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SPATIAL DISTRIBUTION AND ACCESSIBILITY OF PUBLIC SECONDARY SCHOOLS IN SOKOTO METROPOLIS: IMPLICATIONS FOR EDUCATIONAL EQUITY AND URBAN PLANNING

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ABSTRACT

This study investigated the spatial distribution and accessibility of public secondary schools in Sokoto Metropolis, highlighting the implications for educational equity and urban planning. A mixed-method approach was applied to examine patterns and coverage of 88 schools. Location data were obtained using Garmin-60 GPS and Public Secondary School records from the Ministry of Education, Sokoto, and analyzed using Average Nearest Neighbor (ANN) analysis and buffer techniques in ArcGIS. The findings reveal a predominantly clustered distribution of schools across the metropolis, with an ANN ratio of 0.586767, a z-score of -7.331199, and a p-value < 0.001, indicating significant clustering in central urban areas, particularly Sokoto North and South LGAs. Conversely, peripheral regions, such as Wamakko and Kware LGAs, exhibit sparse school distribution and isolated buffer zones, suggesting reduced accessibility for students in these areas. A 2-kilometer buffer analysis shows disparities, with overlapping zones in central areas enhancing accessibility, while peripheral regions face limited school proximity. LGA-specific analyses reveal random distribution patterns in Sokoto North (ANN ratio 1.152340) and Sokoto South (ANN ratio 1.144023), ensuring moderate accessibility but with gaps in peripheral regions. Wamakko LGA exhibits some clustering near urban zones, but fewer schools are found in less populated areas, highlighting geographical and demographic challenges. The study emphasizes the importance of equitable school distribution, with a particular focus on peripheral areas to bridge accessibility gaps. These findings inform policies aimed at improving educational equity and guiding sustainable urban planning in Sokoto Metropolis.

Keywords: Accessibility, Planning, Public Secondary Schools, Spatial

INTRODUCTION

Equitable access to education is widely recognized as a fundamental human right and a key driver of sustainable development (Freeman & Veerman, 2021; Ainscow, 2020; Detrick, 2023). Educational accessibility is often shaped by the spatial distribution of schools, which influences students' ease of access and the quality of education they receive (Rieckmann, 2018). According to UNESCO (2017), achieving educational equity requires that all students have reasonable access to educational facilities within their communities. The spatial organization of schools is crucial for creating inclusive educational systems that ensure equitable access, especially in urban areas where population density and geographical challenges can impact students' access to schooling. In highly urbanized areas, poor school distribution can lead to overcrowding in some schools and underutilization in others, disrupting the quality and inclusivity of educational services (UNESCO, 2017).

According to Van Heerden *et al.* (2022), rapid urbanization and limited planning capacity have made school accessibility a critical issue. The African Union's Agenda 2063 emphasizes the need to provide quality education across urban and rural areas, addressing issues of both quantity and spatial accessibility of educational institutions. However, in many African cities, the spatial distribution of public schools is uneven, often skewed toward affluent neighborhoods or urban centers, leaving peri-urban and rural communities with limited access. This imbalance hinders progress toward educational equity, as students in underserved areas are often forced to travel long distances, impacting their attendance and performance (Walker *et al*., 2019)

Studies on spatial distribution, such as those by Haque and Sharifi (2024) in Nairobi, Kenya, highlight how unequal distribution limits access and creates substantial barriers for low-income and marginalized communities.

In West Africa, similar challenges are prevalent, with educational facilities often concentrated in specific regions or urban centers, exacerbating educational inequalities. Korah, Smith, and Wimberly (2025) found that urban sprawl and ineffective urban planning significantly impacted accessibility. These spatial disparities hinder West African countries' efforts to provide inclusive education as outlined in the United Nations' Sustainable Development Goals (SDGs). Rural and peri-urban populations face significant disadvantages, as they often lack adequate access to well-located public schools. This lack of access can also have economic implications, as the cost and time of travel to schools become prohibitive for many families, restricting their children's educational opportunities (Korah, Smith, & Wimberly, 2025).

In Nigeria, the spatial distribution of public secondary schools has been the subject of numerous studies highlighting educational disparities across urban and rural areas. Nigeria's National Policy on Education emphasizes equitable access to educational resources, yet urbanization challenges, resource limitations, and ineffective planning have led to significant inequalities. Within Nigerian cities, especially in the rapidly urbanizing Northern regions, school distribution is often uneven, creating barriers for students from low-income households. Studies such as those by Mohammed and Edu (2021) have shown that the clustering of schools in specific areas within cities like Lagos and Kano leads to overcrowding and inequities in access, with students in remote neighborhoods facing greater obstacles to attending school.

In Sokoto Metropolis, issues of educational accessibility are amplified by its rapid urban expansion and resource limitations. Public secondary schools in Sokoto are often clustered in central areas, with peripheral and newly developed neighborhoods having limited access. Studies on the educational landscape by Kearney, Childs, and Burke (2023) have highlighted that students from less accessible neighborhoods face travel difficulties, which can lead to irregular attendance and higher dropout rates.

MATERIALS AND METHODS

Study Area

Sokoto Metropolis is located between Latitudes 12° 50’ 12’’ and 13° 20’ 0” North of the equator and Longitudes 4° 10’ 5’’ and 6° 10’ 0’’ as seen in Figure 1estimated population of approximately 5.91 million in 2024, with an average annual growth rate of 2.6%, using 2006 population census data.

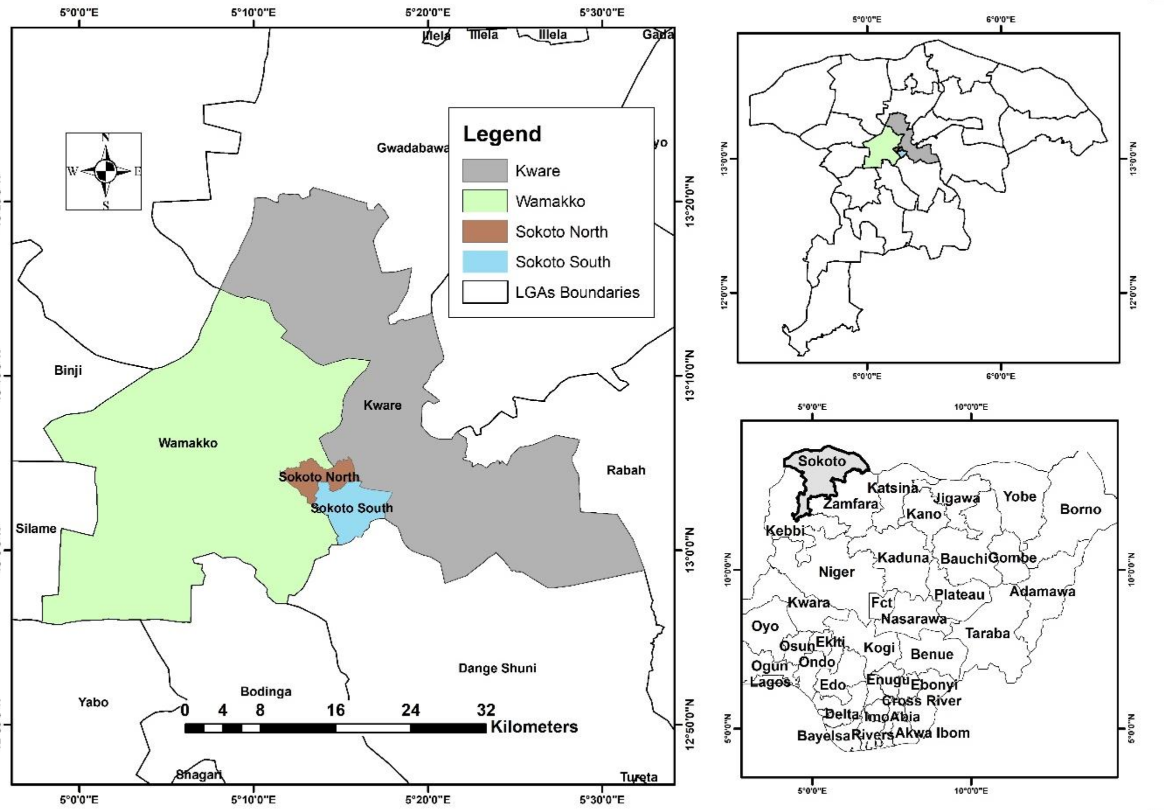

Figure 1: Sokoto Metropolis

Methods

The study employed a mixed-method approach that integrated Geographic Information Systems (GIS) analysis and quantitative assessments to examine the spatial distribution of public secondary schools. The methodology included data collection, GIS integration, and spatial statistical analysis.

Data Collection and Sources

Data for the study were sourced from both primary and secondary sources. Primary data were collected using a handheld Garmin 60 Global Positioning System (GPS) device to capture the precise coordinates of public secondary schools in Sokoto Metropolis. Secondary data included a comprehensive list of 88 public secondary schools (comprising 35 junior and 53 senior secondary schools) obtained from the Ministry of Education, Sokoto. The GPS coordinates of the schools were geo-coded and integrated into an ArcGIS database for further analysis.

GIS Analysis and Data Processing

The geo-coded data were analyzed using nearest-neighbor analysis within the ArcGIS10.7 environment to evaluate the spatial distribution patterns of schools in the study area. Key variables included school locations, the number of schools in each local government area, and the total land area (in square kilometers). The analysis utilized spatial statistics tools to calculate the observed spatial patterns and determine whether they exhibit clustering, randomness, or dispersion.

Spatial Distribution Pattern

The spatial distribution of public secondary schools was analyzed as a reflection of service provision patterns. The study employed the Average Nearest Neighbour (ANN) analysis to assess whether schools were clustered or dispersed around their geographic mean center. The ANN index was calculated as the ratio of the observed average distance (D_0) to the expected average distance (D_E), based on a hypothetical random distribution of the same number of features across the total area. Schools were classified as clustered when the ANN index was less than 1, and as dispersed when the index was greater than 1. Thus;

Clustered *if ANNthan and* Dispersed if ANNI >1

To ensure statistical robustness, the study incorporated z-scores and p-values. The z-score indicates the extent to which the spatial pattern deviates from randomness, while the p-value measures the likelihood of the observed pattern being due to random processes. A small p-value indicates that the observed spatial distribution is highly unlikely to have occurred by chance, enabling rejection of the null hypothesis.

RESULTS AND DISCUSSION

The spatial distribution of public secondary schools in Sokoto Metropolis, as illustrated in Figure 2, indicates significant disparities in accessibility across the central and peripheral regions of the study area. A notable concentration of schools in the central LGAs of Sokoto North and Sokoto South reflects patterns commonly observed in urban planning, where resources are prioritized in densely populated urban centers (Sharma & Patil, 2022). This clustering likely addresses the higher demand for educational infrastructure in these areas, aligning with studies that emphasize population density as a key determinant of school location (Yulong & Zhizhu, 2023). However, the peripheral LGAs of Wamakko and Kware face accessibility challenges due to the sparse distribution of schools, which can create barriers to education for students in these regions.

Accessibility is critical for equitable educational opportunities, as proximity to schools has been linked to better attendance and learning outcomes (Barrett *et al*., 2019). In densely populated urban centers, overlapping buffer zones enhance accessibility and choice, as seen in Sokoto North and Sokoto South. Conversely, in sparsely populated areas like Wamakko and Kware, the lack of overlapping zones implies limited access, which can exacerbate socioeconomic disparities and educational inequities as suggested by Bruna *et al*., (2021).

Moreover, the results underscore the importance of spatial equity in educational planning. While urban students benefit from multiple accessible schools, rural students face longer travel distances, impacting attendance and overall educational outcomes. To address these disparities, according to Yulong & Zhizhu, (2023)., strategic planning is essential to optimize the spatial location and service capacity of schools, ensuring equitable distribution and accessibility.

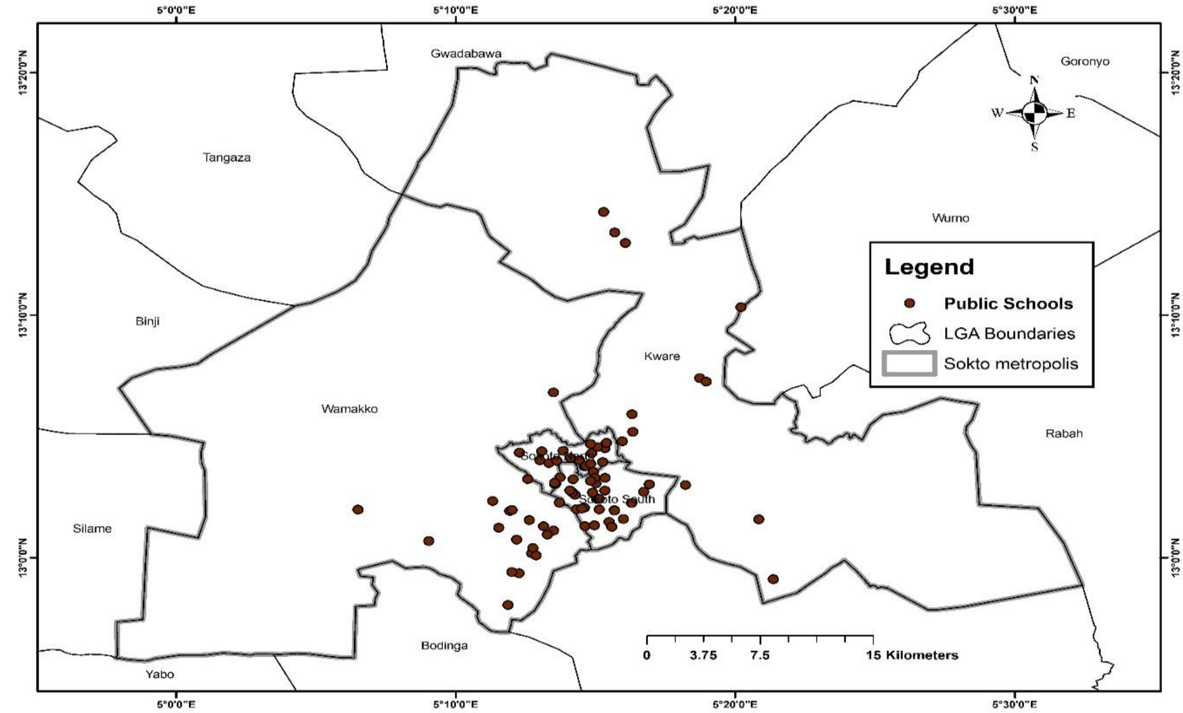

Figure 2: Distribution of Public Secondary Schools in Sokoto Metropolis

The results of the Average Nearest Neighbor (ANN) analysis presented in Figure 3 highlight a clustered spatial distribution of public secondary schools in Sokoto Metropolis, with an ANN ratio of 0.586767, a z-score of -7.331199, and a p-value of 0.000000. These values confirm that the distribution is not random but highly clustered, aligning with findings in Figure 2 that show dense concentrations of schools in the central LGAs of Sokoto North and Sokoto South. This clustering pattern is consistent with urban planning trends where educational resources are typically concentrated in areas of high population density to maximize access and efficiency (Talal & Shawky, 2018). Urban centers often receive priority in resource allocation due to their higher demand for educational services, which explains the significant clustering observed in these parts of the Sokoto Metropolis.

However, the clustered distribution also indicates spatial inequities, as peripheral areas, such as Wamakko and Kware LGAs, experience limited school accessibility. Similar patterns have been observed in other regions, such as Ilorin West in Kwara State, where schools were predominantly located in urbanized zones, leaving rural areas underserved (Oloko-Oba *et al*., 2016). This unequal distribution impacts educational outcomes by creating barriers for students in less densely populated regions, who often need to travel greater distances to access schools (Abdulkarim *et al*., 2023). on the other hand, spatial clustering in urban centers can strain existing school infrastructure, leading to overcrowding and reduced quality of education in high-density areas. Therefore, addressing these concerns requires a balanced approach that considers both urban demand and rural needs (Talal & Shawky, 2018).

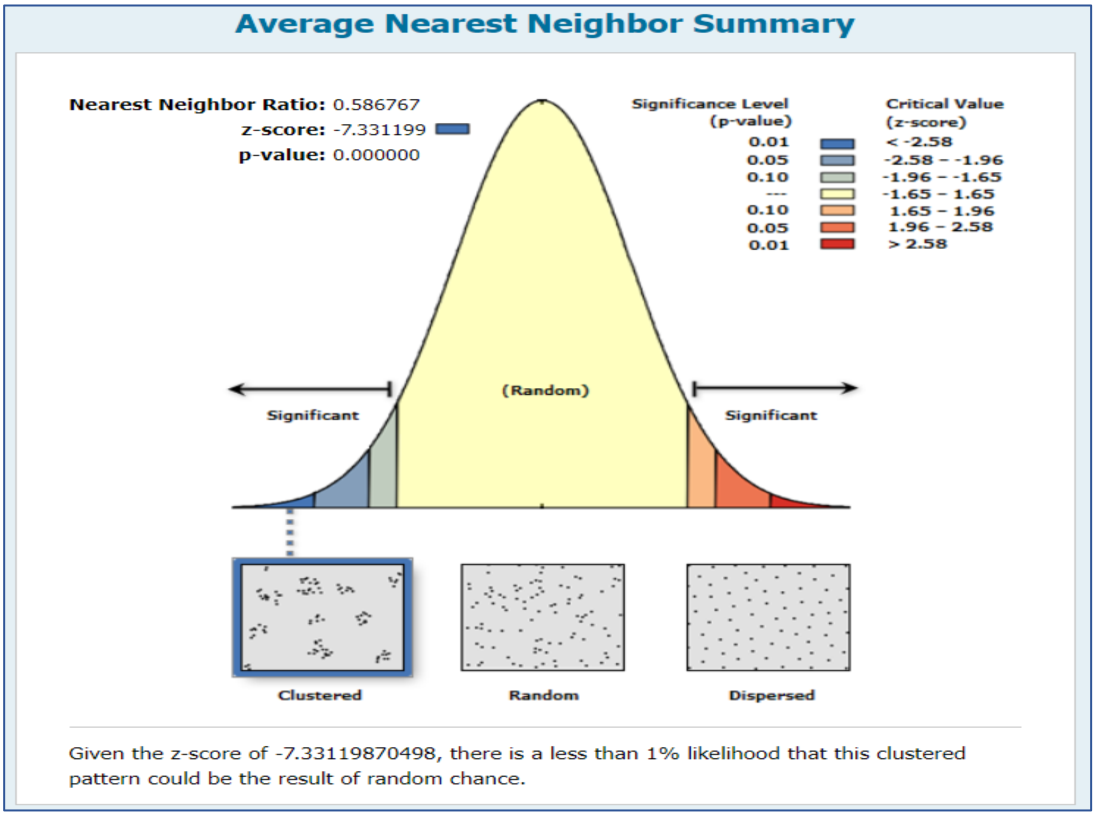

Figure 3: Average Nearest Neighbor of Public Secondary Schools in Sokoto Metropolis

The 2-kilometer (km) buffer analysis presented in Figure 4 reveals disparities in spatial accessibility to public secondary schools in Sokoto Metropolis. Central areas, particularly in Sokoto North and Sokoto South LGAs, exhibit overlapping buffer zones, suggesting that students in these urban zones benefit from proximity to multiple schools, enhancing their accessibility and educational options. In contrast, peripheral LGAs like Wamakko and Kware show isolated buffer zones, reflecting limited school availability within a 2km radius. This disparity indicates that students in outer regions face challenges such as longer travel distances, which may negatively affect attendance and educational outcomes.

These findings align with Cherono (2023), who emphasizes the critical role of proximity in determining accessibility and its influence on educational equity. Students in densely populated central zones often have greater access to educational facilities, enabling better attendance and reducing dropout rates. However, the limited coverage in peripheral areas mirrors observations in Kilifi County, Kenya, where spatial disparities hinder equitable access to education, disproportionately affecting rural populations (Macharia *et al*., 2023). Moreover, accessibility gaps in peripheral areas of Sokoto Metropolis highlight the need for targeted interventions. Yu, Appiah, Zulu, & Adu-Poku (2024). emphasise the importance of integrating spatial accessibility measures into urban planning, advocating for strategies like establishing new schools in underserved areas and improving transportation networks to bridge the gap between rural and urban regions. Schools are to be located in such a way that the average number of pupils does not walk more than two kilometers (2 km) to get to the nearest school (Universal Basic Education Commission (Nigeria), 2010).

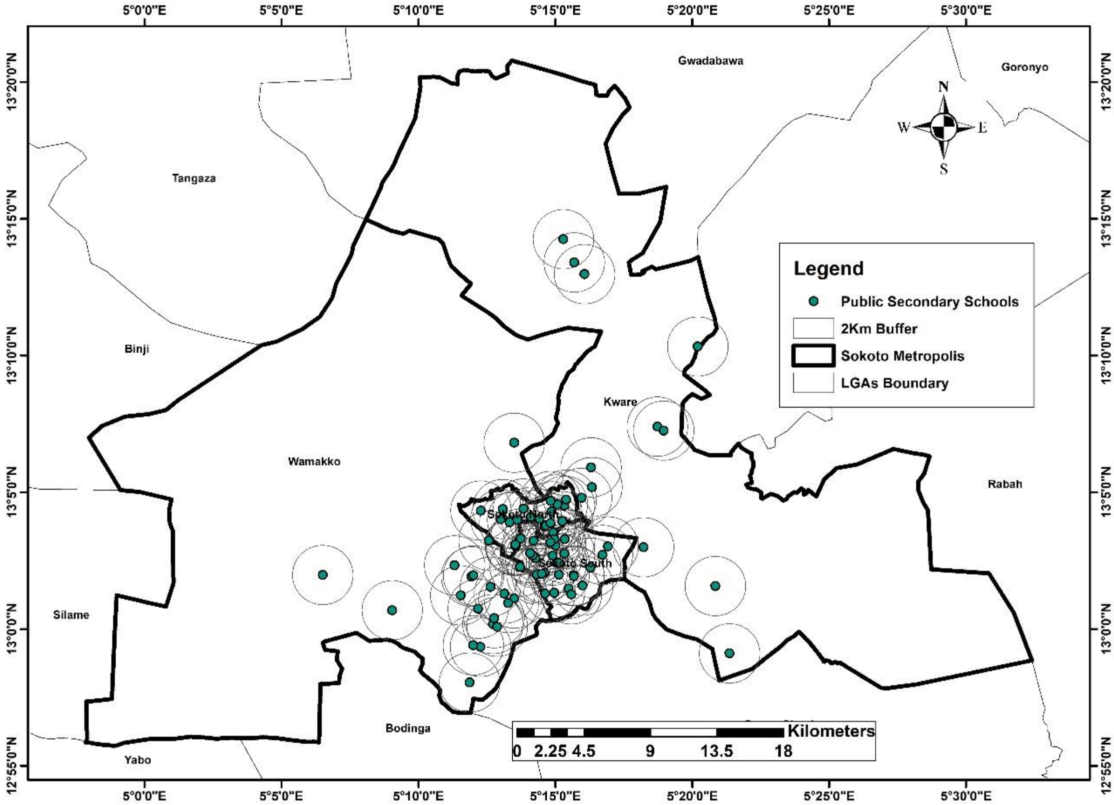

Figure 4: Buffer (2km) analysis of public secondary schools in Sokoto Metropolis

The map on the left in Figure 5 illustrates the spatial distribution of public secondary schools in Sokoto North Local Government Area (LGA), with each school represented as a point within the defined LGA boundary. The right-hand diagram presents the Average Nearest Neighbor (ANN) analysis, a spatial statistical method used to assess the distribution pattern of these schools. The ANN ratio is 1.1523, with a z-score of 1.4258 and a p-value of 0.1531. These results indicate that the spatial distribution of public secondary schools in Sokoto North LGA does not significantly deviate from randomness. Given that the z-score falls within the range of -1.65 to +1.65, the observed pattern is neither strongly clustered nor dispersed but rather approximates a random distribution. This suggests that, on a broad scale, there is no deliberate spatial concentration of schools in any specific area.

However, as Ainscow (2020) emphasizes in his study on educational inclusion and equity, a seemingly random spatial distribution does not automatically translate into equitable access to education. While the ANN analysis suggests an even spread of schools, disparities may still exist in school accessibility, particularly in areas with sparse educational facilities or challenging geographic features. The spatial map further contextualizes this interpretation by revealing that while schools appear evenly distributed across the LGA, some peripheral or underserved areas may still experience difficulty in accessing educational facilities. This aligns with findings from Abdulkarim *et al.* (2023), who observed that spatial patterns of educational institutions, even when statistically random, can still result in localized disparities in school accessibility. Factors such as road networks, population density, and socio-economic conditions play crucial roles in determining the practical accessibility of schools beyond their mere spatial distribution.

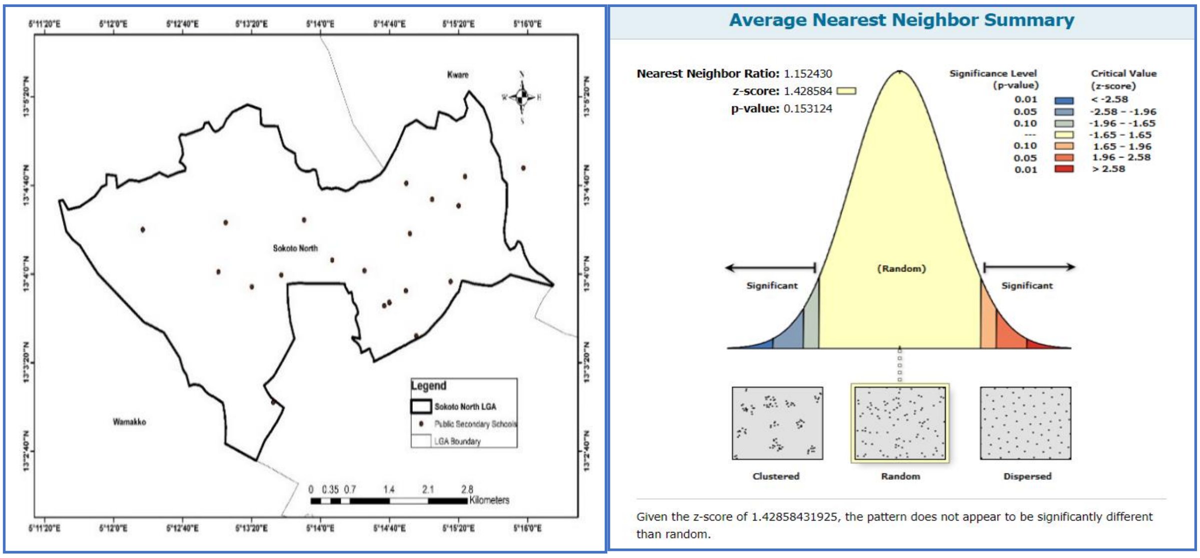

Figure 5: Spatial distribution and ANN of Public Secondary schools in Sokoto North LGA

The Average Nearest Neighbor (ANN) ratio in Figure 6 is calculated as 1.1440, with a z-score of 1.5341 and a p-value of 0.1250. These results indicate that the spatial distribution of public secondary schools in Sokoto South LGA does not significantly deviate from a random pattern. Since the z-score falls within the range of -1.65 to +1.65, the observed distribution is neither strongly clustered nor highly dispersed, aligning closely with spatial randomness. However, while the ANN statistic provides a general measure of spatial arrangement, it does not necessarily reflect equitable accessibility to education. The map analysis offers deeper insights, suggesting that while public secondary schools appear evenly spread across Sokoto South, potential gaps in coverage may exist, especially in peripheral and low-density areas. Such disparities could impact school accessibility for students in these regions, reinforcing the need for a more nuanced accessibility assessment beyond statistical randomness.

According to Barrett *et al*. (2019), the physical distribution of schools plays a significant role in shaping educational outcomes, as inadequate spatial planning can contribute to barriers in learning opportunities, particularly for students from disadvantaged backgrounds. Similarly, Bruna *et al.* (2021) emphasize that even if schools are randomly or evenly distributed, spatial equity in education is influenced by factors such as travel distance, transport infrastructure, and socioeconomic conditions. These variables directly affect students' ability to attend school regularly and benefit from quality education. Furthermore, Cherono (2023) highlights the importance of spatial accessibility modelling in ensuring precision-targeted school interventions. The mere presence of schools within an LGA does not guarantee fair access—considerations such as catchment areas, population density, and school capacity must be integrated into planning processes. Without such considerations, certain communities may still face barriers to education, even when school locations appear randomly distributed.

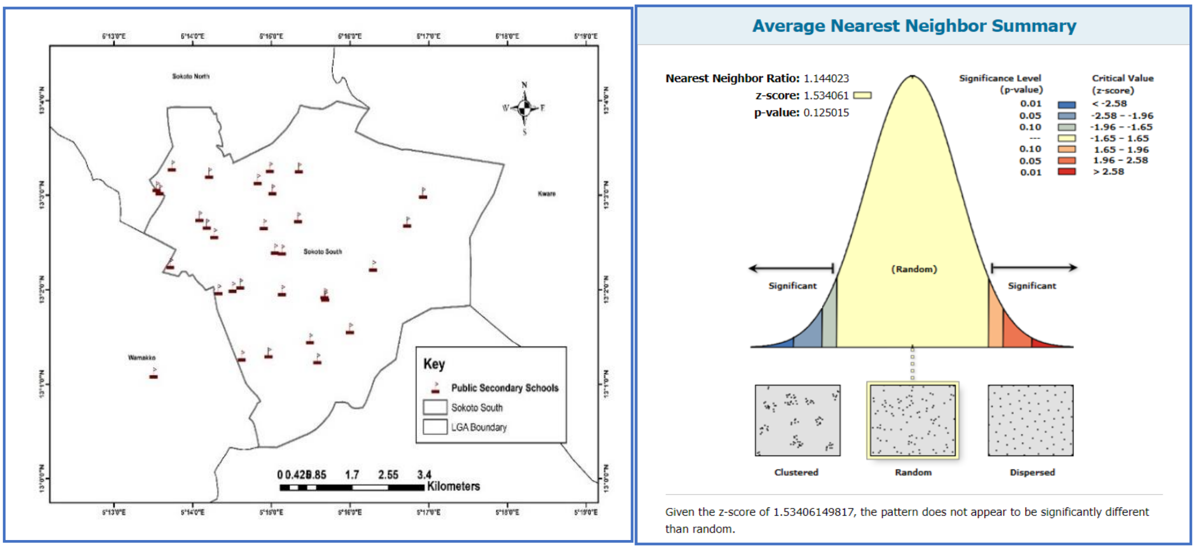

Figure 6: Spatial distribution and ANN of Public Secondary schools in Sokoto South LGA

The map in Figure 7 depicts a noticeable concentration of schools in and around the Southeastern part of Wamakko LGA, particularly closer to Sokoto Metropolis, which may align with higher population density and urbanization in this area. In contrast, the western and northern parts of the LGA show fewer schools, potentially reflecting sparse population settlements or geographical barriers.

The ANN results reveal a nearest-neighbor ratio of 0.891582, a z-score of -0.92757, and a p-value of 0.353630. These statistical values indicate that the spatial pattern of public secondary schools in Wamakko LGA does not significantly deviate from a random distribution. The z-score falls within the range of -1.65 to +1.65, suggesting no strong clustering or dispersion, and the high p-value reinforces the insignificance of the deviation from randomness.

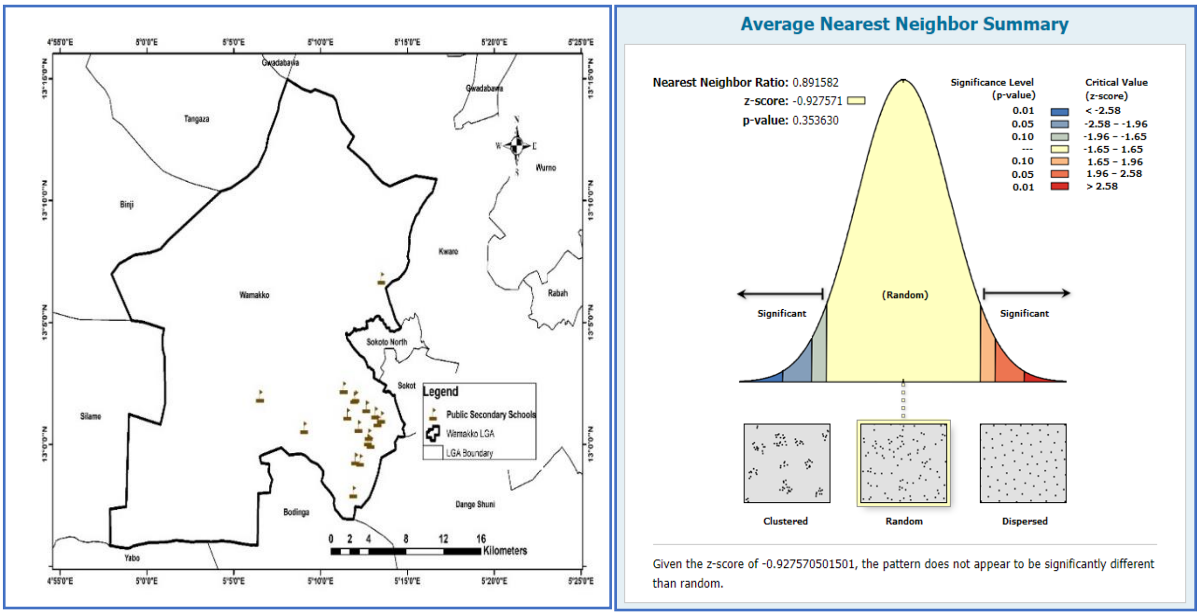

Figure 7: Spatial distribution and ANN of Public Secondary schools in Wamakko LGA

While the ANN results across the four LGAs suggest random spatial patterns, this does not imply optimal or equitable school distribution. Random patterns may fail to meet the specific needs of communities, particularly in less densely populated or geographically isolated areas. As emphasized by Cherono (2023) and Macharia *et al*. (2023), spatial equity in school distribution must consider factors such as population density, catchment areas, and the capacity of educational facilities to serve diverse student populations. The clustering near urbanized areas, as observed in Wamakko LGA, underscores the role of urbanization and resource prioritization in shaping educational infrastructure.

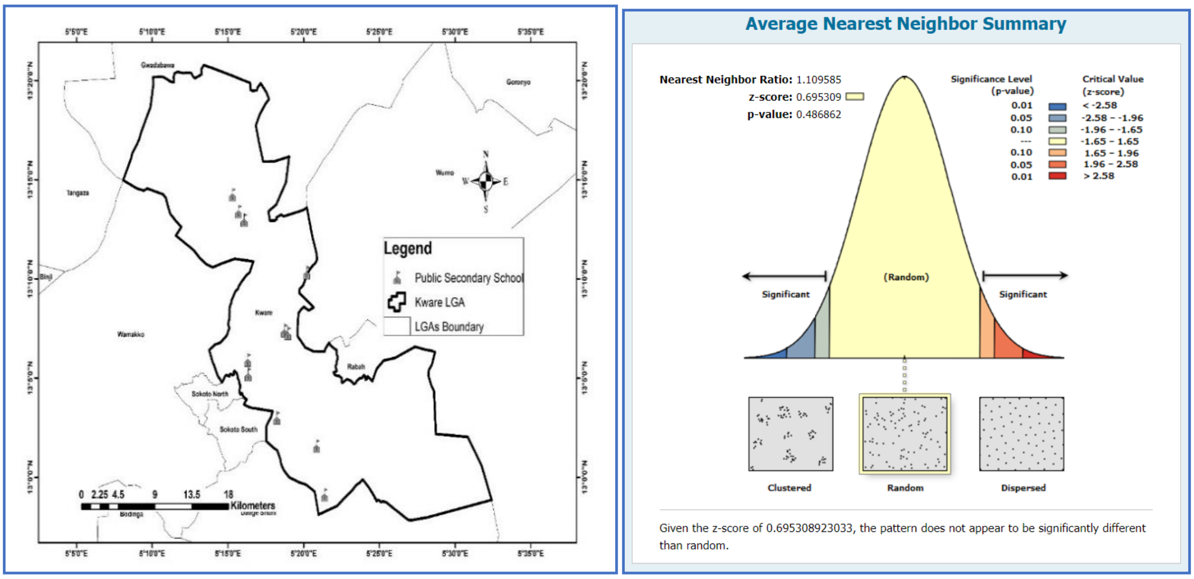

Figure 8: Spatial distribution and ANN of Public Secondary schools in Kware LGA

CONCLUSION

The findings of this study underscore significant disparities in the spatial distribution and accessibility of public secondary schools within Sokoto Metropolis. The analysis revealed a clustered pattern of schools, particularly concentrated in the central areas of Sokoto North and Sokoto South LGAs. This clustering correlates with higher population densities and better urban planning in these zones, providing students with enhanced accessibility and multiple school options within a 2-kilometer radius. On the other hand, schools in peripheral areas, particularly in Wamakko and Kware LGAs, are sparsely distributed, resulting in limited access for students in these regions. The lack of overlapping buffer zones in these areas implies longer travel distances for students, potentially exacerbating educational inequities and impacting school attendance and performance. While the spatial patterns in Sokoto North and Sokoto South LGAs align closely with randomness, indicating a relatively equitable distribution, the outskirts of these regions still exhibit disparities in accessibility. Similarly, schools in Wamakko LGA are more concentrated near urbanized zones, leaving rural areas underserved. These findings highlight the need for targeted policy interventions to address accessibility gaps, particularly in underserved peripheral areas. Strategic school placement, enhanced transportation infrastructure, and equitable resource allocation can mitigate these disparities, fostering educational equity and improved urban planning.

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