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SPECIAL ISSUE: CELEBRATING 20 YEARS OF GEOGRAPHY IN KADUNA STATE UNIVERSITY - ADVANCES AND FRONTIERS IN GEOGRAPHY

Spatial Analysis of Financial Institutions in Kaduna Metropolis, Kaduna State, using GIS and Nearest Neighbor Analysis

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ABSTRACT

This study examines the spatial distribution and locational patterns of financial institutions within Kaduna Metropolis, utilizing Geographic Information Systems (GIS) and Global Positioning System (GPS) technologies to analyze the distribution of commercial banks, development banks, and microfinance banks. A total of 75 commercial banks, 6 development banks, and 24 microfinance banks were identified and mapped within the metropolis. A preliminary field survey employed handheld GPS devices to accurately record the geographic coordinates of these institutions. The Nearest Neighbor Analysis method was used to determine the spatial pattern of their locations, revealing a predominantly clustered distribution with a Nearest Neighbor Index (Rn) of 0.400059 and a Z-score of -15.269540, indicating significant clustering. The analysis showed that commercial banks are mainly concentrated along major roads and commercial centers such as Waff Road, Jos Road, and Ahmadu Bello Way, primarily serving the central business district and high-traffic socio-economic zones. Microfinance banks are dispersed across residential neighborhoods and along major thoroughfares, reflecting their focus on serving small-scale enterprises and low-income households. Development banks, fewer in number, tend to be located along key roads and institutional areas, providing specialized financial services. The findings highlight the strategic placement of financial institutions in accessible, economically active zones that support retail, corporate, and high-order financial activities. However, notable gaps exist in peri-urban and underserved residential areas where financial services are sparse. To address these disparities and improve financial inclusion, the study recommends expanding the physical presence of financial institutions into underserved neighborhoods using GIS-informed site selection.

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1 Introduction

Globally, financial institutions play key roles in increasing access to funding and other credit instruments for individuals, corporate organizations, government and non-governmental institutions, multinational organizations, and other critical stakeholders, thereby enhancing socio-economic development (Luca, 2014). Finance is required by individuals, communities, agencies, groups, and organizations acting as economic agents for various purposes. To provide the necessary financing, a variety of organizations offer financial services. These entities are called financial institutions and can normally be divided into the money and capital markets. A bank is a financial institution licensed to receive deposits and make loans. Banks may also provide financial services, such as wealth management, currency exchange, and safe deposit boxes (Barone, 2019). A bank is a formal organization or institution that primarily deals with money and financial transactions. The most popular type of bank, at least in Nigeria, is a commercial bank, which lends money directly to customers for personal and business purposes (Jibril, 2009).

According to the Central Bank of Nigeria, financial institutions provide an enabling environment for economic growth and development, productive activity, financial intermediation, capital formation, and the management of the payments system (Okosun, 2018). Through intermediation, savers lend to intermediaries, who in turn lend to firms and other fund-using units. The saver holds a claim against the intermediaries in the form of deposits rather than against the firm. Financial institutions provide a useful service by reducing the cost to individuals of negotiating transactions, providing information, achieving diversification, and attaining liquidity. Commercial banks are the most relevant financial institutions in Nigeria for encouraging and mobilizing savings and for channeling savings into productive investment units. These institutions are regulated by the Central Bank of Nigeria (CBN), the Federal Ministry of Finance, the Nigeria Deposit Insurance Corporation (NDIC), the Securities and Exchange Commission (SEC), the National Insurance Commission (NIC), and the Federal Mortgage Bank of Nigeria (FMBN).

According to Simon-Oke and Jegede (2012), microfinance banks provide a financial support system, especially at local levels, to reduce poverty, stimulate economic growth, support human development, and

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empower women. As William (2016) argues, the Nigerian banking industry has undergone serious reforms that have led to consolidation and phenomenal growth, especially over the last decade. For instance, e-banking and mobile banking have improved the banking industry's services and enabled businesses and other organizations to obtain loans and invest to finance specific projects or meet other needs. Due to advances in information and communication technologies in electronic banking, the financial sector is becoming more flexible and experiencing rapid changes in meeting customer needs more virtually. According to Worku et al. (2016), the adoption of Automatic Teller Machines (ATMs) has revolutionized the operations of financial institutions worldwide. However, this effect is more pronounced and developed in advanced countries due to advances in information and communication technology.

As revealed by Ayeni (2006) and Eze (2010), digitized mapping of financial institutions provides practical and analytical ways to understand the spatial distribution and locational patterns, identify new bank locations, support asset monitoring and management, and inform other spatial support systems through thematic maps. Spatial technologies, particularly Geographic Information Systems (GIS), can be used in the banking sector to locate new branches and support the institution's continuous operations. GIS is a veritable tool for vital decision-making in bank location management, provided it is built on a well-designed database (Schneider, 2009). Against this backdrop, the study seeks to demonstrate the applications of GIS for digitized mapping of the spatial distribution of financial institutions, determine the locational patterns of financial institutions, identify factors influencing the choice of locations for financial institutions, and examine other spatial decision-support systems associated with GIS applications.

This paper analyzes the spatial distribution of financial institutions in Kaduna Metropolis. The objectives of the paper are to identify the locations of financial institutions in Kaduna Metropolis and determine the pattern of their spatial distribution. This paper is significant because it highlights the practical application of geospatial technologies in mapping and analyzing the spatial distribution and locational patterns of financial institutions within Kaduna Metropolis. By employing Geographic Information Systems (GIS) and Global Positioning System (GPS) tools, the study establishes a robust methodological framework for spatial data acquisition, visualization, and analysis, which is essential for effective spatial decision-support systems and database management in financial institutions, thereby supporting effective planning. This would make it easier to locate financial institutions in Kaduna Metropolis and improve accessibility for customers and the general public in meeting their various financial needs.

2 Materials and Methods

2.1 Study Area

Kaduna Metropolis is located in north-west Nigeria and serves as the capital of Kaduna State. Kaduna metropolis has four local governments, namely Kaduna North and Kaduna South, with some adjoining of Chikun and Igabi Local Government Areas (Ajayi, 2015). It lies between latitudes 10°20'N and 10°37'N and longitudes 7°17'E and 7°30'E (Figure 1). The metropolis is strategically situated along the Kaduna River, making it a historically significant transport and trade corridor in northern Nigeria (Adamu, 2020). Kaduna experiences a tropical continental climate, characterized by a distinct wet and dry season. The rainy season typically runs from April to October, with annual rainfall of 1,200-1,500 mm, while the dry season spans from November to March. Average temperatures range from 15°C to 36°C, with the hottest months around March and April. The Harmattan wind, laden with dust from the Sahara, is prominent during the dry season.

Kaduna's relief is shaped by erosion and chemical weathering, especially in Kaduna South, resulting in high undulating plains and reduced interfluves, with a generally undulating topography ranging from 600 to 900 meters above sea level. The Kaduna River, originating from the Jos Plateau and flowing through the city, along with seasonal streams and wetlands, governs surface drainage and influences settlement and infrastructure development. The river, with tributaries like the Galma and Romi, fluctuates seasonally and provides water for irrigation, industry, and domestic use. Kaduna is one of Nigeria's fastest-growing urban centers, with a population that surged from over 1.5 million in 2006 to an estimated 2.5 million due to rapid urbanization, driven by its status as an administrative, military, educational, and industrial hub. This growth has led to extensive urban sprawl, often unplanned and informal, amid inadequate planning and weak development controls.

Kaduna serves as an important commercial, administrative, and industrial hub in northern Nigeria. It hosts several public institutions, private businesses, and industrial establishments, including textile industries, petrochemical plants, and the Nigerian Railway Corporation. The financial sector is well represented, with numerous commercial, microfinance, and development banks serving individuals and businesses. Informal economic activities such as trading, artisan work, and transport services also thrive across the metropolis, especially in areas like Central Market, Tudun Wada, and Sabo (Okosun, 2018; Bello & Bako, 2020). These are some of the varied socio-economic and commercial activities that require different financial services.

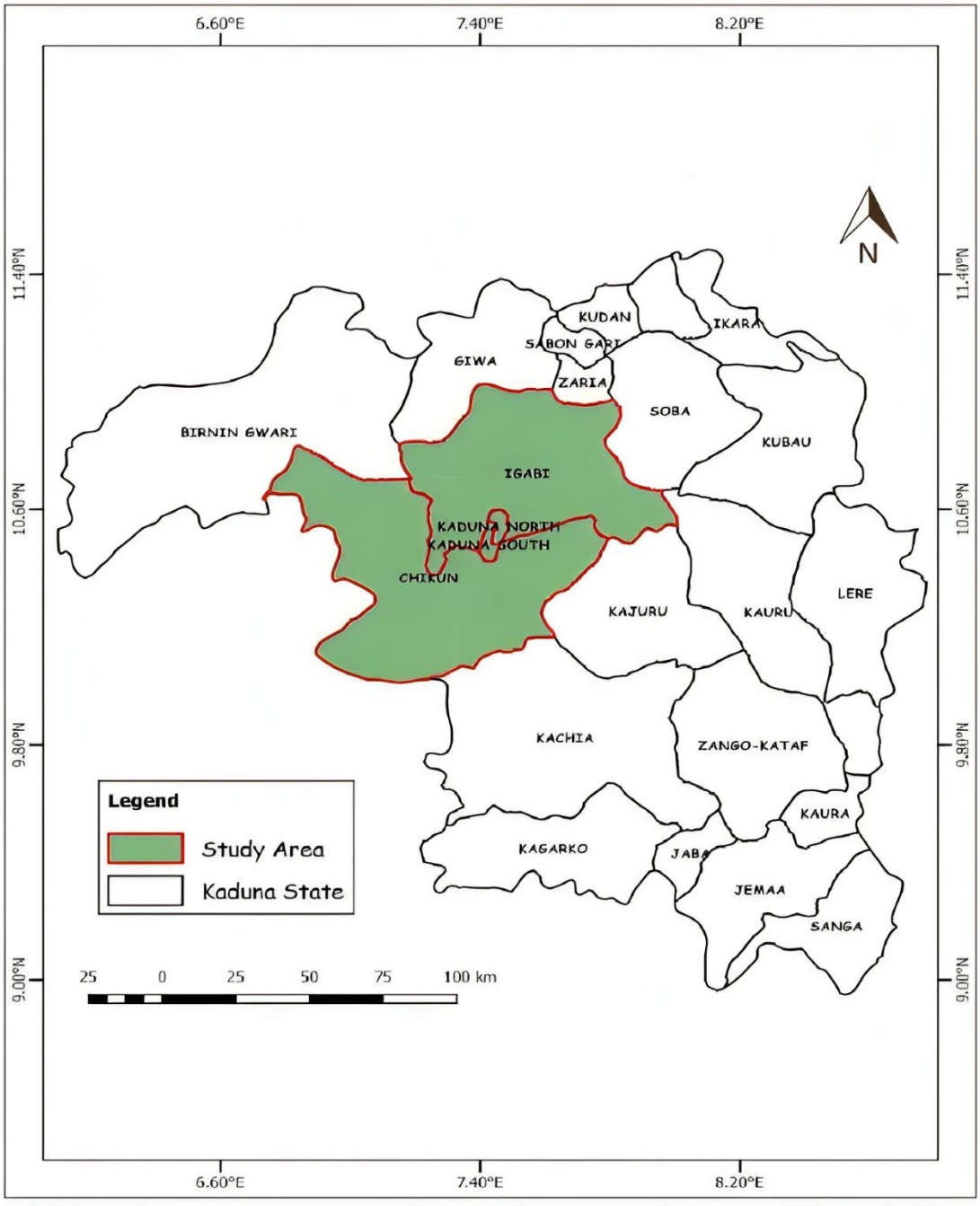

Figure 1: Kaduna State, showing the Study Area
Source: Kaduna Geographic Service, 2024

There are several markets in Kaduna state; some examples include Agwan Dosa Market, Kaduna Central Market, Kakuri Market, Kasua Gold Market, Kasuwan Barci, Kasuwan Kwari, Panteka Market, Sabon Gari Zaria Main Market, Sabon Tasha Market, and Station Market. These markets play a vital role in society, and the financial institutions are ever ready to provide their services and branches within these commercial areas of the metropolis. Some of these markets are known for specific goods. Kasuwar Monday is a business place in Kaduna that serves as a major trade hub for foodstuffs and other goods (MetaStarng, 2017).

2.2 Reconnaissance survey

A preliminary field study was conducted in the study area. This helped identify the locations of financial institutions and obtain their geographic coordinates in the study area. A handheld Global Positioning System (GPS) was used to obtain the geographic coordinates of the identified financial institutions in the study area. The reconnaissance survey also helped identify prevailing land uses, such as commercial areas, markets, financial institutions, primary, secondary, and tertiary educational land uses, linear road networks, residential areas, and other socio-economic activities that increased the influx of people into public places.

2.3 Data sources

A field survey was conducted in Kaduna Metropolis to collect the geographical coordinates of financial institutions using a handheld GPS receiver, while secondary data were obtained from the official list of registered financial institutions in the area. Additionally, the study utilized administrative and land-use maps sourced from the Kaduna Geographic Information System (KADGIS). The research also involved a review of relevant literature from conference proceedings, journals, and other scholarly publications to support the analysis.

2.4 Spatial Analysis using Geographic Information Systems

The administrative and land use maps of the study area were scanned and imported into ArcGIS 10.3 for georeferencing. Geographic coordinates of financial institutions and attribute data on their incidence were collected from various sources. The data were then copied into Microsoft Excel and saved as a CSV (comma-delimited) file, which is recognized and accepted by the ArcCatalog extension of ArcGIS. The administrative boundary map of the study area was also scanned and imported into ArcGIS 10.3 for georeferencing.

Georeferencing enables a space or raster object that has not been tied to a geographic reference to be assigned to a coordinate reference system. This would thereby allow various independent Geographic Information System (GIS) datasets to be combined into an overlay of geographic information. Thus, the scanned map was georeferenced.

The georeferenced map was then digitized on-screen under the following themes:

- The Local government areas and the political wards as polygons; the ward boundaries as lines; the road network, rivers, rail tracks, vegetation, and the geographic coordinates of financial institutions as lines. The coordinates and addresses of financial institutions were copied to Microsoft Excel, saved as CSV (comma-delimited) format, and then imported into ArcGIS 10.3 using the Add XY Command in the Tools menu.
- The base map of the study area was overlaid on the georeferenced map showing the spatial distribution of financial institutions.
- Nearest Neighbour Analysis (NNA) was adopted to determine the locational pattern of financial institutions in the study area. NNA was used in ArcView GIS, in conjunction with a digitised map depicting the locations of financial institutions, to calculate the nearest neighbour index (Rn). The formula is stated as follows:

$$R_n = \frac{D_o}{D_e}$$

Where Rn= Nearest Neighbour Index, D_o = Observed mean distance, and De = Expected mean

In a pure random distribution of points, the expected distance (De) between each pair of points and its nearest neighbour is defined as

$$D_e = (0.5 \div \sqrt{\frac{n}{A}})$$

Density is defined as the number of points per unit area. The general rule for applying the method is based on the fact that the Nearest Neighbour statistic (Rn) has a value that ranges between zero (0) and 2.15. Thus, $0 < Rn < 2.15$. This is shown in Table 1.

Table 1: Nearest Neighbour Analysis value

R-value	Cluster Pattern Tendency
Rn=1	Implies that the distribution is random
Rn=0	Implies that the distribution is clustered
Rn=2.15	Implies that the distribution is regular

The data were presented through thematic maps.

3 Results and Discussion

3.1 Location and Spatial Distributional Pattern of Financial Institutions in Kaduna Metropolis

The study presents the locations of all financial institutions in the study area in Figure 3. The financial institutions included in this study are commercial banks, microfinance banks, and development banks. Using the nearest neighbor index, the study also shows that Rn = 0.400059, indicating a clustered distribution (Rn = 0), while the Z Score = -15.269540 (Figure 2). The Z-score was used to test whether the cluster occurred by chance at the 0.01 significance level. The result was significant. Thus, the distribution of financial institutions in the study area is clustered (Rn = 0). This result also shows that the Rn value of 0.400059 indicates clustering. Hence, the locational pattern of financial institutions in Kaduna metropolis is clustered. This shows that financial institutions are clustered in the Kaduna metropolis.

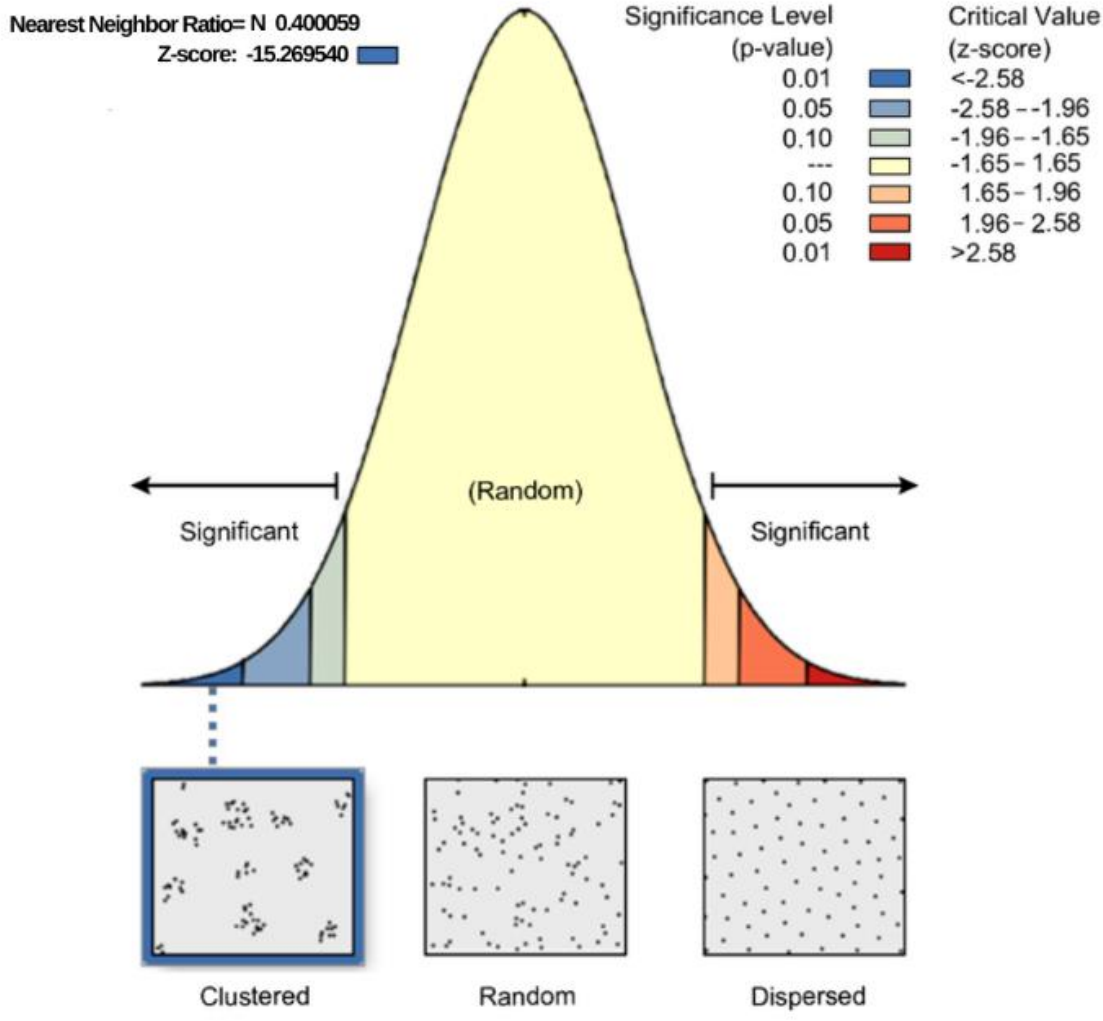

Figure 2: Nearest neighbour index analysis chart of Financial Institutions in Kaduna metropolis

The study agreed with Yazdani and Mijadi (2018) that financial institutions in Ardabil are clustered in the north and south. Monguno et al. (2015) also reported clustering of microfinance banks in the southwest geopolitical region, with the population-to-bank ratio lowest there and highest in the northeast. The study further revealed that at the state level, Lagos, Ogun, Anambra, and FCT had the heaviest concentration of microfinance banks, with ratios of 30,570 – 79,811 persons per bank, while Borno, Yobe, Kano, and Katsina had the least concentration, with ratios of 925,670 – 2,321,339 persons per bank. The study contrasts with Luca (2014), which found that banks are randomly distributed in Romania. In a survey of 10 large community banks in the United States, De Young and Duffy (2002) showed that most branches are concentrated in the Mid-South.

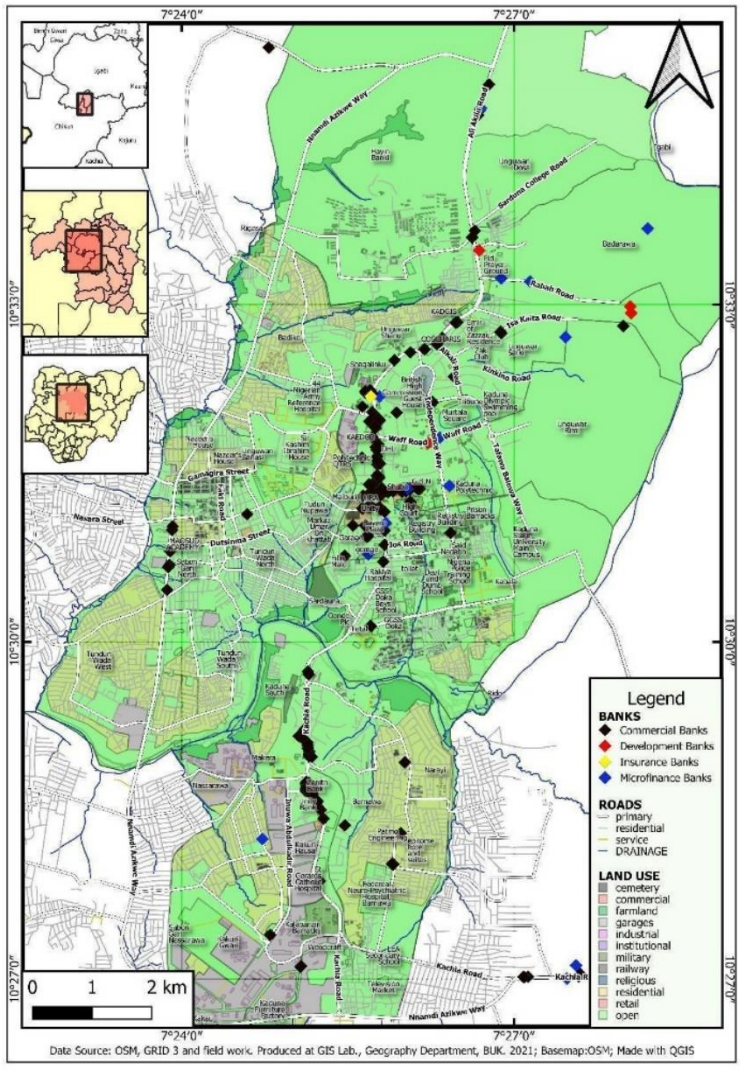

Figure 3: Location of all Financial Institutions in Kaduna metropolis

The paper further shows that commercial banks cluster along major roads and commercial centres, such as markets, and are less concentrated in the city's interior and residential areas/mixed land use. Their locations influence their patronage levels. This finding supports Abdullahi et al. (2011), who reported that about 96% of the total number of banks in Ilorin metropolis are concentrated in the Central Business District, which exhibited a very high degree of clustering (Rn = 0.59). Ifatimehin et al. (2008) revealed that banks clustered in areas with socio-economic potentials as exhibited in Central Business Districts. The findings disagreed with Ayadiuno et al. (2021), who reported a statistically significant difference in the distribution pattern and that banks are randomly distributed in Abaji town, Kogi State, with Rn = 1.75. This may be due to Abaji's smaller size compared to the Kaduna metropolis.

In the same vein, development banks are concentrated along major roads, commercial centers, and institutional buildings, with lower concentrations at the city center's outskirts. The level of service provided by development banks influences their patronage, which may be associated with the fact that they provide technical and high-order financial services. With advances in technology, most commercial bank activities can be done online, whereas, to a large extent, users of development banks may have to physically visit their offices due to the nature of the services they provide. Microfinance banks are concentrated along major roads and in residential areas. This is linked to the fact that microfinance banks serve households by providing soft loans to small-scale enterprises.

At the aggregate level, financial institutions cluster along major roads, commercial centers, educational centers, road intersections, gas stations, markets, shopping complexes, plazas, multiple-chain stores, institutional land uses, and other adjoining locations within the central business districts (CBDs) in the study area. These locations attract financial institutions to the study area. The influx of people within the central business district for various socio-economic and cultural activities increases the spatial distribution of financial institutions in the study area. These locations experience a higher spatial concentration of financial institutions in the

study area. The study supports the findings of Krugman (2004) and O' Sullivan (2007) that the location pattern of banks is not random, resulting from the interplay of locational factors that influence bank locations for easy accessibility.

3.2 Spatial Distribution of Commercial Banks in Kaduna Metropolis

The paper presents the spatial distribution of commercial banks in the study area, as shown in Figure 4. The study reveals that there are 75 commercial banks in the study area. They are spatially concentrated along the business districts, including Waff Road, Jos Road, Ugwan Shanu, Ahmadu Bello Way, Isa Kaita Road, Ali Akilu Road, High Court, British High Commission, Kaduna Polytechnic, Independence Way, Maiburuji, Tudu Nupawa, among others.

Other common urban land uses include commercial centers such as markets, shopping complexes, plazas, and multiple chain stores; educational centers and institutional land uses such as the High Court, the Registry building, Murtala Square, and Polytechnic Quarters, among others. These locations attract a concentration of commercial banks in the study area. The influx of people into the central business district for various socio-economic and cultural activities may increase the locational concentration of commercial banks in the study area. These areas have a higher spatial concentration of commercial banks in the study area.

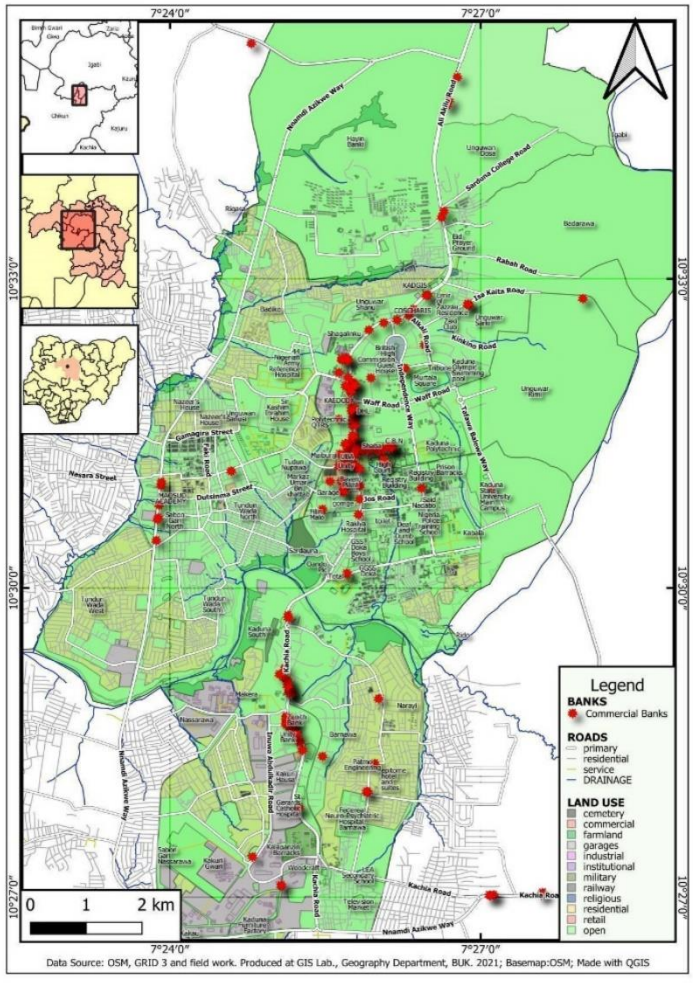

Figure 4: Spatial Distribution of Commercial Banks

There is a relatively low concentration of commercial banks in the interior parts of the central business district, such as Alkali Road, Isa Kaita Road, Eid Prayer Ground, Sardauna College, Narayi Road, Barnawa, Kachia Road, Kaduna Furniture Factory, Kakuri, Sabon Gari North, Maqsood Academy, and Faki Road, among others. The major land uses in these areas are residential, lower-order commercial activities, and other adjoining locations at the fringes or links to the city centers. The low population density, relatively low level of commercial activity, and slow population growth may contribute to a lower concentration of commercial banks in residential areas. The level of socio-economic and cultural activities at these locations is relatively low, which influences the slow pace of commercial activity. Limited accessibility from the peri-urban areas may also account for the lower concentration of commercial banks in these areas.

3.3 Spatial Distribution of Development Banks in Kaduna Metropolis

The study shows the spatial distribution of development banks in the study area, as presented in Figure 5. The

study reveals that there are six development banks, including three NACRDB (Nigerian Agricultural Cooperative and Rural Development Bank), one Bank of Industry, one National Bank for Community Development, and one Central Bank of Nigeria, Kaduna. They are spread along Waff Road, with two development banks located at Independence Way, the CBN office, the Eid prayer ground, and Rabah Road.

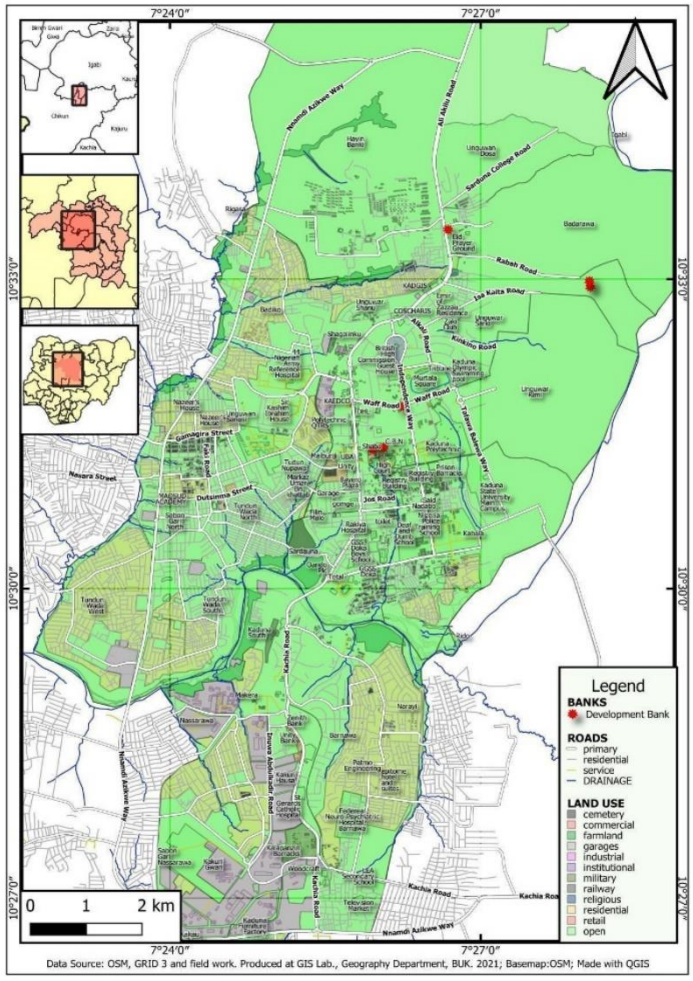

Figure 5: Spatial Distribution of Development Banks

Of the six development banks, three are located in the central business district along Jos Road, Independence Road, and Waff Road. The major land uses in these locations include major roads, commercial activities, and institutional buildings, such as the High Court and the Registry Building. In the same vein, the remaining three development banks are located at the outskirts of the CBD along Eid Prayer Ground and Rabah Road, among others. The low concentration of development banks in the study area may be associated with the nature of the professional and advisory services they provide. Given the limited competition in these services, their locations may not be influenced by the level of patronage, as they offer high-order services such as financial advisory, regulating financial institutions such as the Central Bank of Nigeria, and providing a large pool of funds for investors, such as the Bank of Industry, rather than the retail banking operations of commercial banks.

3.4 Spatial Distribution of Microfinance Banks in Kaduna Metropolis

The study presents findings on the locational distribution of Microfinance banks in the study area, as shown in Figure 6. The study reveals that the major Microfinance banks are Ante Investment Microfinance Bank, Kada Microfinance Bank, Trading Investment, Ribal Global Investment, Abokie Microfinance Bank, Fahimta Microfinance Bank, Lapo Microfinance Bank, Yelwa Microfinance Bank, NUT Microfinance Bank, and Bigthana Microfinance Bank, among others.

The study further reveals that there are 24 Microfinance banks spatially distributed across the central business district, including Waff Road, Bayero Plaza, Garage, British High Commission, Shaba, and Kaduna Polytechnic, among others. Other locations of Microfinance banks include Badarawa, Isa Kaita Road, and Rabah Road, among others. These types of banks are located along major roads and in some pockets of residential areas.

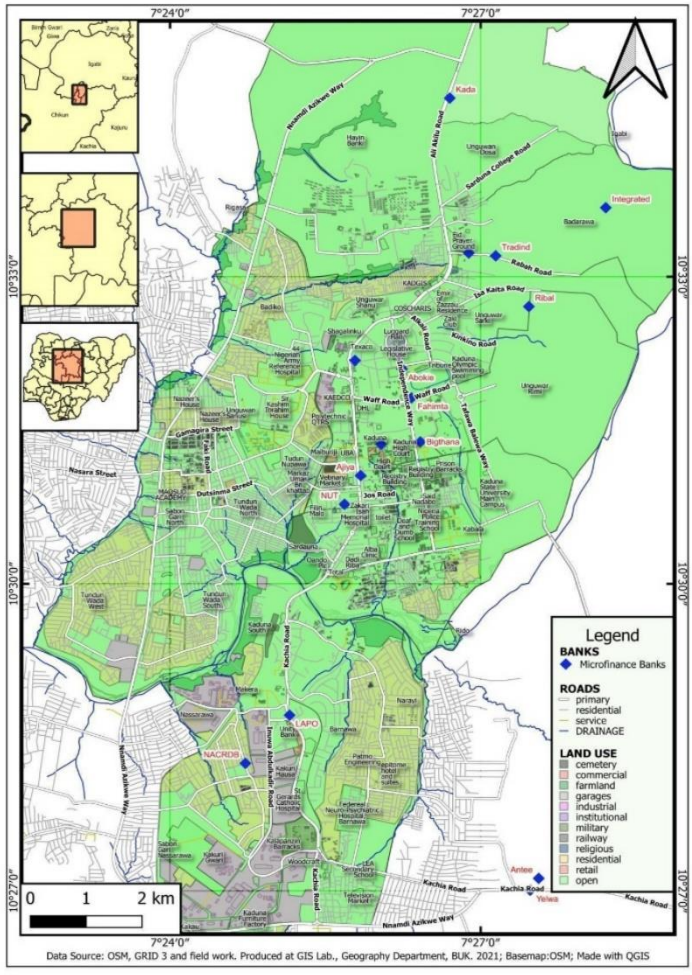

Figure 6: Spatial Distribution of Microfinance Banks

This may be because microfinance banks provide financial services, such as loans, especially to low-income households and other small-scale enterprises. Most small-scale enterprises are located along major roads and in residential areas. This finding supports the assertion by Keeton et al. (2009) that microfinance banks may be distinguished from other banks by two main characteristics they often exhibit. Apart from their relatively small capital outlay, these banks operate within the communities where they are located (Keeton et al., 2009).

According to Acha (2012), microfinance banks were established to make capital available to small-scale businesses through formal channels. This may influence the choice of locations where microfinance banks provide loans to needy households and other small-scale enterprises for start-ups or business expansion. Simon-Oke and Jegede (2012) revealed that microfinance banks provide a financial support system, especially at the local level, to reduce poverty, stimulate economic growth, support human development, and empower women.

4 Conclusion

Based on the findings, the spatial distribution of financial institutions in Kaduna Metropolis is predominantly clustered, with commercial banks, microfinance banks, development banks, and other financial entities primarily located along major roads, commercial centers, and socio-economic hubs such as markets, educational institutions, and government offices. This clustering pattern indicates that financial institutions strategically position themselves in areas with high accessibility, high population density, and significant economic activity to maximize patronage and operational efficiency.

Commercial banks are mainly concentrated in the central business districts, supporting retail and corporate banking activities, while microfinance banks are dispersed across residential neighborhoods to serve small-scale enterprises and low-income households. Development banks are fewer and tend to be situated along major roads and institutional areas, reflecting their specialized high-order financial services. The application of GIS and GPS technology effectively revealed these locational patterns, emphasizing the importance of spatial analysis in financial planning and urban development.

To improve financial inclusion in Kaduna Metropolis, it is essential to expand the physical presence of financial institutions in underserved areas. Specifically, establishing new branches and microfinance outlets in peri-urban and residential neighborhoods that have been identified

through GIS analysis as lacking sufficient banking facilities can significantly increase access to financial services. By targeting these areas, financial institutions can better serve populations that are currently marginalized or face difficulties reaching existing branches, thereby promoting inclusive economic growth.

In addition, leveraging GIS and spatial data should become a routine part of strategic planning for financial institutions. Regular analysis of geographic and demographic data can help identify emerging residential and commercial zones that are likely to benefit from new banking facilities. This proactive approach ensures that new branches are located in areas with high potential for growth and accessibility, optimizing resource allocation and maximizing the impact of expansion efforts. Using GIS for site selection also helps in planning for future development, ensuring that the financial infrastructure keeps pace with urban growth.

Furthermore, promoting digital banking solutions such as mobile and online platforms is crucial for reaching populations in less accessible areas. Digital banking reduces the need for physical branches in every community, making financial services more flexible and convenient for residents. Investing in robust digital infrastructure enables residents to perform transactions, access credit, and manage accounts remotely, which is particularly vital in areas where physical infrastructure development may be slow or costly. This approach not only broadens financial access but also aligns with modern banking trends, fostering greater financial literacy and inclusion across diverse socio-economic groups.

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