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Full Length Research Article

GIS-BASED ANALYSIS OF THE DISTRIBUTION AND IMPACT OF HOUSING ESTATES IN KADUNA METROPOLIS FOR SUSTAINABLE URBAN DEVELOPMENT

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ABSTRACT
Provision of housing to cater for the increasing population remains one of the problems faced by governments and other stakeholders. This study applies geospatial technologies to analyze location of housing estates in Kaduna metropolis. Spatial and attribute data of the housing estates were collected and analyzed using ArcGIS 10.8 software. Findings revealed that most of the estates were located at Unguwan Rimi district of Kaduna North LGA which were 13, representing 28% of the total. This was closely followed by Millennium city in Chikun LGA located in the eastern axis of the metropolis with 11, representing 24% and then Barnawa in Kaduna South LGA with 11 housing estate, representing 24% also. Part of Igabi LGA in Kaduna metropolis do not have any estate. The estates were found to be clustered and randomly distributed with a nearest neighborhood ratio of 0.898467, a z-score of -1.331640, a p-value of 0.182978 and an observed mean distance of 835.9575. It was concluded that housing estates in Kaduna metropolis were both clustered and random. It was recommended among other recommendations that private developers that need government support should be given incentives for more investments towards construction of housing estates in order to bridge housing deficits.

Keywords: GIS and Remote Sensing, Housing Estates, Sustainable Urban Development

INTRODUCTION

Housing estate refers to the collection of homes and buildings constructed together as a unified development, with varying forms and designs or styles from one place to another (Knox, 2008). According to housing development (2016), a housing estate development involves a single developer constructing a group of homes on a plot of land, with a unified management system. The problem of inadequate housing faced by poor people around the world has been a matter of concern to governments in various countries especially in the developing world. In such countries, the housing problem is not only that of quantity but also of the poor quality of available housing units (Bello, 2019).

Kaduna metropolis, is one of the fastest-growing urban centers in northern Nigeria, attracting people for socio- economic and political reasons (Akpu, & Tanko 2017). This influx has led to rapid urbanization, characterized by a growing population and a corresponding increase in housing demand. According to the National Population Commission (NPC, 2021), Kaduna metropolis has witnessed a population growth rate of approximately 3.2% annually, putting pressure on existing housing infrastructure and creating a need for planned residential developments.

The demand of housing is often met by housing estates development and in Kaduna metropolis, there are many of such as Millennium City, Malali GRA, and Barnawa GRA, which are designed to address the housing needs of various socio-economic groups. These estates contribute to urban development by improving living conditions, promoting socio-economic activities, and enhancing the aesthetic quality of the urban landscape (Agbola, 1998). However, they also pose challenges related to environmental degradation, urban sprawl, and socio-economic inequalities.

From the housing estates built, emerged the urban sprawl, often resulting from unplanned or poorly managed urban growth, which is a significant issue in Kaduna metropolis. Additionally, the proliferation of housing estates has led to the conversion of agricultural land and green spaces into residential areas, disrupting ecosystems and altering land-use patterns. Studies by Ayeni et al. (2016) indicate that urban sprawl in Nigerian cities is exacerbated by inadequate urban planning policies, weak enforcement mechanisms, and limited public participation in decision-making processes. In Kaduna metropolis, the expansion of housing estates has raised concerns about the sustainability of land use and the equitable distribution of resources.

According to a study by Bello et al (2020), the spatial distribution of housing estates in Kaduna metropolis reflects disparities in urban development. While some areas, such as Malali and Barnawa, have a high concentration of well-planned estates, other regions remain under-served, lacking basic infrastructure and services. These disparities highlight the need for comprehensive spatial analyses to guide urban planning and ensure balanced development. Geographic Information Systems (GIS) and remote sensing technologies have proven effective in mapping and analyzing the spatial distribution of housing estates, enabling planners to identify gaps and propose solutions.

The socio-economic impacts of housing estates on surrounding communities are equally significant. Housing estates often attract commercial activities, improve access to services, and increase property values. However, they can also contribute to traffic congestion, strain existing infrastructure, and displace low-income residents. Adebayo (2021) emphasizes the importance of integrating social equity considerations into urban planning to minimize negative impacts of housing estates and promote inclusive development. This idea also reflects the sustainable development goal 11 [sustainable communities and cities] (SDG, 2015).

This study aims to analyze the location, distribution, and impact of housing estates in Kaduna metropolis, using GIS and Remote Sensing and providing insights to guide sustainable urban development.

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MATERIALS AND METHODS

The Study Area

Kaduna metropolis is located between latitude $10^0$25'36''N to 10^0 38'58'' North of the Equator and longitude $7^0$22'14'' to $7^0$32'00'' East of the Greenwich Meridian. It covers an area of a distance of about 22km long from Queen Amina Bridge, Kawo in the north to command junction in the South. There is extension in both sides of the divide making parts of Igabi and Chikun Local Government Areas (LGAs) to join the whole of Kaduna North and South LGA (Muhammed, et al., 2023).

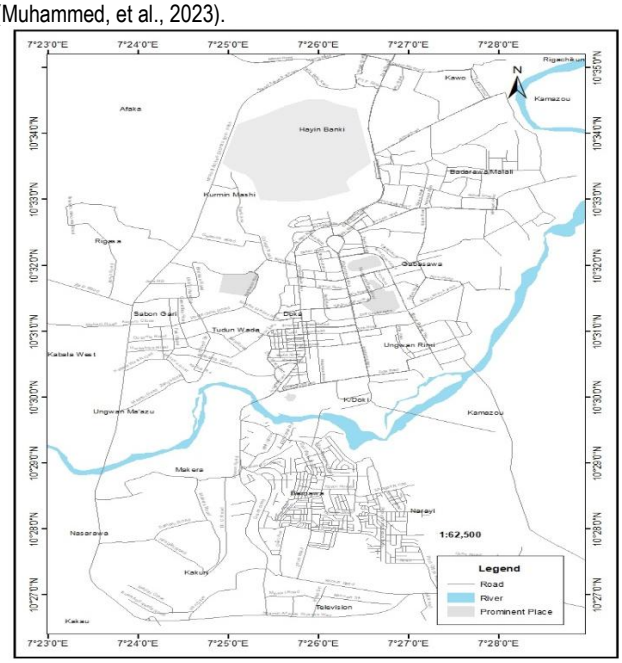

Figure 1: Kaduna Metropolis
Source: Modified and adapted from Street guide of Kaduna. (KADGIS 2024)

METHODOLOGY

Types of Data

Data used for this study include coordinates of the housing estates, map of Kaduna metropolis, satellite image and attributes of each housing estates.

Table 1: Data Sources and Functions of Data

S/N	Data	Source	Function/Analysis
1.	Geographic Coordinates	Field Work	Mapping, spatial distribution and query
2.	Street map	KADGIS, Grid 3	Base map of Kaduna Metropolis
3.	Satellite image	Google Earth/SPOT C-NES 2025	Ground truthing and validation
4.	Attribute data	Field work, KASUPDA/KADGIS	Spatial Query/ Data mining (Categories, ownership, amenities)

Source: Authors' Analysis 2025

Sources of Data

Data for this study was derived from various sources which include field work carried out by the researchers and relevant government agencies; Kaduna State Urban Planning and Development Authority (KASUPDA) and Kaduna Geographic Information System (KADGIS). Online resources were obtained from Grid 3 website and also Google Earth image was used for data validation as displayed in Table 1, above.

Methods of Data Analysis

Location of housing estates

The Estate in the metropolis were identified and mapped by collecting coordinates of the housing estates using Garmin76csx hand-held G.P.S. device. Result was tabulated in Microsoft Excel in CSV format for integration into the ArcGIS 10.8 environment. The coordinates were added as x and y events which were further converted to shapefile for spatial processing, result of which was displayed after analysis for visualization and presentation.

Pattern of distribution of housing estates

The Average Nearest Neighbor (ANN) tool was used to analyze the spatial pattern of distribution. The Average Nearest Neighbor tool measures the distance between each feature centroid and its nearest neighbor's centroid location. It then averages all these nearest neighbor distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered.

Categories of houses, ownership and amenities available in the estates

Locating the houses was achieved through field work and available records from public agencies; KASUPDA and KADGIS. Result was

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entered into Microsoft Excel spreadsheet and displayed using descriptive analysis for easy comprehension. This was also entered as attribute table for each of the estates for visualization on a map.

Proximities of the Housing Estates to Physical and Environmental Hazards

Spatial query was conducted on the estates to determine their proximities to physical and environmental hazards. The "Select By Location" in ArcGIS 10.8 software tool let us select features based on their location relative to features in another layer. This operator provides the same results as "Are Within" unless the target feature is entirely on the boundary of the source feature, with no part of the target feature inside the source feature. In this case, using the *Are Within Clementini* operator does not select the target feature, whereas the *Are Within* operator does. *Clementini* states that a polygon's boundary is separate from its inside and outside.

RESULTS AND DISCUSSION

This finding revealed that most of the housing estates in Kaduna metropolis are located at Unguwan Rimi district closely followed my New Millennium city in Chikun L.G.A. in the eastern axis of the metropolis. Barnawa district comes third in Kaduna South L.G.A. in the southern part of the metropolis as depicted in Table 2 in numbers and percentages. Appendix also shows coordinates of estates collected in Geographic Coordinates Systems which is displayed on Table 4.

Finding also revealed little intervention of the state urban planning and development board intervention in regulating and encouraging housing development.

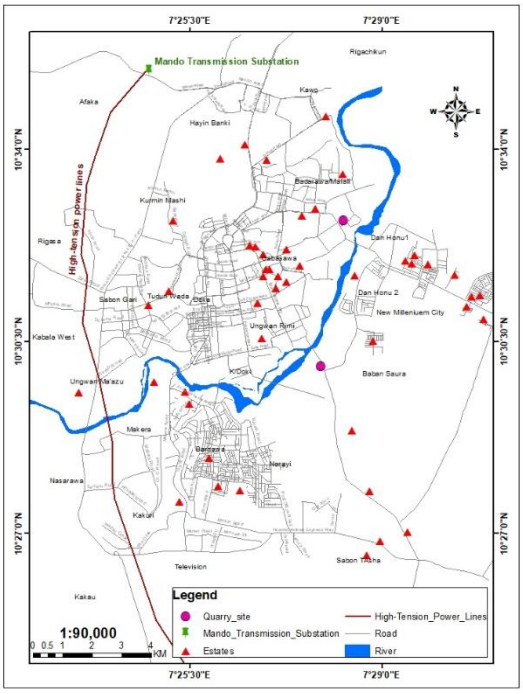

Figure 2: Location of Estates by District/L.G.A.s
Source: Authors' Analysis 2025

Table 2: Location of Estates by L.G.A.s

S/N	L.G.A.	No. of Estates	Percentage %
1.	Kaduna North	20	44
2.	Kaduna South	11	24
3.	Chikun	16	32
4.	Igabi	-	-
Total		47	100

Source: Authors' Analysis 2025

This finding agrees with the study conducted by Ibrahim et al. (2021) in Kaduna metropolis which revealed that housing estates were primarily concentrated in areas with robust infrastructure, such as Ungwan Rimi and Barnawa. However, peripheral areas like Chikun Local Government Area are increasingly witnessing estate developments, driven by urban expansion and land affordability. Figure 2 above shows the location of housing estates by districts, clusters of housing estates can be visualized in the center of the map which is Kaduna North L.G.A. and the south-east corner which is Millenium City, Chikun L.G.A. It can be seen that Rigasa district in Igabi L.G.A from northwestern part of the figure had no housing estate as revealed in Table 2 above.

Pattern of Distribution of the Housing Estates

Using the Nearest Neighborhood Analysis tool from the Arc-tool box of ArcGIS 10.8, the housing estates were found to be randomly distributed across the metropolis with a Nearest Neighborhood ratio of 0.898467, a z-score of -1.331640 and a p-value of 0.182978. Observed mean distance between the housing estates across the study area was found to be 835.9575.

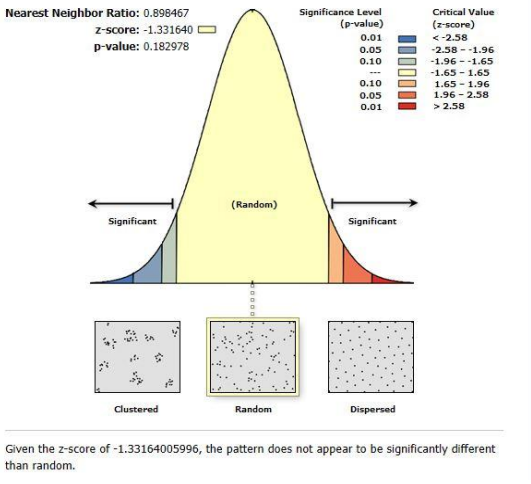

Figure 3: Average Nearest Neighbor Summary
Source: Author's Analysis 2025

Table 3: Average Nearest Neighbor Summary

S/N	Parameters	Result
1. Meters	Observed Mean Distance	835.9575
2. Meters	Expected Mean Distance	930.4264
3.	Nearest Neighbor Ratio	0.898467
4.	Z-score	-1.331640
5.	P-value	0.182978

Source: Author's Analysis 2025

Figure 3 and Table 3 above show a graphical illustration and summary of average nearest neighborhood respectively. However, number of estates vary according to districts with Barnawa, parts of the Central Business Districts in Kaduna South L.G.A. and also Chikun L.G.A. having more clustering than other districts. Tudun Wada, and Kakuri in Kaduna South L.G.A. have two housing estates each while Unguwan Muazu district have only one housing estate. Rigasa district Igabi L.G.A. which happens to be part of the metropolis from Igabi LGA does not have any housing estate. Various studies on location and distribution of housing estates conducted by (Ajibola et al., 2016; Bello, et al., 2020; Ibrahim, et al., 2021; Ayeni et al., 2016; Akintola, 2018) support this finding that spatial distribution pattern have strong correlation with availability of infrastructure and amenities. Kaduna metropolis by virtue of its status as the administrative capital of the defunct northern region enjoys a fair advantage of development in terms of road network infrastructure and also the urban renewal, championed by the last administration.

Conclusion

The study revealed that housing estates in Kaduna metropolis were both clustered and random with the clustering being seen mostly at Barnawa district, indicating significant development of road infrastructure around the area. More notably areas with the clustered housing estates were the Millenium City and Unguwan Rimi districts suggesting a preference of these locations by the housing developers and residents which can be attributed to the wide spaces and infrastructural development of the areas.

The clustering of housing estate has implications for urban planning and development in Kaduna metropolis. It underscores the need for efficient land use planning and management to ensure that the development is spread in all parts of the city like Parts of Igabi L.G.A where no housing estate was identified to ensure equity and city sustainability. Additionally, having the concentration on few areas would lead to pressure on infrastructure and services provided by government and housing developers.

Overall, this study contributes to our understanding of the spatial distribution and impact of housing estates in Kaduna metropolis which will help potential residents on what to expect. It will also help developers to identify areas that need these services for future investment. The findings have also implications on government, urban planners and developers seeking to promote sustainable cities and communities as enshrined by the sustainable development goals.

Recommendations

The following recommendations were made based on findings from the study gained:

1. Government at all levels must encourage more constructions of housing estates through direct interventions and public/private partnerships.
2. Private developers that need government support should be given incentives such as tax rebates to enable them channel more investments towards construction of housing estates in order to bridge housing deficits especially at Rigasa district of Kaduna metropolis
3. Relevant government agencies such as KASUPDA must enforce development control to checkmate un-wholesome practices.
4. KASUPDA and KADGIS must ensure strict adherence to the stipulated land use plan on the Certificate of Occupancy (C of O) with reference to the master plan of the metropolis.

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Appendix

Table 4: Geographic Coordinates of the Housing Estate in Kaduna Metropolis

S/N	Name of Estates	District/L.G.A.	Coordinate
1.	Kotoko Barracks	Kawo /Kaduna North	10.568346° 7.441709°
2.	Ribadu Cantonment	Old. N.D.A. Ung. Kanawa	10.564043° 7.434235°
3.	SMC Quarters	Ung. Dosa/Kaduna North	10.563477° 7.448312°
4.	Legislative Quarters	Ung. Dosa/Kaduna North	10.576846° 7.466372°
5.	Malali Low-cost Housing	Malali/Kaduna North	10.559238° 7.471492°
6.	Federal Coop. Quarters	Malali/Kaduna North	10.546630° 7.458977°
7.	Capital School Quarters	Malali/Kaduna North	10.548795° 7.462976°
8.	NITR Quarters	Shehu Laminu Road Ung. Rimi	10.526590° 7.454377°
9.	NNDC Housing Estate	Ung. Rimi/Kaduna North	10.520165° 7.445501°
10.	Skyview Estate	Ung. Rimi/Kaduna North	10.528129° 7.447250°
11.	Unnamed	Nagwamatse Rd. Ung. Rimi/ Kaduna North	10.531345° 7.458394°
12.	Unnamed	Lamido Road Ung. Rimi/ Kaduna North	10.536300° 7.454339°
13.	Fadal Estate	Surami Road Ung. Rimi	10.528297° 7.451722°
14.	Unnamed	Yakubu Avenue Ung. Rimi	10.537213° 7.444858°
15.	Unnamed	Kwato Road Ung. Rimi	10.530330° 7.449159°
16.	Unnamed	Kwato Road beside. UBE Primary sch Ung. Rimi/Kaduna North	10.530330° 7.448157°
17.	Easer-Sphere Ltd.	Yakubu Avenue Ung. Rimi/ Kaduna North	10.534800° 7.447246°
18.	Unnamed	Surami Road Ung. Rimi /Kaduna North	10.524502° 7.451000°
19.	Hafdala Smart Apartments	Yakubu Avenue Ung. Rimi /Kaduna North	10.537583° 7.443247°
20.	Police Barracks Const. Road	Doka/Kaduna North	10.509343° 7.446899°
21.	Stephen Shekari	Kurmin Mashi/Kaduna South	10.545133° 7.419861°
22.	Poly Quarters	Tudun Wada/Kaduna South	10.523654° 7.418548°
23.	Police Barracks	Tudun Wada/Kaduna South	10.519357° 7.412389°
24.	Ung. Muazu Estate	Ung. Muazu/Kaduna South	10.424716° 7.385991°
25.	Nuru Siraj Estate	Millenium City/ Chikun	10.522457° 7.513150°
26.	Ministerial Post Housing Estate	Millenium City/ Chikun	10.531900° 7.497444°
27.	Rheyno Estate	Millenium City/Chikun	10.532174° 7.492341°
28.	Al-Aya Estate	Millenium City/ Chikun	10.534729° 7.493277°
29.	Gidan Iyali Estate	Millenium City/ Chikun	10.515180° 7.514248°
30.	MD Abubakar Police Estate	Millenium City/Chikun	10.508449° 7.480659°
31.	Urban Shelter	Millenium City/Chikun	10.528406° 7.475107°
32.	Unnamed	Millenium City/Chikun	10.528586° 7.505545°
33.	Unnamed	Millenium City/Chikun	10.522050° 7.510668°
34.	Unnamed	Millenium City/Chikun	10.519092° 7.509229°
35.	Yelash Estate	Millenium City/Chikun	10.532941° 7.490492°
36.	Poly Quarters	Barnawa/Kaduna South	10.489442° 7.424716°
37.	Mamman Kontagora Estate	Barnawa/Kaduna South	10.493013° 7.423463°
38.	Middle Income Earner's Estate	Barnawa/Kaduna South	10.463176° 7.440091°
39.	Shagari Low-cost Housing	Barnawa/Kaduna South	10.464316° 7.433436°
40.	Barnawa Low-cost Housing	Barnawa/Kaduna South	10.473041° 7.430619°
41.	Railway Quarters	Kakuri/Kaduna South	10.496001° 7.413971°
42.	Kalapanzi Barracks	Kakuri/Kaduna South	10.459582° 7.421687°
43.	KRPC Quarters	Sabo/Chikun	10.443422° 7.478778°
44.	Makarfi Estate	Sabo/Chikun	10.447705° 7.482761°
45.	NAPH Estate	Mahuta/Chikun	10.450401° 7.491105°
46.	Triple A Homes	Jan-Ruwa/Chikun	10.462878° 7.479486°

Source: Authors' Analysis 2025