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GEOSPATIAL ANALYSIS OF TELECOMMUNICATION MASTS DISTRIBUTION IN ILORIN SOUTH, KWARA STATE, NIGERIA USING GIS TECHNIQUES

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Abstract

Effective management of telecommunication infrastructure is essential for the sustainable development of peri-urban and rapidly growing cities such as Ilorin metropolis, Nigeria. This study aims to map the distribution of telecommunication masts in Ilorin South Local Government Area using Geographic Information System (GIS) technology. Primary data were collected through field observations with handheld GPS devices to record mast locations, while secondary data were sourced from service providers and satellite imagery. The data were analyzed using ArcGIS and Microsoft Excel to visualize and assess the spatial distribution of masts. Findings reveal that 86 telecommunication masts are distributed across the study area, with the majority operated by major network providers such as MTN Nigeria, GLO, 9Mobile, and Airtel Nigeria. The analysis indicates a clustered pattern of mast distribution, with several instances of co-location where multiple providers share infrastructure. This clustering is likely influenced by population density, network demand, and regulatory considerations. The study underscores the value of GIS in supporting network planning, ensuring equitable infrastructure distribution, and addressing safety and environmental concerns related to mast siting. The insights gained are crucial for telecommunication companies and urban planners, facilitating informed decision-making for future mast deployment and promoting compliance with regulatory standards. This approach can be replicated in other fast-developing regions to enhance telecommunication infrastructure management and urban development.

Keywords - ***Telecommunication, Mast, GIS, Mapping, GPS***

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1.0 INTRODUCTION

Telecommunication infrastructure, particularly telecommunication masts, plays a pivotal role in the modern communication landscape by enabling wireless transmission of data, voice, and multimedia signals over vast distances. These masts, which support antennas and other transmission equipment, are fundamental to the operation of mobile networks and have become indispensable in facilitating socio-economic development worldwide [3]; [8]. As urban populations grow and digital connectivity becomes increasingly critical, the demand for efficient and well-managed telecommunication networks intensifies, especially in rapidly developing urban and peri-urban areas [15].

In Nigeria, the telecommunication sector has witnessed exponential growth over the past two decades, driven largely by the introduction and expansion of Global System for Mobile Communications (GSM) services. Since the early 2000s, service providers such as MTN, Airtel, GLO, and 9mobile have deployed thousands of telecommunication masts nationwide to meet the surging demand for mobile connectivity [12]. This expansion has been particularly pronounced in urban centers where population density and commercial activities necessitate robust network coverage. However, the rapid proliferation of masts has also raised concerns related to spatial planning, environmental safety, and equitable access to telecommunication services.
Despite the critical importance of telecommunication masts, there remains a significant knowledge gap regarding their spatial distribution and management in many Nigerian cities, particularly in peri-urban areas like Ilorin South Local Government Area (LGA), Kwara State. While major metropolitan areas such as Lagos, Abuja, and Port Harcourt have been the focus of numerous studies on telecommunication infrastructure [14], [13], smaller yet fast-growing cities have received comparatively less attention. This uneven research focus limits the understanding of telecommunication infrastructure dynamics in these regions, which are often characterized by rapid urbanization, informal settlements, and evolving land use patterns.

The swift expansion of mobile telecommunication masts, although significantly improving connectivity, presents challenges related to land use, including issues of space consumption, land acquisition, and ownership disputes [7]. The absence of comprehensive spatial data on telecommunication masts in peri-urban areas complicates network optimization, regulatory compliance, and infrastructure planning [2]. Moreover, poorly planned mast deployment can lead to environmental degradation, health concerns among residents, and inefficient use of resources [5]. Therefore, there is an urgent need for systematic mapping and spatial analysis of telecommunication masts to support sustainable infrastructure development and effective network management.

Geographic Information Systems (GIS) offer a powerful solution to these challenges by enabling the collection, visualization, and analysis of spatial data related to telecommunication infrastructure. GIS facilitates the integration of various data sources, including field surveys, satellite imagery, and service provider records, to create detailed maps and attribute databases of mast locations and characteristics [1]. Through spatial analysis techniques such as clustering,

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proximity, and network analysis, GIS can reveal patterns of mast distribution, identify coverage gaps, and support evidence-based decision-making for infrastructure planning and regulation. Recent studies have demonstrated the effectiveness of GIS in telecommunication mast mapping in Nigerian urban centers. For example, [14] used GIS to analyze mast distribution in Lagos State, highlighting spatial clustering and areas of high demand. Similarly, [13] applied remote sensing and GIS to assess mast deployment in Port Harcourt, providing insights into ownership patterns and spatial characteristics. However, these studies primarily focus on large cities with well-established infrastructure, leaving a research void in peri-urban and smaller urban centers where telecommunication infrastructure is rapidly evolving but less documented.

This study addresses this gap by focusing on Ilorin South LGA, a peri-urban area experiencing significant population growth and urban expansion. By employing GIS techniques to map telecommunication masts within this locality, the research aims to generate a comprehensive spatial database and conduct spatial pattern analysis. The objectives include identifying and mapping the spatial distribution and clustering of masts, analyzing the ownership and distribution patterns of telecommunication masts among different service providers, and assessing co-location practices among service providers. The outcomes will provide valuable insights for telecommunication companies, urban planners, and policymakers to optimize network coverage, enhance infrastructure management, and mitigate potential risks associated with mast deployment. This objective emphasizes the practical application of the study's findings, supporting informed decision-making for future mast deployment, promoting infrastructure sharing, and minimizing environmental impact.

The innovative aspect of this research is its examination of peri-urban settings in Nigeria, which is underrepresented in telecommunication infrastructure research, and its comprehensive use of GIS for spatial data integration and analysis. By bridging the data gap in Ilorin South LGA, this research contributes to a more nuanced understanding of telecommunication infrastructure dynamics beyond Nigeria's largest cities. Furthermore, it underscores the potential of GIS as a critical tool in supporting sustainable urban development and digital inclusion in emerging urban centers. As telecommunication infrastructure continues to expand in Nigeria, there is an imperative to adopt spatially informed approaches to infrastructure planning and management. This study's GIS-based mapping and analysis of telecommunication masts in Ilorin South LGA provide a timely and necessary contribution to this effort, offering a replicable model for other peri-urban areas facing similar challenges.

2.0 THE STUDY AREA

The research was conducted in Ilorin South Local Government Area (LGA), Kwara State, Nigeria, a peri-urban area experiencing rapid urbanization and increased deployment of telecommunication infrastructure. Ilorin South LGA is one of the local government areas in Kwara State, North Central of Nigeria, and it is in the Kwara Central Senatorial Zone. It is geographically defined by latitude 80°26'29.6"N and Longitude 40°40'46.6"E, relative to the Greenwich meridian, and has a total landmass of approximately 174 km², with its administrative headquarters located in Fufu. The total

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population of the Ilorin South Local Government Area is 282,500, according to the National Population Census, 2016. Ilorin South Local Government Area is subdivided into eleven (11) electoral wards. The wards are Akanbi I, Akanbi II, Akanbi III, Akanbi IV, Akanbi V, Balogun-Fulani II. Balogun-fulani III, Balogun-fulani I, Okaka I, Okaka II, Oke-ogun. Oke-ogun.

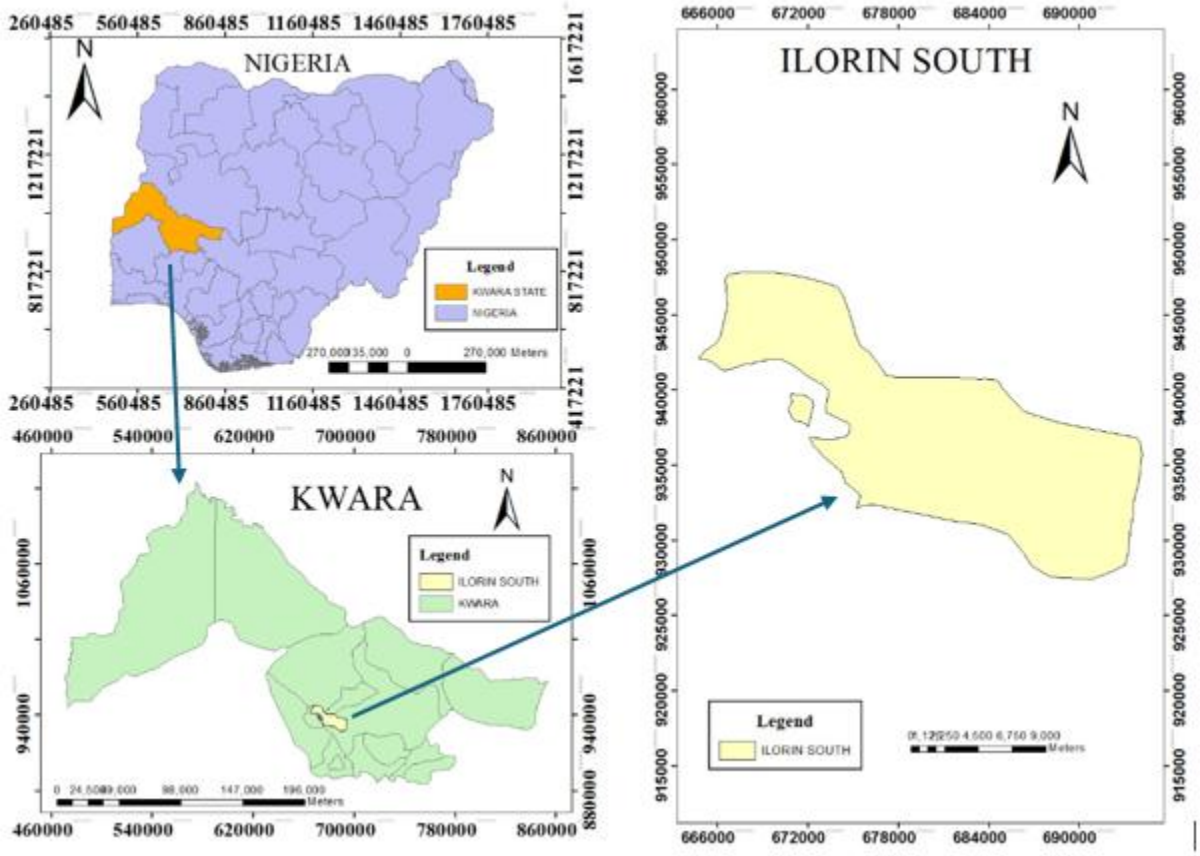

Figure 1: The Study area map

3.0 MATERIALS AND METHODS

3.1 Data Acquisition

The data acquisition phase was designed to ensure high spatial and attribute accuracy for mapping telecommunication masts in Ilorin South Local Government Area.

3.2 Primary Data Collection

3.21 Field Survey with Handheld GPS

Primary spatial data were collected through extensive field surveys using a Garmin handheld GPS device, which provides a typical horizontal accuracy of ±3 meters under open-sky conditions [6].

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This device was used to record the precise latitude and longitude coordinates (WGS84 Datum) of each GSM base station, ensuring reliable geolocation for subsequent analysis.

To complement the field data, Google Earth satellite imagery was sourced for spatial visualization of the study area locations and surrounding land use.
Secondary attribute data, including mast address, height, Cell ID, type of fence, operational status, and provider name, were obtained from telecommunication service providers and corroborated through direct field observation. All attribute information was systematically recorded and cross-checked to ensure completeness and accuracy.

3.3 Secondary Data Collection

3.31 Satellite Imagery

Google Earth satellite imagery (30cm spatial resolution) was sourced from Maxar Technologies' WorldView-3 satellite [11], which is suitable for urban infrastructure mapping due to its ability to resolve small features such as mast footprints and fencing [10].

3.32 Service Provider Records

Mast attribute data, including site IDs, technical specifications, and ownership, were obtained from the major network providers (MTN, GLO, 9Mobile, Airtel, Multilinks, GOTV) and cross-validated with field observations.

3.4 Data Processing and Analysis

Data processing and spatial analysis were conducted using ArcGIS software and Microsoft Excel, following a structured workflow as highlighted in the subsequent sub-sections:

3.4.1 Image Preprocessing and Geo-referencing

• Geo-referencing

The acquired satellite imagery was geo-referenced using established ground control points collected during the GPS survey. The imagery was registered to the Universal Transverse Mercator (UTM) coordinate system, Zone 31 North, based on the Minna Datum, ensuring spatial consistency across all datasets [4].

• Vector Data Creation (Digitizing)

Geo-referenced imagery was digitized in ArcGIS to produce vector shapefiles representing mast locations and relevant infrastructure. This step transformed raster data into vector feature layers, facilitating advanced spatial queries and map production.

• Geospatial and Attribute Database Development

A comprehensive geodatabase was created to store both spatial and non-spatial information. Attribute tables were constructed in Microsoft Excel with fields for provider name, site/cell ID, X and Y coordinates, mast height, address, fence type, and functionality status. These tables were then imported into ArcGIS and linked to the spatial data for integrated analysis.

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3.4.2 Data Analysis

Spatial Analysis Tools and Rationale

Several GIS operations were employed to analyze mast distribution and inform planning.

Spatial Join: It was used to associate mast locations with administrative boundaries and demographic data, enabling analysis of coverage to population density.
Buffering: It was applied to create zones around each mast to assess compliance with setback regulations and identify potential safety or environmental risks.
Density Mapping (Kernel Density Estimation): This was generated to visualize and quantify areas of high mast concentration, supporting the identification of clustering patterns and service gaps.
Nearest Neighbour Analysis: Nearest Neighbour Analysis (NNA) spatial statistical technique, was used to evaluate the distribution pattern of points within the study area by measuring the average distance between each point and its closest neighbor. This observed average distance is then compared to the expected average distance under a random spatial distribution to determine whether the points are clustered, randomly distributed, or uniformly spaced. A ratio less than 1 indicates clustering, around 1 suggests randomness, and greater than 1 implies a regular or uniform pattern.
Query and Selection Tools: This was utilized to extract specific subsets of data, such as by provider, mast status, or co-location, for analysis and reporting.

These GIS operations were chosen to provide a comprehensive understanding of mast distribution, ensure regulatory compliance, and support strategic network planning. The integration of spatial and attribute data enabled the production of detailed maps and actionable insights for telecommunication infrastructure management in Ilorin South LGA.

3.5 Map Production

Thematic maps showing mast locations, provider distribution, buffer zones, and density surfaces were produced in ArcGIS Pro. These maps will support both visual interpretation and decision-making by stakeholders.

4.0 RESULTS AND DISCUSSION

4.1 Distribution of Telecommunication Masts in the Study Area

A total of 86 telecommunication masts are distributed across the wards within the study area. Table 1 provides a detailed breakdown of mast ownership by service provider, while Figure 2 presents this data in a pie chart for visual clarity. Analysis of the data reveals that MTN holds the largest market share, accounting for 35% of all masts. GLO follows with 29%, while ETISALAT and AIRTEL represent 11% and 7% respectively. MULTI LINKS and GOTV have smaller shares, with

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2% and 1% each. The remaining 15% of masts are shared among various other telecommunications providers.

Table 1: Telecommunication Service Providers and their mast number in Ilorin South LGA.

Telecommunication Service Provider And Its Masts		
S/NO	**PROVIDERS**	**NUMBER OF MAST**
1.	MTN	30
2.	GLO	25
3.	ETISALAT	9
4.	AIRTEL	7
5.	MULTILINKS	2
6.	GOTV	1
7.	CO-LOCATION	12
	TOTAL	**86**

Source: Field Survey (Researcher)

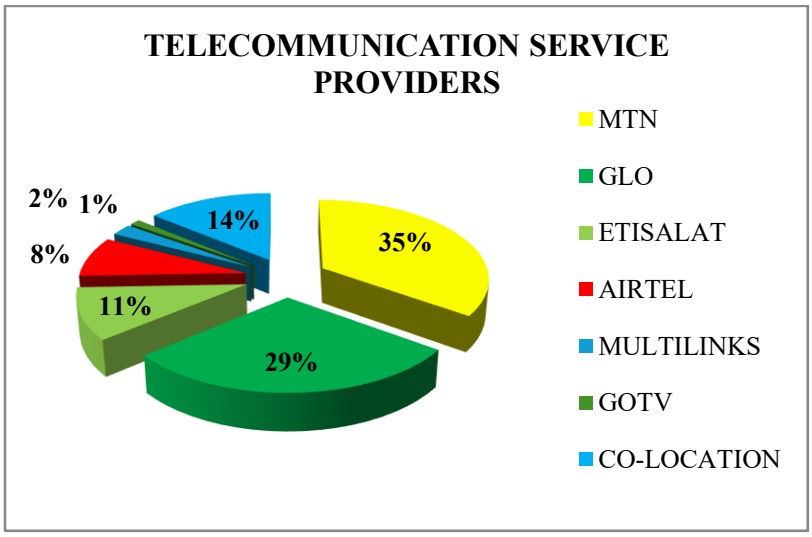

Figure 2: Pie chart of the Telecommunication service providers in the Ilorin South Local Government area

This distribution highlights MTN's dominant presence in the local government area, which is consistent with broader trends in Nigeria's telecommunications sector, where MTN has maintained a leading position in terms of infrastructure and subscriber base. The significant share held by GLO further underscores its role as a key competitor. The presence of multiple providers, including

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those with smaller shares, suggests a competitive environment that may foster improved service quality and coverage for end users.

The implications of these findings are noteworthy. Areas with a higher concentration of masts from leading providers like MTN and GLO are likely to experience better network coverage and service reliability. Conversely, wards with limited mast presence or dominated by providers with smaller market shares may face challenges related to connectivity and service quality. The 15% of masts co-provided by various operators indicates ongoing infrastructure sharing, which can enhance efficiency and reduce environmental impact, a trend increasingly encouraged by regulatory authorities in Nigeria to optimize resource utilization and minimize duplication of infrastructure.

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Table 2: Attribute Data of the Telecommunication Masts in the Study Area

MTN TELECOMMUNICATIONS MAST IN ILORIN SOUTH LOCAL GOVERNMENT AREA								
S/N	**NETWORK PROVIDER**	**SITE ID**	**EASTING**	**NORTHING**	**HEIGHT**	**TYPE OF FENCE**	**ADDRESS**	**REMARK**
1	MTN	MTNKW4733	684215	938089	40m	STEEL FENCE	OPPOSITE FACULTY OF ARTS, UNIVERSITY OF ILORIN	WORKING
2	MTN	KW4722	683899	937987	35m	BLOCKWALL	AROUND UNILORIN CLINICAL CENTER	WORKING
3	MTN	KW4713	684194	938092	35m	STEEL FENCE	OPPOSITE FACULTY OF ARTS, UNIVERSITY OF ILORIN	NOT WORKING
4	MTN	T310	684601	937598	25m	STEEL FENCE	AROUND BANK AREA, UNIVERSITY OF ILORIN	WORKING
5	MTN	KW005	680908	936188	45m	STEEL FENCE	STAFF QUARTERS, UNIVERSITY OF ILORIN	WORKING
6	MTN	KW2340	679574	937583	65m	BLOCKWALL	AT ROYAL FM STATION, TANKE, OKE-ODO	WORKING
7	MTN	T3154	677684	937788	35m	BLOCKWALL	ILESANMI STREET, TANKE	NOT WORKING
8	MTN	T3150	677431	938754	35m	STEEL FENCE	F-DIVISION	WORKING
9	MTN	KW6404	677235	939033	35m	STEEL FENCE	BEHIND F-DIVISION	WORKING
10	MTN	KW6414	676551	938372	35m	BLOCKWALL	AKOREDE STREET	NOT WORKING
11	MTN	T3141	675347	936717	35m	STEEL FENCE	BESIDE G-PINNACLE HOTEL	WORKING
12	MTN	KW013	675204	936322	35m	BLOCKWALL	PIPELINE ROAD	WORKING
13	MTN	T3155	676524	935543	35m	STEEL FENCE	AGBO DANLALU, GAA-AKANBI	WORKING
14	MTN	IHS KWA1009B	677326	935766	35m	STEEL FENCE	OKE-OGUN	WORKING
15	MTN	KW2314	677696	934508	35m	STEEL FENCE	OPPOSITE INTERNATIONAL ARTS & SCIENCE ACADEMY, AGBABIAKA	WORKING
16	MTN	KW2215	674369	935979	35m	BLOCKWALL	GAA-AKANBI	WORKING
17	MTN	T3160	673812	935059	40m	BLOCKWALL	OPPOSITE PRINCESS HONEY AND MAGIC PAINTS, OFFA GARAGE	NOT WORKING
18	MTN	IHS ILO-015V	674955	933551	40m	BLOCKWALL	ITA ALAMU	WORKING
19	MTN	KW2317	674751	934634	35m	BLOCKWALL	ITA ALAMU	WORKING
20	MTN	T3168	676112	938912	35m	BLOCKWALL	AROUND ECWA FATE TANKE	WORKING
21	MTN	KW6422	675786	940464	35m	STEEL FENCE	OMOTAYO STREET, BASIN	WORKING
22	MTN	KW3368	674879	939243	35m	BLOCKWALL	G.R.A	WORKING
23	MTN	T3100	674867	939206	35m	BLOCKWALL	AROUND E-PHOENIX HOTEL, G.R.A	NOT WORKING
24	MTN	T3102	673516	938032	40m	STEEL FENCE	WITHIN KWARA HOTEL	WORKING

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25	MTN	KW015	672957	938003	40m	BLOCKWALL	WITHIN ST. JOSEPH NURSERY AND PRIMARY SCHOOL, OFFA ROAD	WORKING
26	MTN	KW003	672735	937904	40m	BLOCKWALL	WITHIN POLICE STATION HEADQUARTERS, AHMADU BELLO WAY	WORKING
27	MTN	KW2329	673051	939056	40m	BLOCKWALL	ALALUBOSA	WORKING
28	MTN	KW4761	671679	939512	30m	STEEL FENCE	ISALE KOKO	NOT WORKING
29	MTN	IHS KWA09390	674827	938536	45m	STEEL FENCE	AFTER FOREST INN HOTEL, G.R.A	WORKING
30	MTN	IHS KWA1008	676940	937323	35m	STEEL FENCE	VARSITY AVENUE, TANKE	WORKING

AIRTEL COMMUNICATION MAST IN ILORIN SOUTH LOCAL GOVERNMENT AREA

S/NO	NETWORK PROVIDER	CELL ID	EASTING	NORTHING	HEIGHT	TYPE OF FENCE	ADDRESS	REMARK
1	AIRTEL	402664	683834	937267	55m	STEEL FENCE	OPPOSITE UNILORIN STADIUM	NOT WORKING
2	AIRTEL	402666	680901	936155	40m	STEEL FENCE	STAFF QUARTERS, UNIVERSITY OF ILORIN	NOT WORKING
3	AIRTEL	402675	675344	935930	50m	STEEL FENCE	OPPOSITE RCCG LIVING SEED PARISH, GAA-AKANBI	WORKING
4	AIRTEL	402667	674283	935884	35m	STEEL FENCE	GAA-AKANBI ROUNDABOUT	NOT WORKING
5	AIRTEL	402662	674466	934030	50m	STEEL FENCE	ITA ALAMU	WORKING
6	AIRTEL	KW0025	674600	939313	40m	BLOCKWALL	G.R.A	WORKING
7	AIRTEL	402741	673052	939069	40m	STEEL FENCE	ALALUBOSA	WORKING

ETISALAT TELECOMMUNICATION MAST IN ILORIN SOUTH LOCAL GOVERNMENT AREA

S/NO	NETWORK PROVIDER	CELL ID	EASTING	NORTHING	HEIGHT	TYPE OF FENCE	ADDRESS	REMARK
1	ETISALAT	B4765	684023	938104	35m	BLOCKWALL	OPPOSITE FACULTY OF LAW, UNIVERSITY OF ILORIN	NOT WORKING
2	ETISALAT	B4760	683853	937193	40m	BLOCKWALL	OPPOSITE UNILORIN STADIUM	WORKING
3	ETISALAT	B4735	676684	938068	35m	STEEL FENCE	ALANGUA STREET	WORKING
4	ETISALAT	B4757	673445	934944	35m	STEEL FENCE	OFFA GARAGE	WORKING
5	ETISALAT	B4731	674736	933777	35m	STEEL FENCE	ITA ALAMU	WORKING
6	ETISALAT	B4705	675709	938595	40m	BLOCKWALL	OPPOSITE AKOREM BUILDERS, OLUWATOYIN STREET	WORKING
7	ETISALAT	B4709	675377	941213	35m	STEEL FENCE	BEHIND BASIN HILL, BASIN	WORKING
8	ETISALAT	KW008	672411	938289	40m	BLOCKWALL	WITHIN KWARA STATE LIBRARY	WORKING
9	ETISALAT	B4727	673215	938478	35m	STEEL FENCE	SABO-OKE	WORKING

GLO TELECOMMUNICATION MAST IN ILORIN SOUTH LOCAL GOVERNMENT AREA

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S/NO	NETWORK PROVIDER	CELL ID	EASTING	NORTHING	HEIGHT	TYPE OF FENCE	ADDRESS	REMARK
1	GLO	IHS ILO010	684168	938110	35m	BLOCKWALL	OPPOSITE FACULTY OF ARTS, UNIVERSITYOF ILORIN	WORKING
2	GLO	IHS ILO086	684609	937593	35m	STEEL FENCE	AROUND BANK AREA, UNIVERSITY OF ILORIN	WORKING
3	GLO	IHS ILO063	681628	935934	40m	STEEL FENCE	STAFF QUARTERS, UNIVERSITY OF ILORIN	WORKING
4	GLO	IHS ILO065	680855	936432	35m	STEEL FENCE	STAFF QUARTERS, UNIVERSITY OF ILORIN	WORKING
5	GLO	IHS ILO070	679339	937449	35m	BLOCKWALL	JALALA ROUTE, OKE-ODO	WORKING
6	GLO	IHS ILO074	679207	938457	35m	STEEL FENCE	BEHIND BEKADIMS, TANKE OKEODO	WORKING
7	GLO	IHS ILO024	676737	938343	35m	BLOCKWALL	MOGAJI STREET	WORKING
8	GLO	IHS ILO043	676864	938027	35m	BLOCKWALL	BEHIND AHMADIYAH MOSQUE	NOT WORKING
9	GLO	IHS ILO008	674987	936187	45m	BLOCKWALL	PIPELINE ROAD	WORKING
10	GLO	IHS ILO048	676541	935563	35m	BLOCKWALL	DANLALU-AGBO	WORKING
11	GLO	IHS ILO044	677463	935511	35m	BLOCKWALL	GAA-AKANBI	WORKING
12	GLO	IHS ILO071	677463	935511	35m	BLOCKWALL	OKE-OGUN	WORKING
13	GLO	IHS KWA-0926C	677781	935337	35m	STEEL FENCE	AGBABIAKA	WORKING
14	GLO	IHS ILO032	674061	935462	35m	BLOCKWALL	AROUND HOLY GHOST CENTER, OFFA GARAGE	WORKING
15	GLO	IHS ILO029	674159	934828	36m	BLOCKWALL	WITHIN OFFA GARAGE PARK	WORKING
16	GLO	IHS ILO007	674812	933521	50m	STEEL FENCE	WITHIN GLO TECHNICAL OFFICE, ITA ALAMU	WORKING
17	GLO	IHS ILO005	675600	940762	35m	STEEL FENCE	BASIN	WORKING
18	GLO	IHS ILO001	675447	939332	35m	BLOCKWALL	WITHIN CONOIL FILLING STATION, FATE ROUNDABOUT	NOT WORKING
19	GLO	IHS ILO009	673617	937709	50m	BLOCKWALL	OPPOSITE KWARA HOTEL, ILORIN CLUB	WORKING
20	GLO	IHS ILO053	673109	939246	40m	BLOCKWALL	ALALUBOSA	WORKING
21	GLO	IHS ILO056	671584	939139	35m	BLOCKWALL	ISALE KOKO AROUND AMILEGBE	WORKING
22	GLO	IHS ILO040	672201	939996	40m	STEEL FENCE	ADURALERE	WORKING
23	GLO	IHS ILO045	672675	938510	35m	STEEL FENCE	ORO-AGO CLOSE, SABOOKE	WORKING
24	GLO	IHS ILO031	675896	937725	40m	BLOCKWALL	IYERU OKIN CLOSE	WORKING
25	GLO	IHS ILO046	677800	937385	35m	STEEL FENCE	BEFORE ITEM7, SANRAB, TANKE	WORKING

GOTV MAST IN ILORIN SOUTH LOCAL GOVERNMENT AREA

S/NO	NETWORK PROVIDER	CELL ID	EASTING	NORTHING	HEIGHT	TYPE OF FENCE	ADDRESS	REMARK

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1	GOTV	NULL	675663	939616	50m	STEEL FENCE	OPPOSITE ADENIYI STORE, BASIN ROAD	WORKING

MULTILINKS TELECOMMUNICATIONS MAST IN ILORIN SOUTH LOCAL GOVERNMENT AREA

S/NO	NETWORK PROVIDER	CELL ID	EASTING	NORTHING	HEIGHT	TYPE OF FENCE	ADDRESS	REMARK
1	MULTILINKS	NULL	676080	937925	35m	BLOCKWALL	TIPPER GARAGE	NOT WORKING
2	MULTILINKS	NULL	676039	939771	35m	BLOCKWALL	OJOMU BASIN	NOT WORKING

CO-LOCATION MASTS IN ILORIN SOUTH LOCAL GOVERNMENT AREA

S/NO	NETWORK PROVIDER	CELL ID	EASTING	NORTHING	HEIGHT	TYPE OF FENCE	ADDRESS	REMARK
1	MTN AND GLO	MTNKW4739, IHS ILOO066	684369	938677	35m	STEEL FENCE	BESIDE FACULTY OD CIS, UNIVERITY OF ILORIN	WORKING
2	MTN AND GLO	MTNKW4734, IHS ILOO064	683425	937745	55m	STEEL FENCE	BEHIND UNILORIN BUSINESS SCHOOL	WORKING
3	MTN AND GLO	KW0461 IHS ILO044	677589	937188	35m	STEEL FENCE	AGBOOLA STREET	WORKING
4	AIRTEL AND MTN	402655, KW013	677147	938220	35m	STEEL FENCE	FOLUKE BELLO STREET	WORKING
5	MTN AND AIRTEL	KW2342, KW0411	676526	937497	35m	STEEL FENCE	KATOLA STREET	WORKING
6	MTN AND ETISALAT	T3171, B4711	675694	940447	35m	BLOCKWALL	BEHIND RCCG, SANCTUARY OF PRAISE, BASIN	WORKING
7	AIRTEL AND GLO	402657, IHS ILO003	673735	937773	40m	STEEL FENCE	OPPOSITE ILORIN CLUB	WORKING
8	MTN AND ETISALAT	T3140, B4713	672310	939404	50m	STEEL FENCE	AMILEGBE	WORKING
9	AIRTEL AND GLO	402668, IHS ILO050	672223	939814	40m	STEEL FENCE	ADURALERE	WORKING
10	GLO AND MTN	IHS ILO033, KW4613	671893	938965	40m	STEEL FENCE	BALOGUN FULANI WARD III	NOT WORKING
11	GLO AND MTN	IHS KW1006B, KW6710	674064	938523	40m	BLOCKWALL	OPPOSITE FLOWER GARDEN	WORKING
12	ETISALAT AND MTN	B5896, KW4708	675800	937815	40m	STEEL FENCE	BEHIND CLASSIC GUEST INN, DAVID OYINLOYE CRESCENT	WORKING

Source: Field Survey (Researcher)

4.2 Geospatial Analysis of Telecommunication Masts

The data covering network provider, cell ID, easting and northing coordinates, mast height, fence type, address, and operational status are comprehensively detailed in Table 2. The spatial distribution of individual telecommunication masts is visually represented in Figures 3a, 3b, 3c, 3d, 3f, and 3g, each illustrating the location patterns of masts for specific providers or categories. Additionally, Figure 4 presents a composite map that integrates the spatial distribution of all masts across the various networks within the study area. This organized presentation aids in understanding both individual and collective mast placements, supporting thorough geospatial and network coverage analyses.

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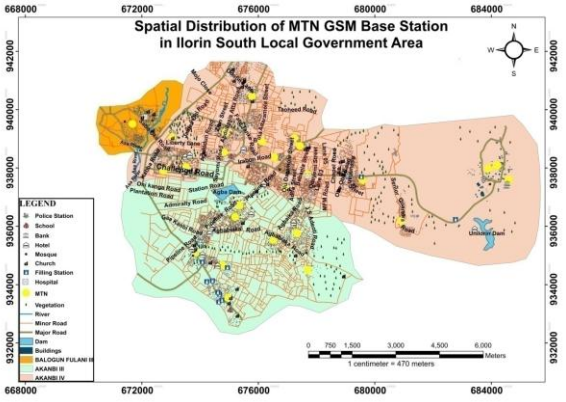
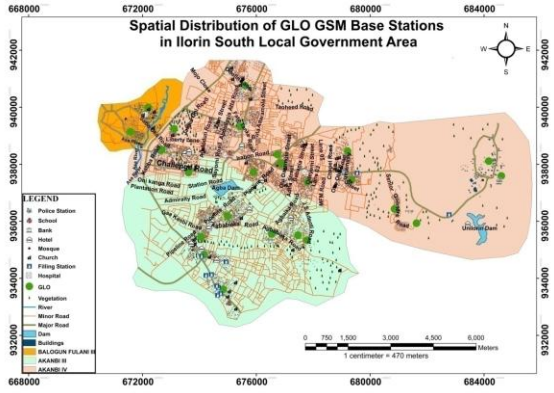
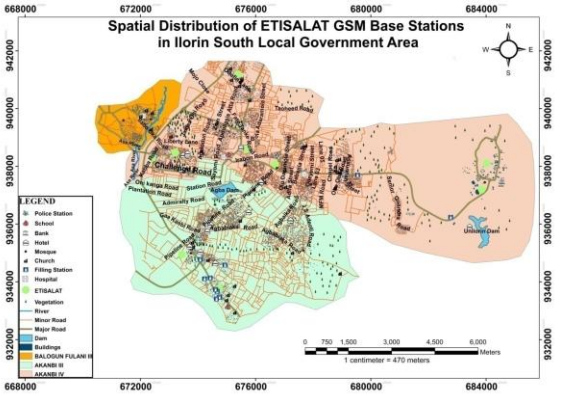
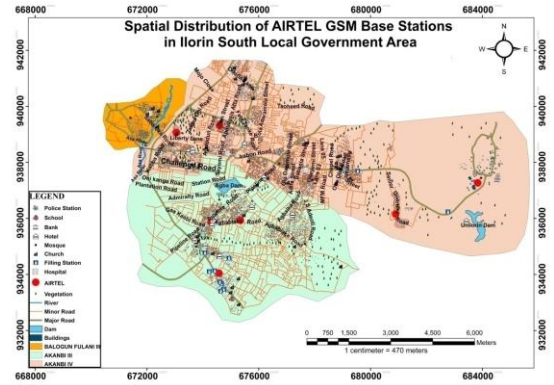




(a)(b)





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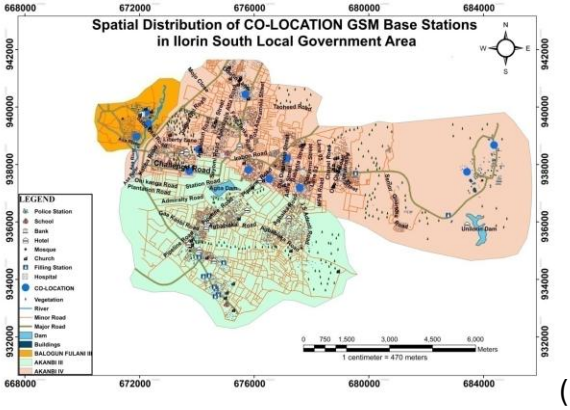

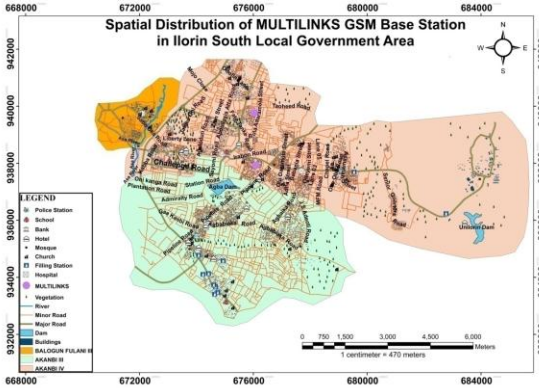

(e)(f)

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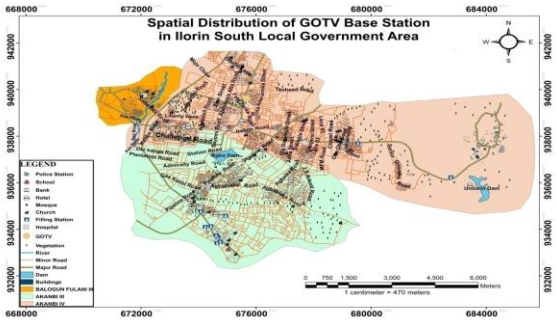
(g)



Figures 3 (a), (b), (c), (d), (e), (f), (g) Spatial Distribution of MTN, GLO, ETISALAT, AIRTEL, CO-LOCATION, MULTI LINKS, GOTV BASE Stations in the Study Area

The spatial distribution maps reveal patterns of mast placement that correspond to population density, urban infrastructure, and network provider strategies. Areas with higher concentrations of masts typically align with zones of greater telecommunication demand, reflecting strategic siting to optimize coverage and capacity. The mapping also highlights areas with fewer masts, which may indicate potential coverage gaps or underserved regions.

On the operational and physical characteristics, the analysis of mast height and fencing types provides insights into infrastructure standards and security measures. The working conditions data, integrated spatially, allow for the identification of non-functional or poorly maintained masts, which can negatively impact network performance. This geospatial overlay supports targeted maintenance and upgrade efforts by network operators.

The integration of geospatial data into telecommunication mast analysis enhances network monitoring and management by improving response times to network issues through precise location data, facilitating the efficient deployment of new technologies by identifying optimal mast sites, enabling assessment of network coverage and service quality at mast distribution, supporting infrastructure sharing, and regulatory compliance monitoring. Moreover, the use of GIS and GPS technologies as demonstrated in this study aligns with best practices in telecom network design, where geospatial approaches enable accurate, safe, and efficient planning by incorporating detailed environmental and infrastructural data.

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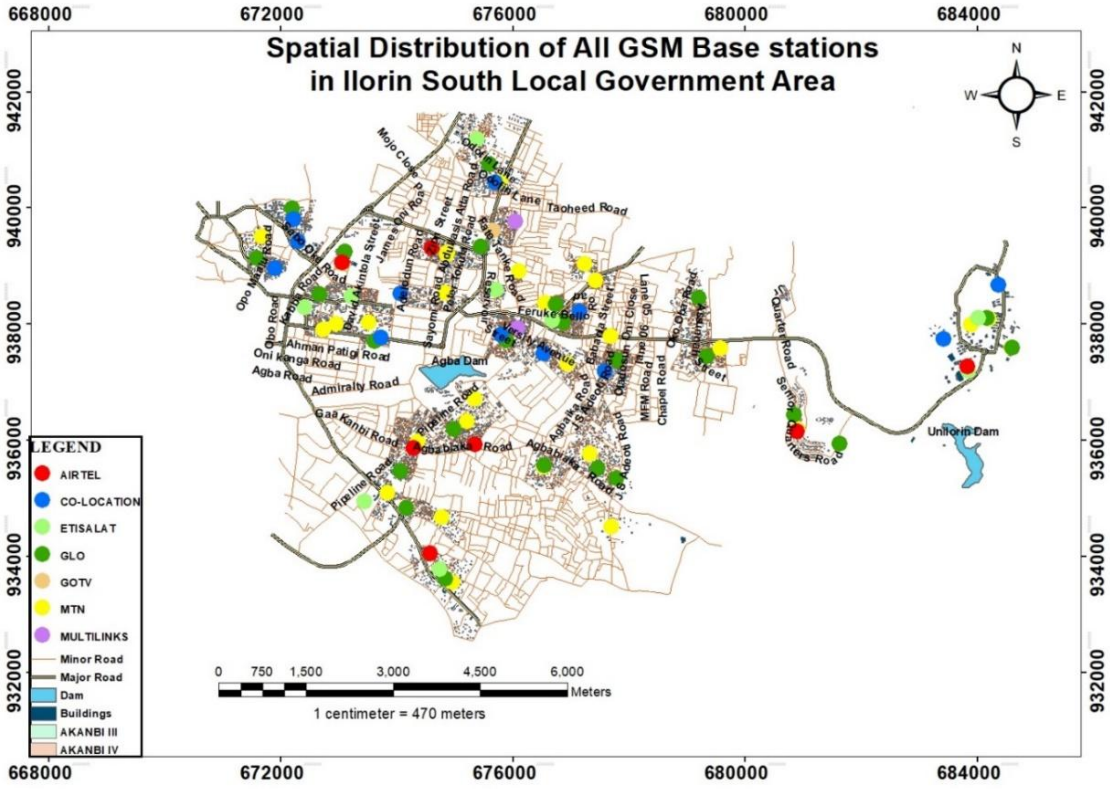

Figure 4: Spatial distributions of all GSM base stations in the Ilorin South Local Government Area.

4.3 Ward-Level Distribution and Analysis of Telecommunication Masts

4.3.1 Locational Spread

- Akanbi III Ward

The query analysis for Akanbi III ward reveals a total of twenty-two (22) telecommunication masts. MTN leads with nine (9) masts, followed closely by GLO with eight (8). Airtel and Etisalat have three (3) and two (2) masts respectively. Notably, there are no masts from Multilinks, GOTV, or co-location sites within this ward. This distribution suggests a moderate level of network infrastructure concentrated primarily among the leading providers, MTN and GLO, which may translate to relatively good coverage but limited diversity in service options for residents.

- Akanbi IV Ward

Akanbi IV ward exhibits a significantly higher concentration of masts, totaling fifty-eight (58). MTN maintains the largest share with twenty (20) masts, followed by GLO with fifteen (15). Etisalat and Airtel have seven (7) and four (4) masts respectively. Additionally, there are two (2) Multilinks masts, nine (9) co-location masts, and one (1) GOTV mast. Importantly, all major network providers have infrastructure present in this ward, indicating a highly competitive

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telecommunications environment. The presence of co-location masts also reflects infrastructure sharing practices, which can enhance network efficiency and reduce environmental impact.

- Balogun Fulani Ward IV

In contrast, Balogun Fulani Ward IV has a total of six (6) masts, with co-location sites accounting for half (3). GLO has two (2) masts, and MTN has one (1). There are no masts from Airtel, Etisalat, or Multilinks in this ward, indicating limited network diversity and potentially reduced service options for users. The dominance of co-location masts suggests reliance on shared infrastructure, possibly due to lower demand or geographic constraints.

The ward-level analysis highlights significant disparities in telecommunication infrastructure distribution within the study area. In terms of the network coverage and quality, wards like Akanbi IV with a high density and diversity of masts are likely to experience superior network coverage, higher data speeds, and better service reliability. Conversely, wards with fewer masts or limited provider presence, such as Balogun Fulani Ward IV, may face connectivity challenges and reduced competition-driven service improvements.

4.3.2 Analyzing the Infrastructure Sharing

Analyzing the Infrastructure Sharing, the presence of co-location masts, especially in Akanbi IV and Balogun Fulani Ward IV, underscores the growing trend of infrastructure sharing among providers. This practice can optimize resource use, reduce costs, and minimize environmental impact, aligning with regulatory encouragement for sustainable network expansion. Telecommunications companies and regulators can use these insights to identify underserved areas and prioritize infrastructure investments. Enhancing mast deployment in wards with limited coverage can improve digital inclusion and support socio-economic development. The spatial distribution and provider presence across wards reflect varying levels of telecommunication service accessibility, with clear opportunities for targeted infrastructure development to ensure equitable network coverage throughout the study area.

4.3.3 Mast Security

Regarding mast security, 39 masts are fenced with block walls. This includes 15 out of 30 MTN masts, 15 GLO masts, 4 Etisalat masts, 2 co-located masts, and 1 Airtel mast. Meanwhile, 47 masts are secured with steel fences, comprising 15 MTN masts, 10 GLO masts, 5 Etisalat masts, 10 co-located masts, 6 Airtel masts, and 1 GOTV mast. This distribution of fencing types reflects varied security measures across network providers within the study area

4.3.4 Status functionality of the mast

A query analysis of the telecommunication masts' operational status within the study area reveals that 70 masts are currently functional. Akanbi IV hosts the majority with 47 working masts, distributed among MTN (16), GLO (13), Etisalat (6), Airtel (2), and GOTV (1). Akanbi III has 19 operational masts, including MTN (7), GLO (8), Airtel (2), and Etisalat (2). Balogun Fulani Ward III contains 4 functional masts, comprising 2 co-located and 2 GLO masts.

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Conversely, there are 15 non-functional masts in the local government area. Akanbi IV accounts for 11 of these, with MTN (4), GLO (2), Multilinks (2), Airtel (2), and Etisalat (1) masts out of service. Akanbi III and Balogun Fulani Ward III each have 2 non-working masts, with Akanbi III's being one MTN and one Airtel mast, and Balogun Fulani Ward III's comprising one MTN and one co-located mast. These findings highlight notable spatial variations in mast functionality, revealing clusters of both operational and non-operational masts that could guide maintenance efforts and improve network reliability.

4.4 Spatial Pattern of the Location of Base Stations

Nearest Neighbor Analysis

Figure 5 reveals a clustered spatial distribution of telecommunication masts within the study area. This pattern was quantitatively assessed using nearest neighbour analysis. The analysis yielded a nearest neighbour ratio of 0.568104, a negative z-score of -7.662302, and a p-value of 0.000000, collectively indicating a statistically significant clustering of the masts. These metrics reflect the degree of spatial regularity, randomness, or clustering, confirming that the masts are predominantly sited in clusters relative to the overall area perimeter.

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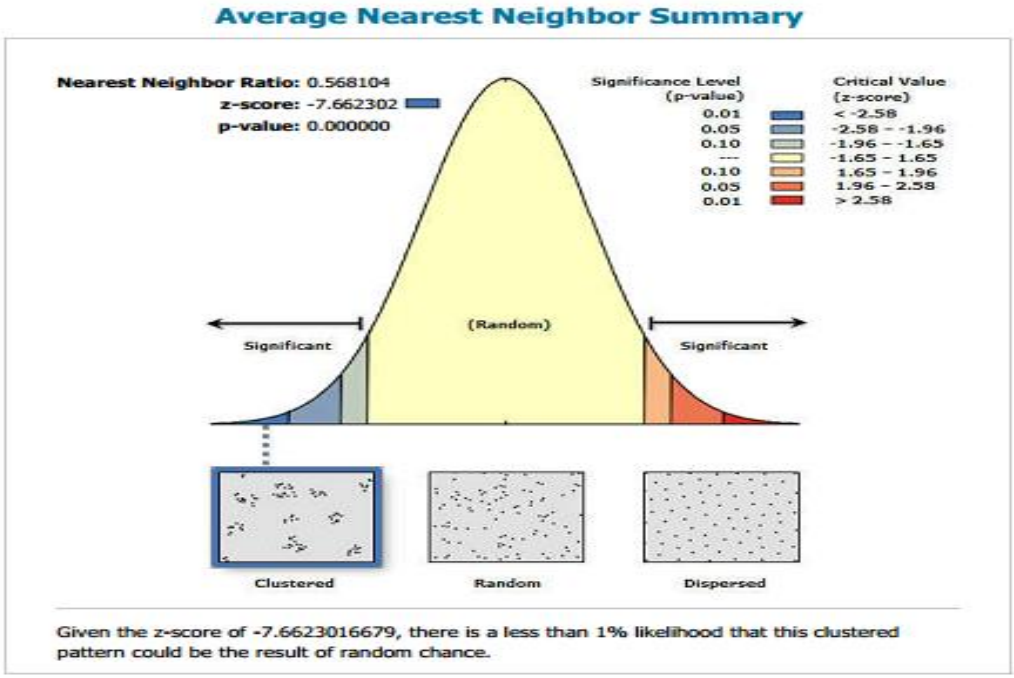

Average Nearest Neighbor Summary

Observed Mean Distance:	280.9708 Meters
Expected Mean Distance:	494.5763 Meters
Nearest Neighbor Ratio:	0.568104
z-score:	-7.662302
p-value:	0.000000

Dataset Information

Input Feature Class:	ALL_MAST
Distance Method:	EUCLIDEAN
Study Area:	84144350.833597
Selection Set:	False

Figure 5: Average nearest neighbor analysis of the masts

The statistically significant clustered pattern of telecommunication masts in the study area indicated by a nearest neighbor analysis, has several important implications such as the clustering leading to overlapping coverage areas, which can improve signal strength and capacity in high-demand zones but may also cause interference if not properly managed. Concentrated mast locations can facilitate easier and more cost-effective maintenance and monitoring due to reduced travel distances between sites. Clusters of masts in certain areas may raise concerns about electromagnetic exposure and visual pollution, necessitating careful regulatory oversight and community engagement. Clustering reflects spatial preferences or constraints in mast siting, which may affect land use patterns and require integration with urban development plans to minimize conflicts with residential or sensitive areas. Overall, understanding this clustering pattern supports

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more informed decisions regarding network optimization, infrastructure investment, and regulatory compliance within the local government area.

Kernel Density Estimation

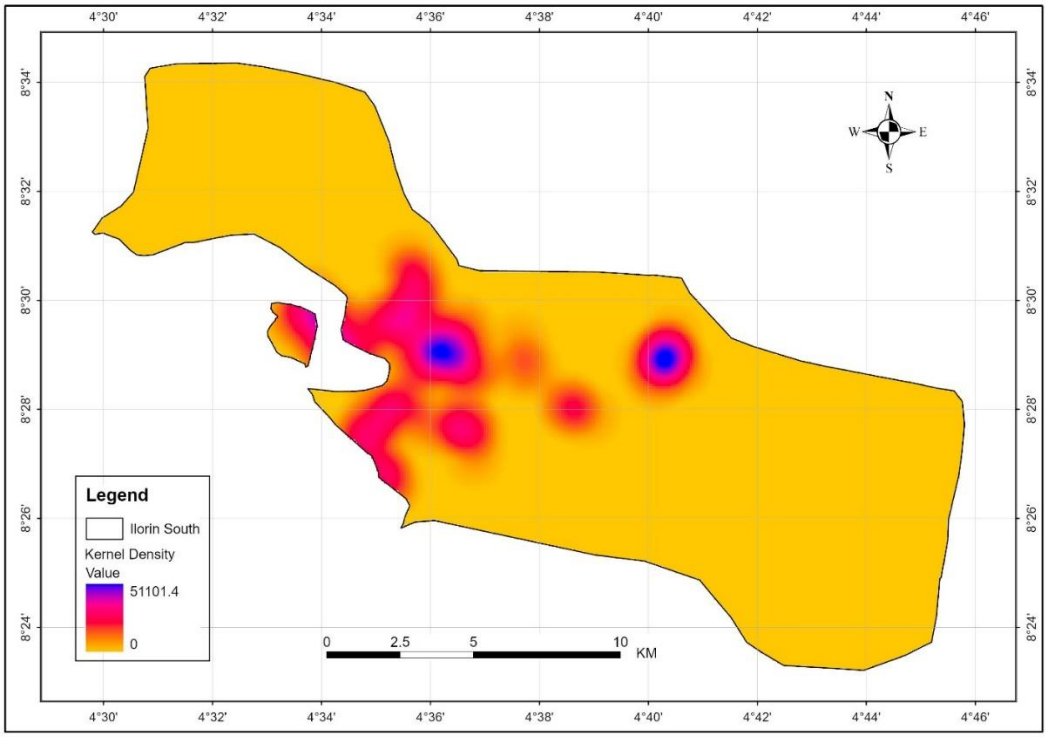

Figure 6: Kernel Density Map of Telecommunication Masts in Ilorin South Local Government Area

Spatial patterning trends of telecommunication masts within the Ilorin South Local Government Area were critically assessed based on Kernel Density Estimation (KDE). Following the georeferencing of point data, showing the precise locations of all the telecommunication masts, in a Geographic Information System (GIS) platform, KDE served as the central spatial analysis method.

The primary objective of applying KDE was to transform the discrete point features into a continuous surface and thus enable visualization and quantitative analysis of the spatial agglomeration attributes of telecommunication infrastructure. KDE calculates the density of point features around each output raster cell and generates a smooth, graduated surface that delineates high and low concentrations. For this study, kernel density analysis gave a heat map, as indicated in Figure 6, graphically illustrating the varying densities of telecommunication masts across the study area.

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As evident from Figure 6, the Kernel Density Value legend ranges from 0 (yellow), indicating areas of low or zero mast density, to 51101.4 (magenta/blue), indicating areas of highest mast concentration. The resulting heat map precisely depicts a non-even pattern of distribution. Clear high-density clusters appear in the middle and slightly eastern parts of the research area, as indicated by the color switch from red to magenta/blue shades, indicating significant aggregation of the telecommunication masts. Of great interest are several well-defined hot spots in the central area, which indicate highly concentrated areas of masts. However, most of the study area, particularly the eastern, western, and southern periphery, has readily apparent lower kernel density values, predominantly in yellow color, suggesting a sparser distribution of infrastructure. This graphical suggestion strongly supports the hypothesis of a clustered pattern in telecommunication mast distribution, a phenomenon most likely dictated by socio-economic factors such as human population density, user demand, and strategic network planning by service firms. These findings derived from this kernel density analysis are fundamental in determining the current spatial pattern of telecommunication infrastructure and future network planning and urban development initiatives.

5.0 CONCLUSION

This study has demonstrated the critical role of Geographic Information System (GIS) technology in mapping and analyzing the spatial distribution of telecommunication masts within Ilorin South Local Government Area. By meticulously documenting the locations and ownership of 86 masts primarily operated by major providers such as MTN Nigeria, GLO, 9Mobile, and Airtel Nigeria the research has revealed a pronounced clustering pattern, with several instances of mast co-location. This spatial arrangement is influenced by factors such as population density, network demand, and regulatory frameworks.

The findings underscore the value of GIS-based analysis for telecommunication network providers and urban planners. Not only does this approach support more strategic and equitable infrastructure deployment, but it also highlights the importance of adhering to safety and environmental standards, particularly regarding mast siting and setback distances. The identification of clustered masts and co-location opportunities offers practical insights for optimizing network expansion, enhancing service coverage, and minimizing environmental impact.

Ultimately, the study provides a replicable model for other rapidly developing urban and peri-urban regions facing similar challenges in telecommunication infrastructure management. By leveraging GIS, stakeholders can make informed decisions that promote sustainable urban development, improve network efficiency, and ensure compliance with regulatory requirements. These insights are invaluable for guiding future investments, policy formulation, and the ongoing evolution of telecommunication networks in Nigeria and beyond.

5.1. Recommendation

- *Integration of GIS for Strategic Planning and Equitable Mast Distribution*
  Telecommunication providers and urban planners should adopt GIS-based analysis for effective planning, ensuring that mast placement addresses coverage gaps, avoids excessive clustering, and promotes equitable distribution across the region.
- *Encouragement of Infrastructure Sharing and Regulatory Compliance*
  Network providers should be incentivized to share mast infrastructure (co-location) to reduce environmental and land use impacts. Regulatory authorities must also enforce compliance with safety standards, especially regarding minimum setback distances from buildings.
- *Fostering of Collaboration and Regular Data Updates*
  Strengthen collaboration among service providers, urban planners, regulators, and local communities. Maintain and regularly update a comprehensive spatial database of mast locations to support ongoing monitoring and informed decision-making.

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