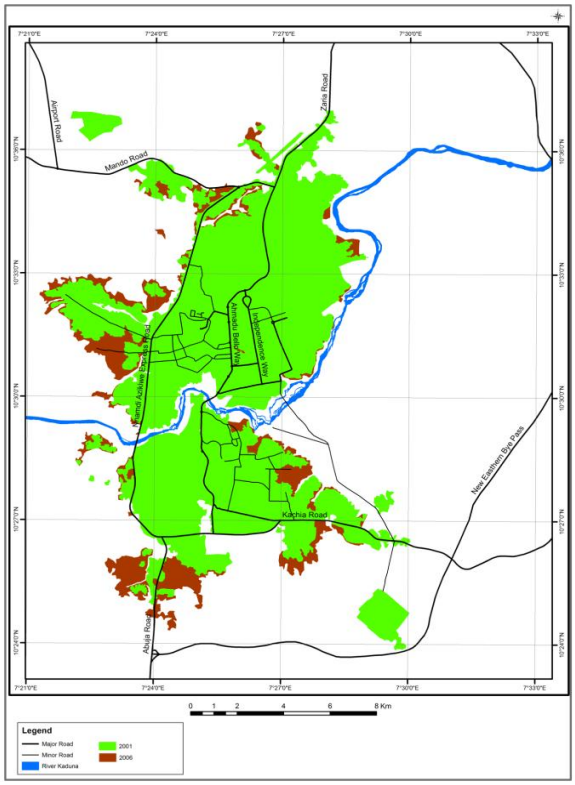


Fig.: 4.7: *The built-up area of Kaduna metropolis for 2001 and 2006*

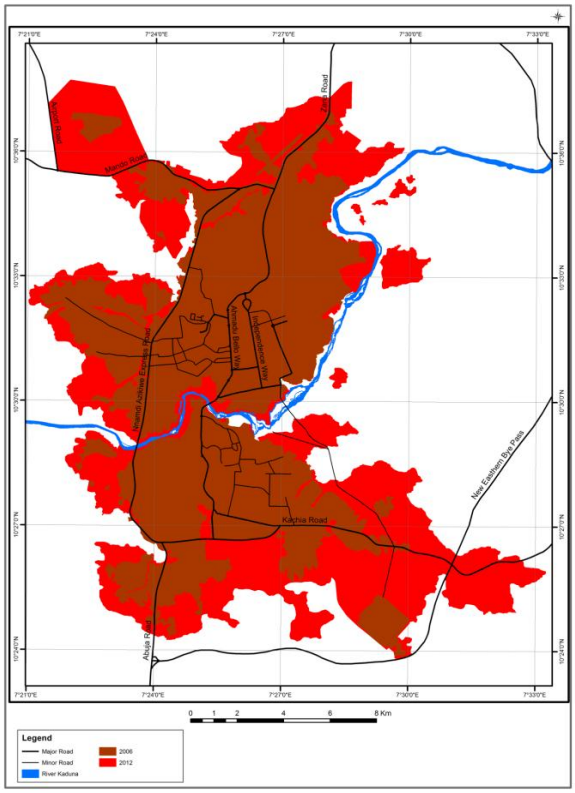


Fig.: 4.8: *The built-up area of Kaduna metropolis for 2006 and 2012*

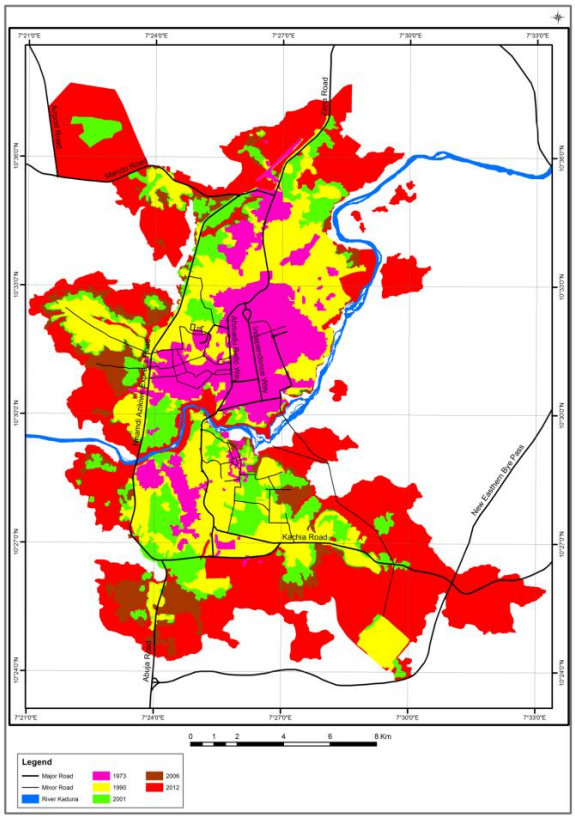


Fig.: 4.9: *The built-up area of Kaduna metropolis for 1973, 1990, 2001, 2006 and 2012.*

Table 2: Trends analysis of the growth of Kaduna metropolis from 1973 to 2012.

Year	AREA (km^2)	Period in years	Growth within period (Km^2)	Annual growth rate (%)
1973	35.10			
1990	92.39	17	57.3	9.6
2001	129.39	11	37.0	3.6
2006	145.94	5	16.6	2.7
2012	263.24	6	117.3	13.4

5.2 Population Growth of the study area for the years under study.

The study also revealed that the metropolis also witness a tremendous population increase from the 149,910 that was recorded during the 1963 census to a population of over 1.3 million people. The two base census data from the metropolis which was the 1963 and the 1991 revealed a population difference which is an increase of around 195,905 people within the metropolis in 28 years. That is the growth rate of about 130.68% within the census years. According to the National Urban Research Health Index NURHI, (2014), the metropolis had a population of about 1,139,578 people in 2006. This indicated that the population of the metropolis grow at the rate of 229.53% between 1991 to 2006 and 660.174% between 1963 to 2006 (See Table 3).This population increase could be connected to the natural population increases which was earlier predicted in the developing countries of the world. This variation in population growth conforms to the findings of

Table 3: Population figures of the study area for the years under study.

Year	Population figure	Source.
1973	191,898	Researchers estimate from 1963 population (149,910)
1990	332,995	Researchers estimate from 1963 population (149,910)
2001	504,556	Researchers estimate from 1991 population (345815)
2006	1,139,578	NURHI (2014).
2012	1,323,883	Researchers estimate from NURHI (2014).

5.3 Relationship between Population Growth and Urban Growth.

The study of population is one of the major corner stone to urban studies and this is because every aspect of the urban environment has its carrying capacity. This include light, water, road hospital among other social and basic amenities within the urban environment. This signifies the importance of population to urban studies. The result of the analysis as shown on Figure 4, revealed that the period between 1990 and 2001 witnessed the least population density among the years under study with 3604 per Km^2 and 3899 per Km^2 respectively. It was also discovered that 2006 had the highest population density of about 7808 people per Km^2. It was also observed from the result that the population density in 1973 lead to the high rate of growth between 1973 and 1990. This finding was also replicated between 2006 and 2012. This finding established that there is a relationship between population growth and urban growth in the study area. This findings was further supported the increase in Land consumption rate and land absorption coefficient on Table 5.

Table 4: Showing the relationship between Population growth and Urban growth

Year	Population figure	Built-up Area (Km^2)	Population Density (Per Km^2)
1973	191,898	35.10	5467
1990	332,995	92.39	3604
2001	504,556	129.39	3899
2006	1,139,578	145.94	7808
2012	1,323,883	263.24	5029

Table 5: Showing Land consumption rate and Land absorption co efficiency for the study area

Year	Land consumption rate	Year	Land absorption coefficient
1973	0.0183 ha	1973/1990	0.0406
1990	0.0277 ha	1990/2001	0.0216
2001	0.0256 ha	2001/2006	0.0026
2006	0.0128 ha	2006/2012	0.0202
2012	0.0198 ha	1973/2012	

6.0 Summary of findings

The study, using the techniques of RS and GIS has revealed the spatial dynamics of Kaduna metropolis from 1973 to 2012, which is a period of 39 years. The study was carried out with the aid of Landsat Imagery of 1973, 1990, and 2001 and NigeriaSat-1 of 2006 and GeoEye image of 2012. The study also established that Kaduna metropolis have been increasing like most cities of the world of which the highest growth was witnessed between 2006 to 2012 with 13.4% growth rate per annum. The study also revealed

that there is a relationship between population growth and urban growth in Kaduna metropolis.

6.1 Conclusion

The study was able to show that RS and GIS is a very important tool in environmental monitoring and evaluation which is one of the corner stone of urban planning. This study was able to provide information on the dynamics of urban growth in the study area of which the methodology can be applied to other phenomenon as well as other study areas. This was possible because of the availability of a reliable data which was extracted using RS and analysed using GIS.

6.2 Implication of the study

With the rate at which the study area is growing, there is the need for policy maker to imbibe the use of accurate and up-to-date data so as to ensure effectiveness of such policies. This is because without accurate data, it will be very difficult to arrive at an effective policy. Secondly, with the rate at which the Kaduna metropolis is growing, if care is not taking to monitor and regulate developments, the issue of unwanted growth will be the resultant effect of which issues of over stretching of basic facilities will the case. Thirdly, as the metropolis is situated within the river Kaduna tributaries if not properly monitored, the growth could extend into vulnerable areas reliable to flood which could lead to loss of life's and properties. In view of the implications noticed within the study area, the study opined that synergy need to be created between the residents and the urban regulator on the need from monitoring measure that will guide towards ensuring the growth of Kaduna metropolis is a blessing to the metropolis rather than a curse. Increasing commitment in the part of the government need to be increased in term of site and serviced schemes as well as regulatory measures in form of development plans need to be enforced so as to regulate the used of land within the urban environment in a view to promote functionality, safety and aesthetics.

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