



**IMPACT OF URBANIZATION ON WATER SUPPLY IN KADUNA METROPOLIS,
KADUNA STATE, NIGERIA.**

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Abstract:

This paper examined the impact of urbanization on water supply in Kaduna metropolis, with a view to generating population and urban growth data over the years. The study employed the use of Remote Sensing (RS) and Geographical Information System (GIS). Data used include: Landsat Imagery of 1973, 1990, 2012 and 2022. The data was used to determine the rate of growth within the study area and its impact on water supply to the study area. The study revealed that, the water supplied to Kaduna metropolis remained at 18,400,089 l/c/d; while the population drastically changed from 191,898 people to 3,046,000 people from 1973 to 2022. The study concluded that, Remote Sensing (RS) and Geographical Information System (GIS) to be applied in monitoring changes in population and the rapid growth of Kaduna metropolis. The study recommended that, the Kaduna State Water Corporation (KASWAC) is to apply current global technology of Remote Sensing (RS) and Geographical Information System (GIS) in providing adequate water supply to Kaduna metropolis at any given time.

Keyword: Urbanization, Water Supply, Remote Sensing (RS), Geographical Information Service (GIS).

INTRODUCTION

The emergence of people on earth has always been characterized by their dependence on, and exploration of natural resources in the environment to satisfy human needs. Hence the clustering of the human population brings about

the formation of settlements occasioned by the need to satisfy not only the basic requirements of needs, which include food, clothing and shelter, coupled with the tiredness of wandering around, but also the need to ensure physical development, safety and security of lives and properties (Abimbola, Ayobami, and Umar, 2022). As a result, Akanmu, Salisu, Daramola, (2021) opined that communities, within spatial territories and around the world continued to grow and expand in a variety of ways, even beyond their traditional borders. In fact, this growth and expansion of communities, which was undoubtedly aided by trade, spatial interaction and other political developments continued unabated with the industrial revolution playing a major role in Europe and other American settlements in the nineteenth century. This led to the emergence of cities and other forms of expanded human settlements of varying nomenclature, including sub-urban, rural-urban fringe etc. In addition, the colonization of many African communities in the late 18th and 19th centuries also brought many African communities into the limelight with increasing urbanization and population growth (Aloba, 2004). Therefore, the world has not only become relentless but also increased in the gathering majority of the human population in urban areas, marked by a remarkable increase in the absolute numbers of urban dwellers since 1990 (Moreno, 2017). In this way, the United Nations Habitat (2016) estimated that urban population increased by an average of 57 million people between 1990 and 2000 and 77 million between 2010 and 2015.

Urbanization refers to the population shift from rural to urban areas, the corresponding decrease in the proportion of people living in rural areas, and the ways in which societies adapt to the changes. It is predominantly the process by which towns and cities are formed and become larger as more people begin living and working in central areas (Wikipedia, 2022).

Although the two concepts (urbanization and urban growth) are sometimes used interchangeably, urbanization should be distinguished from urban growth. Urbanization refers to the proportion of the total national population living in those areas classified as urban, whereas urban growth strictly refers to the absolute number of people living in those areas (Wikipedia, 2022).

Water supply refers to water that is provided for humans, for example as a source of drinking water supply or irrigation water. 97% of the water on the Earth is salt water and only three percent is fresh water; slightly over two thirds of this is frozen in glaciers and polar ice caps. The remaining unfrozen freshwater is found mainly as groundwater, with only a small fraction present above ground or in the air. Natural sources of fresh water include surface water, under river flow,

groundwater and frozen water. Artificial sources of fresh water can include treated wastewater (wastewater reuse) and desalinated seawater. Human uses of water resources include agricultural, industrial, household, recreational and environmental activities (Wikipedia, 2022).

Kaduna metropolis is not an exception to the globally witnessed urbanization and unprecedented population increase as Kaduna metropolis has experienced a progressive increase in the built-up area. In 2006 it had an aerial coverage of 13,980 hectares, a rise of 107.91% from 2001 aerial coverage of 6724 hectares. In 2012, the city had an aerial coverage of 15,808 hectares, an increase of 13.08% from 2006. Conversely, there had been a remarkable decrease in percentage of vegetation (1,458 hectares) and agricultural (11,739 hectares) land areas. In turn, such changes had adversely affected urban facilities or utilities such as pipe-borne water, electricity, health facilities, schools, security, transportation, wastewater infrastructures and fire safety services, which had become overstressed. Economic crisis had manifested in the rise of unemployment and escalating number of urban poor. Residential land use had encroached into open spaces while commercial activities overrun residential areas. Increase in distance and journey time make travel cost unbearable to the common man. These and social fragmentation retard livability in the city. This calls for a balance sustainable development in Kaduna metropolis, environs and effective management of urban growth by the Kaduna State Urban Planning and Development Authority (KASUPDA).

EXISTING DEVELOPMENT AND THEIR IMPACT ON WATER SUPPLY IN KADUNA METROPOLIS

This research covers the settlements within the Kaduna Metropolis which comprises of four Local Government Areas within the State (Igabi, Kaduna North, Kaduna South and Chikun LGAs).

The Kaduna city region is drained by the Kaduna River and its tributaries, the Tubo, Sarkin Pawa, Udawa, Kara mi and the Galma. The Kaduna River provides all the water requirements of the city region. The source of the Kaduna River lies on the Jos Plateau. It flows for 210 kilometers before reaching the Kaduna city. It crosses the city dividing it traditionally into north and south. But now, with developments to the east of the Kaduna metropolis being undertaken, into east and west also. Beyond Kaduna it flows for 100 kilometers, discharging into the Shiroro reservoir. It flows out of the Shiroro hydro-electricity dam and continues for another 200 kilometers before finally discharging into the River Niger.

Changes in land use upstream of Kaduna over the years have increased the flood risk in the Kaduna Urban area. In 1970s, the predominantly shifting agriculture and nomadic pastoralism had a very small impact on vegetation and soils. Rapid changes can be observed since the 1980s. With an increasing proportion of land under permanent cultivation it is very likely that the more recent flood had taken place on less well drained soils in comparison with earlier practices. The flood risk is therefore high and needs to be taken into consideration (Maxlock, 2010). Afon (2008) 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 livable 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). The analysis of long term remote sensing imagery enabled an in depth monitoring of urban growth pattern. Based on this investigation, growth indicators have been developed for a parameterization of the development.

Remote sensing is defined as the science of obtaining information about objects or areas from a distance. This includes air borne and satellite remote sensing (Wikipedia, 2022).

Geographical Information System on the other hand is defined as a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data (Olorunfemi, 1983). As urban populations grow and spread, the importance of GIS lies in its ability to pull together the vast amounts of information necessary to balance competing priorities and solve complicated problems, such as optimizing new building placement or determining the feasibility of a waste disposal site.

MATERIALS AND METHODS

Study area

Kaduna State is located in the North – West zone of Nigeria as shown in Figure 1. Kaduna North Local Government Area is one of the Local Government Areas that constitutes Kaduna metropolis, the capital of Kaduna State as in Figure 1. Kaduna North L.G.A is bounded by Igabi L.G.A to the North, East and West and Kaduna

South L.G.A to the South, as shown in Figure 1. It is located approximately within latitude $10^{\circ} 34'21''$ N to $10^{\circ} 35'24''$ N and $7^{\circ} 27'36''$ E to $7^{\circ} 28'39''$ E of the Greenwich Meridian (Wikipedia, 2022).

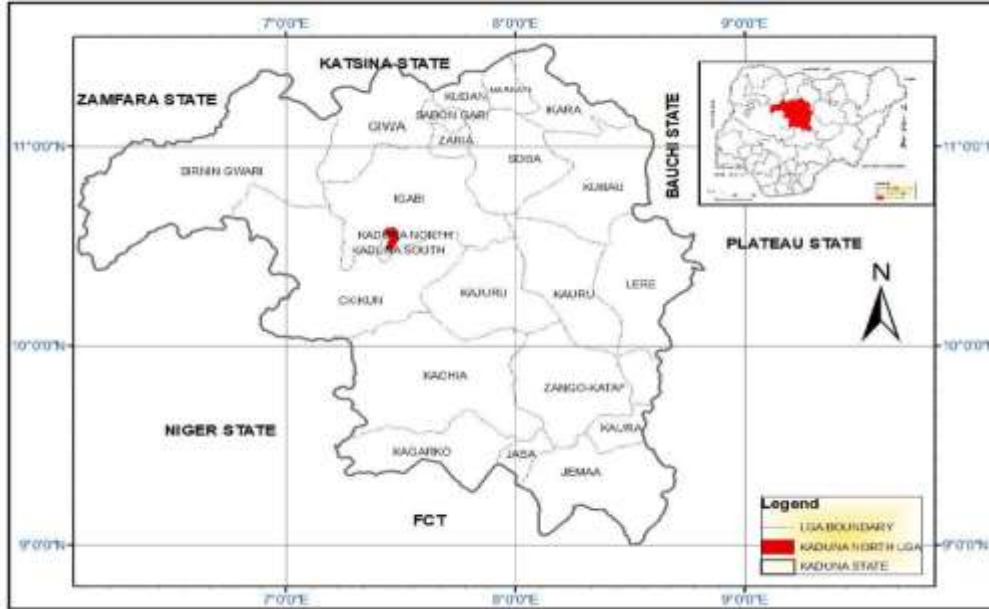


Figure 1: Map of Nigeria showing Kaduna State.

Source: Google Earth, 2022

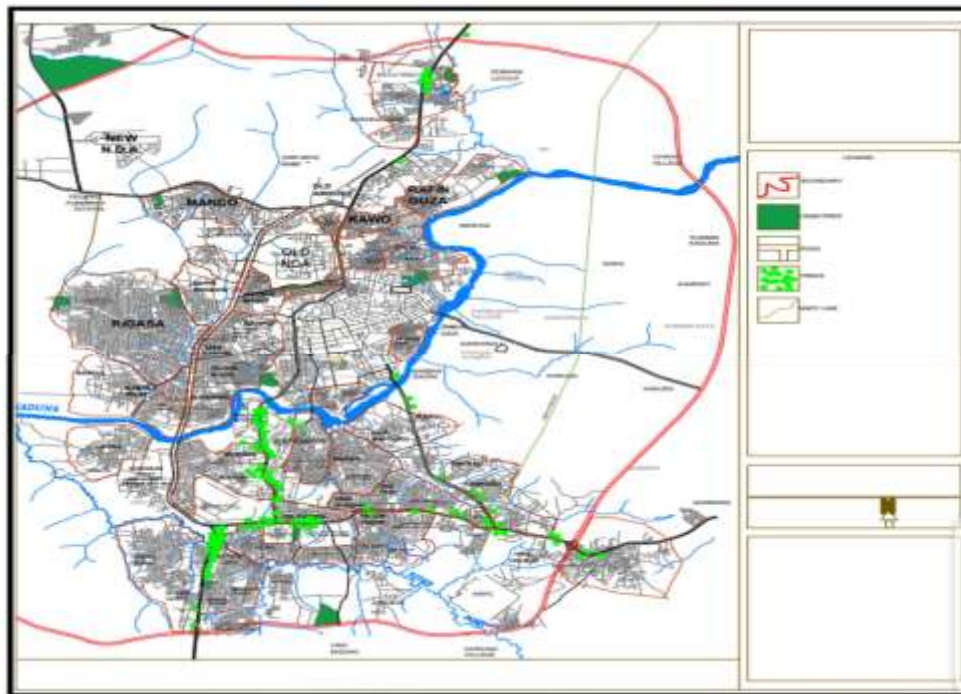


Figure 2: Map of Kaduna Metropolis Source: Google Earth, 2022.

The metropolis according to Maxlock, (2010) was formed as a garrison town in 1900, which transformed to the regional capital of the Northern Protectorate in 1912 and presently the capital of Kaduna state in north western Nigeria. The metropolis was designed by MaxLocks (2010) 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 cities in Nigeria (Mohammed, 2013). The spatial extent of the metropolis covers Kaduna North and Kaduna South Local government Areas and spread into Igabi and Chukun local government areas of the state towards the Northern and Southern directions 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 2).

Study Methodology

The study aimed at generating population and urban growth data on the impact of urbanization on water supply in Kaduna Metropolis.

This was achieved through the application of Remote Sensing (RS) and Geographical Information System (GIS) in collecting and analyzing the data.

The study employed both primary and secondary data, which include both spatial and non-spatial data. Multi-temporal Landsat Satellite Imageries (MSS of 1973, Geo-eye image of 1990, 2012 and satellite imageries of 2022 alongside 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, were sourced from Global Land Cover Facility (GLCF) an Earth Science Data Interface, while the images of 1990, 2012 and 2022 were obtained from Google earth respectively (Table 1).

Table 1: Data set used for the study

S/n	Data Type	Date Captured	Resolution	Source
1	Landsat imagery	25 Dec. 1973	80 m (MSS)	GLCF
2	Landsat imagery	27 Nov.1990	30 m (Tm)	GLCF
3	Geo-eye image Geo-	12 Nov. 2012	0.6 m	Google
4	eye image	28 Nov. 2022	15 m	earth.

Google
earth

Source: GCLF (1973 and 1990) and Google Earth (2012 and 2022).

FINDINGS AND DISCUSSION

The Impact of Increase in Population on Water Supply in Kaduna Metropolis

Impact on portable Water supply

Population growth is the increase in the number of humans on earth. For most of human history population size was relatively stable. But with innovation and industrialization, energy, food, water and medical care became more available and reliable. Consequently, global human population rapidly increased and continues to do so, with dramatic impacts on global climate and ecosystems (Wikipedia, 2022).

Kaduna State is not different from this global trend as a great increase in rural urban migration from her rural areas and other parts of the country contribute to the great increase in the metropolis, thereby causing great impact on the water supply in the state. Water consumption varies from one area to another, depending on socio economic standard of the people, the level of education and development, nature of prevailing climate, the hygienic characteristics of the people, level of provision of sanitation facilities and general sanitary habits of the people. However, it is generally agreed that a minimum of 50 l/c/d is needed by an individual to satisfy his basic need irrespective of socio-cultural background (Abdullahi, Abubakar, & Olufunmilayo, 2018).

In 1973, the population of the Kaduna metropolis according to Afon, and Alwadood, (2016) was 191, 898 which was estimated from the 1963 population of 149,910. The total water demanded was 9,594,900 l/c/d and the Kaduna State Water Board was treating and able to supply about 18,400,089 l/c/d (Kaduna State Water Board, 2014), for both residential, commercial, industrial and recreational areas. See figure 3 for built up areas in Kaduna metropolis as at 1973. As at 1990, the population of Kaduna metropolis was 332,995. See figure 4 for built up areas in Kaduna metropolis, as at 1990. The estimated water consumption was 16,649,750 l/c/d for residential areas and 14,239,560 l/c/d for commercial, industrial and other land uses, making it a total of 30,889,310 l/c/d, in which the Kaduna State Water Board was still producing 18,400,089 l/c/d for all the various land uses within the metropolis. In 2012, the population was approximated to about 1,323,883 (Researchers Estimated from NURHI, 2014).

See figure 5 for built up areas in Kaduna metropolis as at 2012. The water supply from Water Board remained the same, just the way it was as at 1973. The same scenario played out in 2022, with population estimation of about 3,046,000 (estimating 1973 population with a growth rate of 6.3%. See figure 6 for built up areas in Kaduna metropolis, as at November 2022. Even when the National standard for water consumption according to the Ministry of Water Resources is now 120 l/c/d for urban areas; 60 – 80 l/c/d for semi urban areas; and 40 l/c/d for rural areas; the water supply for Kaduna metropolis remains the same (Table 2).

Table 2: Water Demanded and Supplied in Kaduna Metropolis 1973 – 2022

S/NO.	YEAR	POPULATION	WATER DEMANDED(l/c/d)	WATER SUPPLIED(l/c/d)	ASSESSMENT (l/c/d)	REMARKS
1.	1973	191,898	9,594,900	18,400,089	+8,805,189 (+192%)	Surplus
2.	1990	332,995	30,889,310	18,400,089	-12,489,221 (-168%)	Deficit
3.	2012	1,323,883	66,194,150	18,400,089	-47,794,061 (-360%)	Deficit
4.	2022	3,046,000	365,520,000	18,400,089	-347,119,911 (-1,987%)	Deficit

Source: Author's Assessment, 2022.

Table 2 revealed the following:

- (i) From 1973 to 2022, a period of 49 years, the water supplied to Kaduna metropolis remained the same, at 18,400,089 l/c/d; while the population of the metropolis changed drastically, from 191,898 people to 3,046,000 people. This calls for serious concern by the Kaduna State Government through the KSWB, to ensure that water is supplied to Kaduna metropolis in line with the dynamic changes of population in the metropolis.
- (ii) It was only between the periods of 1973 and 1980s that surplus was realized in water supply from KSWB in Kaduna metropolis. From 1990 to date, gross deficit of water supply have been recorded ranging from 168% to 1,987% deficits. This helps in explaining the shortage of public water supply in some parts of Kaduna metropolis.

(iii) As the residents of Kaduna metropolis could not bear with the inadequacy of water supply from KSWB, they have to resort to alternative sources of water supply, mainly from the bore holes, dug on commercial or private basis, which made the number to be extremely large and even threatens the underground water available in Kaduna metropolis. This calls for proper regulation by KSWB and the adequate public water supply by the Kaduna State Water Corporation (KASWAC) or the defunct KSWB.



Figure 1: Built up Areas in Kaduna Metropolis as at 1973
Source: GLCF, 1973 and Author field survey



Figure 2: Built up Areas in Kaduna Metropolis as at 1990
Source: GLCF, 1990 and Author field survey

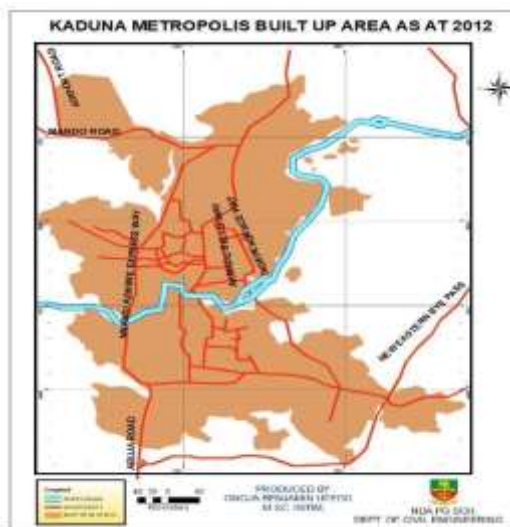


Figure 3: Built up Areas in Kaduna Metropolis as at 2012
Source: Google Earth, 2012 and Author field survey.



Figure 4: Built up Areas in Kaduna Metropolis as at 2022
Source: Google Earth, 2022 and Author field survey.

Impact on River Kaduna

According to Alayande, and Agunwamba (2010), the increasing urbanization along the Kaduna River floodplain is responsible for the problem of flooding experienced in recent times along the river floodplain and that encroachment into the traditional flood prone areas of the Kaduna River as a result of urbanization has attained 85.31%, 68.47% and 67.54% respectively in Reach 2, Reach 3 and Reach 1, over the period of 1962 and 2009. Because the Kaduna River usually attained its bank full flow capacities in all its sections along the City of Kaduna early August each year, their result further indicated that the 2yr, 5yr, 10yr, 25yr, 50yr, and 100yr floods when occurred can cause maximum inundation of between 82.53% to 94.48% of the floodplain areas between the Eastern Bypass bridge and the Kaduna South Waterworks with Ungwan Rimi, Kabala Doki and Kigo road extension as the most critical areas where the right banks are lower than the left banks and developments are almost to the right bank of the river. For these reasons, all forms of illegal development along the flood plain of River Kaduna have to be stopped and the flood plain is to be reserved as buffer zone, devoid of any adverse physical development.

CONCLUSION

The study was able to show that Remote Sensing and GIS are very important tools 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 Remote Sensing and analysed using Geographical Information System.

RECOMMENDATIONS

Based on the foregone discussion, the following recommendations are hereby made:

(i). The Kaduna State Water Corporation (KASWAC), formally the Kaduna State Water Board (KSWB) is to apply current and projected population data of Kaduna metropolis to determine the quantity of water supply to provide to the inhabitants of Kaduna metropolis, at any given point in time, for both the present and future population.

(ii). Remote Sensing (RS) and Geographical Information System (GIS) tools are to be applied in monitoring urban growth and urbanization in Kaduna metropolis, being the modern global tools used in monitoring rapid urbanization.

(iii). The Kaduna State Water Corporation is to monitor and control the proliferation of bore holes in Kaduna metropolis, and other urban areas in Kaduna State, in order to protect the available ground water in Kaduna metropolis and Kaduna State in general.

(iv). All flood plains along River Kaduna and other rivers in Kaduna State are to be reserved as buffer zones, devoid of any adverse physical development. Any landed illegal development that encroached the flood plains have to be demolished, in order to give way for the reservation of the area as buffer zones, for River Kaduna and other rivers in Kaduna State.

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