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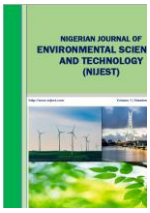

The Geospatial Analysis of Electoral Polling Units: A Case Study of Osogbo Local Government Area

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ABSTRACT

The geospatial data of 282 electoral polling units constituting Osogbo Local Government Area of Osun State, southwestern Nigeria, was examined in this study. The study investigated the spatial distribution of the electoral polling units, and the voter accessibility within the study area, with a view to foster polling procedure management on election days. The secondary data sourced from the from the Independent National Electoral Commission (INEC), State Headquarters, Osun State, Nigeria were used for the study. The ArcGIS 10.6 was used to plot the spatial coordinates of electoral polling units, with queries conducted to determine the electoral polling units with voting strength exceeding 500 registered voters. The distribution pattern and voter accessibility of electoral polling units were analysed using the Nearest Neighbour Analysis (NNA), K-Means Clustering Algorithm and other GIS techniques. The results showed a z-score of -15.882398, a p-value of 0.000000 and a Nearest Neighbours Index (NNI) value of 0.505620, implying that the distribution is clustered. Oba Iyiola Oyewale Govt Pry School (522 voters), Gbadebo Street, behind A.U.D. Pry School I & II (969 and 899 voters), and the open space beside Jerry Paul Filling Station (729 voters) were identified as the electoral polling units furthest away. Conclusively, the recommended that additional electoral polling units should be created in the distant areas to shrink voter congestion and optimise polling procedure management on election day; effectively efficient road network and infrastructure were suggested for improved voter access. Additionally, deploying extra election staff and materials to remote polling units may prevent delays on election days.

Keywords: Distribution pattern, Electoral polling units, geospatial analysis, voter accessibility, Osogbo

1.0. Introduction

Adequate voters' access to electoral polling units goes beyond establishing new electoral polling units. It is crucial to Nigerians' voting rights. This is a fundamental element in the pursuit of a functioning electoral democracy and its consolidation. It entails positioning electoral polling units in locations that are environmentally conducive to implementing the voting process and polling procedures (INEC-Discussion-Paper-I, 2021). In the 2019 general elections in Nigeria, the state of electoral polling units had grown worse. The average voting strength per electoral polling unit rose from 700 registered voters to as high as 2,000 and 15,000 in places like the Federal Capital Territory and Nasarawa State, respectively. Several electoral polling units were incorrectly sited in difficult and remote locations, such as areas controlled by partisan political actors. This complicated voter access, especially for persons with disabilities (PWD), results in low turnout at elections(INEC-Discussion-Paper-I, 2021).

This was why the Nigerian electoral umpire decided, in the 2019-2023 electoral cycle, to solve the electoral polling unit-related problems to improve voter access (INEC-Discussion-Paper-I, 2021). However, according to the European-Union-Election-Observation-Mission (2023), access to electoral polling units was still a problem.

1.1 Electoral Polling Units

Electoral polling units (PUs) constitute the basic structure of the electoral system and democracy in Nigeria. They are locations designated for voters on election days to cast their votes(Manual-For-Election-Officials, 2016). Electoral polling units are structured places established by election management bodies to serve as voter registration centres and voting points. They are usually spread across all levels of electoral jurisdictions, where eligible citizens register as voters in preparation for the elections and cast their votes during election time(Tata, Victor, Taiwo Oludayo, & Titilade, 2024). Whenever viable, electoral polling units shall be located within enclosures in public places such as public schools, civic centres, town halls, and communal open spaces accessible to every voter, including Persons with Disabilities (PWDs). Polling Units shall not be in places of worship, palaces of traditional rulers, or private homes(PLACng, 2022).

1.2 Brief History of Electoral Polling Units in Nigeria

In 1996, the defunct National Electoral Commission of Nigeria (NECON) created 120,000 electoral polling units spread across diverse levels of electoral jurisdiction, clustered into 8,809 wards or registration areas. It was this electoral polling unit structure that was used in 1999, 2003, 2007, and 2011 for general elections in Nigeria(Bala, Pirasteh, Aliyu, Aliyu, et al., 2022; Chair's-Press-Conference-On-PUs, 2014).

As presented by Bala, Pirasteh, Aliyu, Aliyu, et al. (2022) and Chair's-Press-Conference-On-PUs (2014). The congested electoral polling units generally experienced by voters across Nigeria during the 2011 general elections were occasioned by exponential population growth and a chronic demographic shift resulting from the new settlements in major urban areas.

According to the Chair's-Press-Conference-On-PUs (2014), the Independent National Electoral Commission (INEC), under the leadership of Professor A. Jega, had attempted to re-configure the structure of the electoral polling units and create additional ones, citing reasons such as to decongest the over-crowded electoral polling units, disperse voters as evenly as possible among all the electoral polling units and locate electoral polling units more effectively within commuting distances of voters because movement is usually restricted on Election Day.

Other reasons cited included relocating the electoral polling units from “in front of” private houses and other unsuitable places to public buildings or, where this is not possible, to public open spaces where tents can be provided.

INEC also outlined the movement of the electoral polling units located inside the classrooms or other unsuitable enclosures in line with international best practices, splitting of the large electoral polling units such that each unit would possess a voting capacity of 500 registered voters on average, and creating additional electoral polling units to cater for the splitting of large polling units as well as new settlements not serviced by any existing electoral polling units, as part of the reasons for electoral polling units re-configurations(Chair's-Press-Conference-On-PUs, 2014).

The Jega-led INEC could not implement the initiatives that would have added 30,027 electoral polling units to the existing ones. This inability was due to the fierce criticism and opposition from several Civil Society Organisations across Nigeria, who posited that such a move was a ploy to distribute electoral polling units across Nigeria disproportionately. And foster the dominance of one section of the country over the others for political advantage(Chair's-Press-Conference-On-PUs, 2014). The baby electoral polling units, tagged voting points, were created and positioned beside the existing overcrowded electoral polling units to micromanage the voter congestion(Chair's-Press-Conference-On-PUs, 2014).

However, in 2021, Professor Yakubu-led INEC, after a series of wider and intensive consultations and dialogues with a lot of electoral stakeholders such as Media executives, 37 different Civil Society Organisations (CSOs), Groups of PWDs, National Economic Council (NEC), among others, was able to

secure national consensus and acceptance to convert the existing voting points (VPs) and voting point settlements (VPS), to full fledge electoral polling units and create new ones where necessary across the country(INEC-Communique-On-Voter-Access-Expansion, 2021). This was done essentially to decongest the overcrowded electoral polling units, bring voting points closer to the voters' residences, create an equilibrium between the sparsely populated polling units and overcrowded electoral polling units, and simplify the balloting process and voting procedures at the poll This implemented initiative led to the creation of 56, 873 additional electoral polling units spread across Nigeria, moving the 119, 973 PUs to 176, 846 PUs(INEC-Communique-On-Voter-Access-Expansion, 2021).

1.3 Geospatial Data in Election Management

Data is information in its raw state(Barrowman, 2018; Bastarache *et al.,* 2022; Miyakawa, 2020; Walford, 2017), but geospatial data refers to geographic information usually associated with specific locations on the Earth's surface. This information includes coordinates, addresses, regions, and other location-specific information(Bill et al., 2022; Li & Hsu, 2022; Tapia-McClung, Sánchez-Siordia, González-Zuccolotto, & Carlos-Martínez, 2022). Geospatial data is vital across various fields of study as it aids the analysis and understanding of spatial relationships and patterns within our world(Silván-Cárdenas, Alegre-Mondragón, & Ruiz-Reyes, 2021; Yan, Mai, Hu, & Janowicz, 2020).

Just like a smart map with the capability to point to and provide contextual information about where things are placed, geospatial data is instrumental in making informed decisions based on the specific locations of elements. The basic components of this type of data include location information (e.g., coordinates, addresses, and regions), attributes (e.g., population, land use, elevation, and other environmental factors), and temporal data such as geographic changes over time and object movement tracking (Bill et al., 2022; Li & Hsu, 2022; Tapia-McClung et al., 2022).

Election management experts have used geospatial data several times to map voter registration details, verify voters' addresses, and appropriately assign voters to their respective electoral polling stations.

They have also been used to map the location of electoral polling units in a manner that optimises their efficient distribution across electoral jurisdictions, plan and optimise transportation of election materials and election personnel deployment, evaluate the geographical voter turnout to solve a voter apathy problem, used in map-based election results visualisation, electoral dispute resolutions, election security planning, voter accessibility analysis, and real-time election monitoring(Adeleke, Alabede, & Amusan, 2022; Bala, Pirasteh, Aliyu, Aliyu, et al., 2022; Bill et al., 2022; Chloe-Carrington, 2019; Ingwe, Odu, Ojong, & Angiating, 2012; Salifu, Sule, & Idoko, 2021; Silván-Cárdenas et al., 2021; Usman, Eneye, & Mahmud, 2021). All these speak to how profoundly useful geospatial data has been in the field of election management and administration worldwide.

2.0. Methodology

This study area covered the Osogbo Local Government Area (LGA) in Osun State, Nigeria. As shown in Figure 1, the LGA is situated at Latitudes 7°42'20" N and 7°49'20" N and Longitudes 4°30'20" E and 4°38'20" E with a population of 3,416,959 in a 17 27km² area according to Nigeria's 2006 nationwide census(Ezeamama & Ofozoba, 2023; Oluwaseun, 2014; Taiwo & Ijaware, 2024). The LGA's headquarters is in Oke-Baale, Osogbo. The LGA is subdivided into Okefia, Fagbewesa, Idi Seke, Odiolowo, Ota Efun, and Ring Road districts.

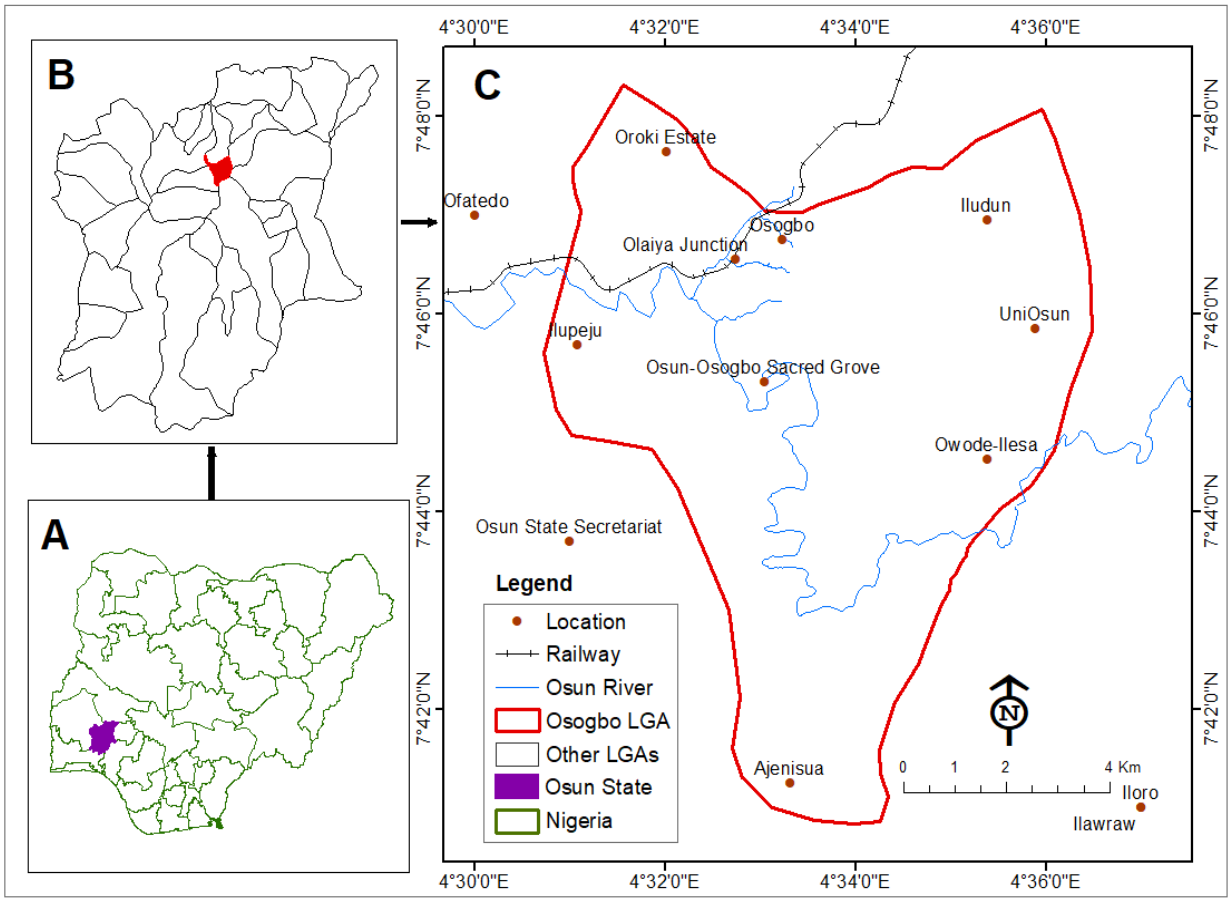


Figure 1: The study area (Insert A: Osun State in Nigeria, B: Osogbo LGA in Osun State, and C: Osogbo LGA)

The LGA's local economy focuses on agriculture, including crops like cassava, maize, and cocoa, and crafts such as weaving and dyeing. Osogbo is famous for the Osun-Osogbo Sacred Grove, which attracts tourists and spiritual followers. Other notable economic activities of the LGA include trading, artisan crafts, and small-scale industries(Agwu & Adeniran, 2009; Ezeamama & Ofozoba, 2023; Taiwo & Ijaware, 2024).

2.1 Secondary Data Collection

The spatial coordinates of 282 electoral polling units constituting the Osogbo Local Government electoral jurisdiction were sourced from the Independent National Electoral Commission (INEC) State Headquarters, Osun State. Other secondary data was sourced from the Internet, journals, manuals, textbooks, reports, archives, documents, libraries, etc.

3.0 Results and Discussions

To understand the distribution pattern of electoral polling units, the ArcGIS 10.6 software was used to plot the electoral polling units' coordinates, analyse Geospatial polling unit data, and present cartography. Microsoft Excel was used to arrange the data. Google Maps and Google Earth were used to geocode and visualise the electoral polling units, respectively.

These were followed up with a spatial statistics assessment (Average Nearest Neighbour Analysis) to determine the electoral polling unit distribution pattern within the study area.

Table 1: Extract of electoral polling units' geospatial data sourced from INEC

S/N	UP_ID	PU Name	PU Voting Strength	Latitude	Longitude
1	29/30/01/001 - 6, Winjobi Street	6, WINJOBI STREET	466	7.7778562	4.557673596
2	29/30/01/002 - 8, Laro Street	8, LARO STREET	634	7.7647062	4.555030949
3	29/30/01/003 - 26, Laro Street	26, LARO STREET	674	7.7634588	4.554451257
4	29/30/01/004 - 26, Laro Street	26, LARO STREET	609	7.7633598	4.55438789
5	29/30/01/005 - 5, Laro Street	5, LARO STREET	539	7.76475	4.555270001
6	29/30/01/006 - 10, Winjobi	10, WINJOBI	353	7.7644995	4.556080364
7	29/30/01/007 - 6, Laro Street	6 LARO STR	463	7.7650331	4.555562027
8	29/30/01/008 - Farm Settlement	FARM SETTLEMENT	213	7.734495	4.541508257
9	29/30/01/009 - Farm Settlement	FARM SETTLEMENT	344	7.734575	4.54018157
10	29/30/01/010 - Lasinmi Village I	LASINMI VILLAGE I	50	7.6981299	4.565408416

The significance levels used were 0.1, 0.05, and 0.01. In two-tailed tests, the null hypothesis is rejected when the p-value is less than α, indicating a spatial pattern is clustered or dispersed. A positive z-score means the pattern is dispersed; otherwise, it is clustered(Getis & Ord, 1992; Tata et al., 2024).

As shown in Figure 2, the spatial pattern is clustered, the p-value is less than the significance level, the z-score is negative, and electoral polling units are clustered. Essentially, the Spatial Distribution Pattern (Nearest Neighbour Analysis) of the electoral polling units in the Osogbo Local Government Area, as shown in Figures 3a and 3b, revealed that:

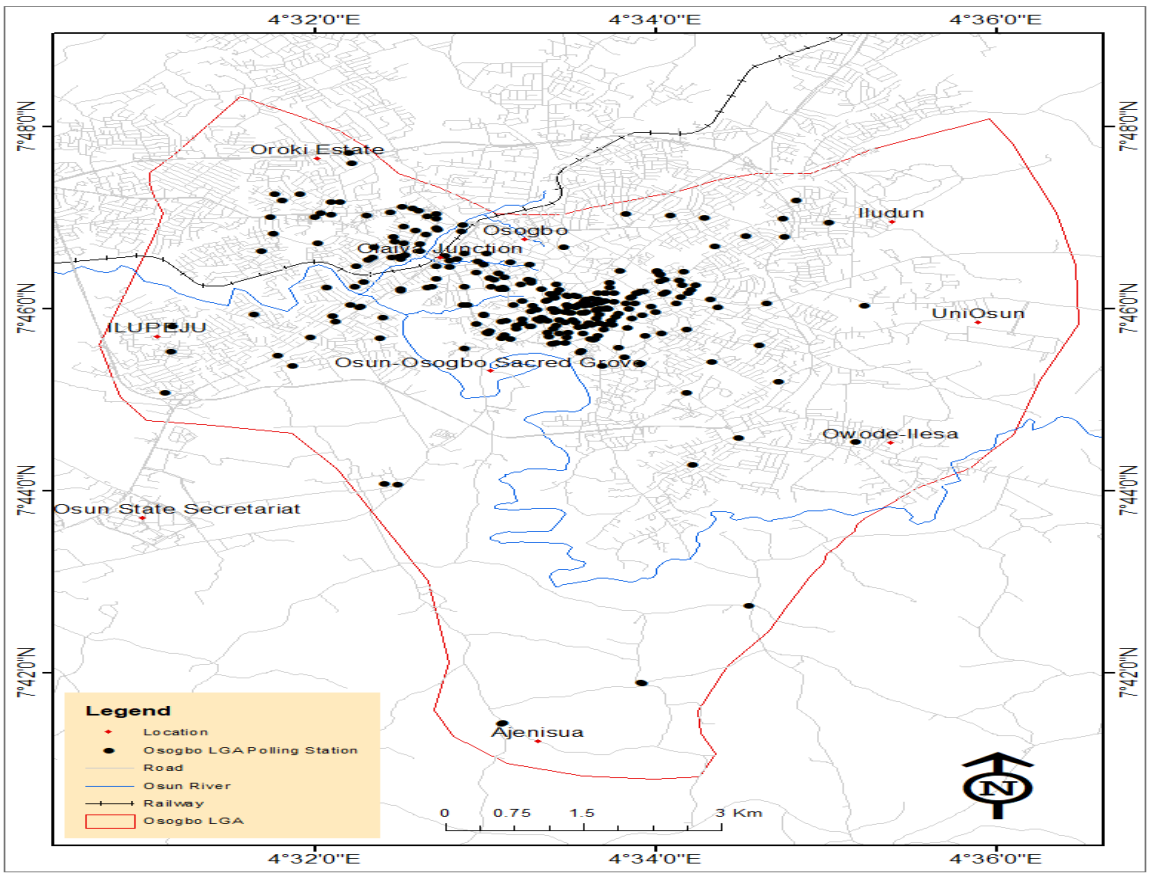
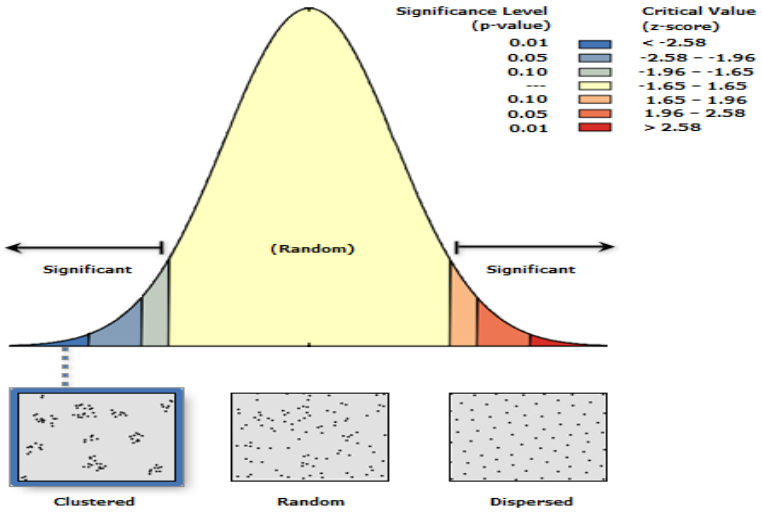


Figure 2: Polling station spatial distribution in Osogbo LGA



Average Nearest Neighbour Summary

Nearest Neighbour Ratio: 0.505620

Z-score: -15.882398
p-value: 0.000000

Given the z-score of -15.8823979795, there is less than 1% likelihood that this clustered pattern could be the result of random chance.

Figure 3a: Distribution pattern of Polling stations in Osogbo LGA

Observed Mean Distance:	138.4397 Meters
Expected Mean Distance:	273.8017 Meters
Nearest Neighbour Ratio:	0.505620
z-score:	-15.882398
p-value:	0.000000

Average Nearest Neighbour Summary

Input Feature Class:	Osogbo_Polling_Station
Distance Method:	EUCLIDEAN
Study Area:	84563179.690185
Selection Set:	False

Dataset Information

Figure 3b: Distribution pattern of Polling stations in Osogbo LGA

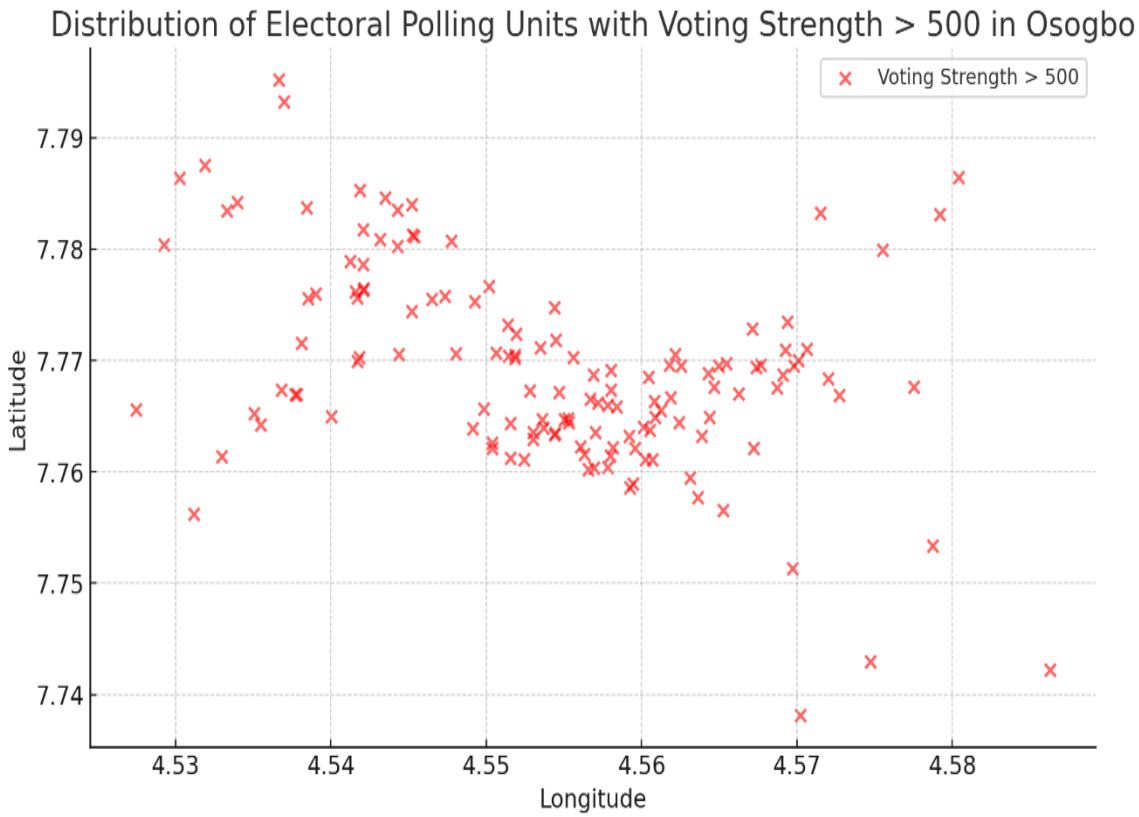


Figure 4: The scatter plot shows the spatial distribution of polling units in the Osogbo Local Government Area, where the voting strength exceeds 500.

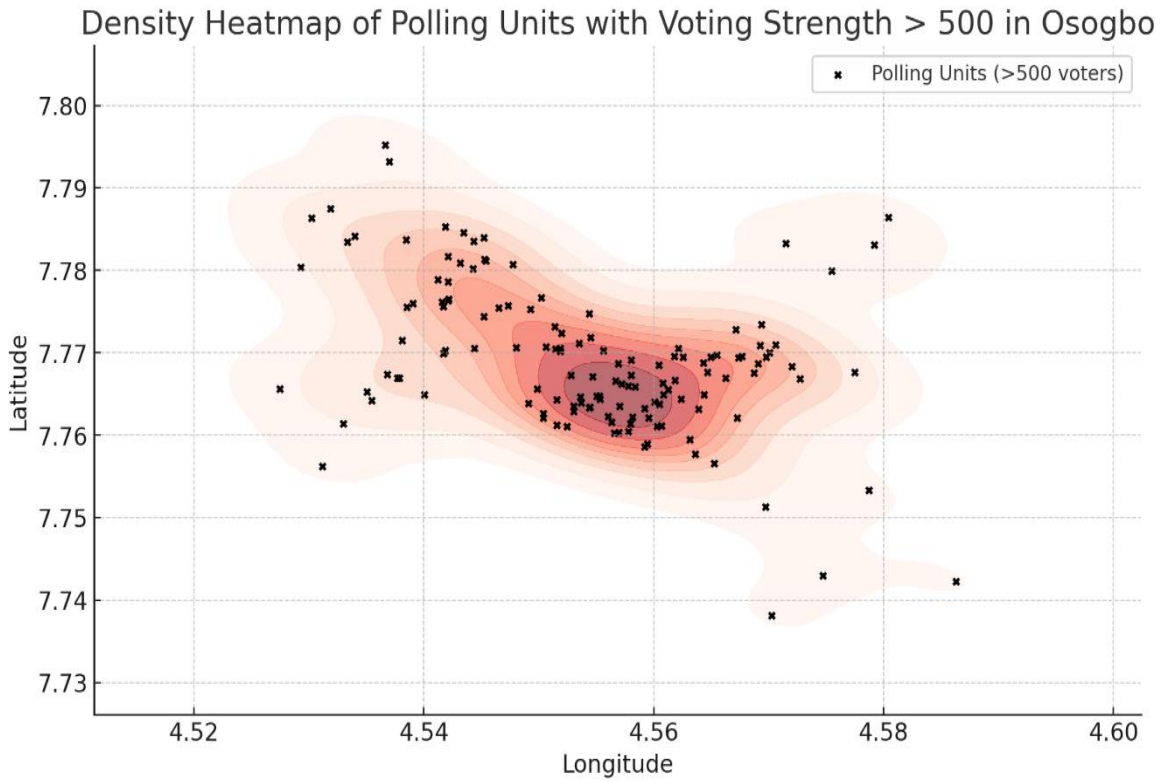


Figure 5: The density heat map highlights areas with a high concentration of polling units having more than 500 voters.

i. The Nearest Neighbour Ratio (0.5056) suggests that the polling stations were clustered, meaning that the Osogbo electoral polling units were not evenly distributed likely in certain areas rather than being randomly or regularly spaced.
ii. The z-score (-15.88) is significantly negative, and the p-value (0.000) showed that the clustering was statistically significant, not due to random chance. It probably emerged from the population density variations, urban planning, or political factors.
iii. The observed mean distance of 138. 44 meters, much lower than the expected mean distance of 273. 80 meters, emphasizing the clustering pattern of electoral polling units in the study area. There could be an over-concentration in urban areas, leaving rural areas with fewer polling units, which might impact voter accessibility

To investigate the voter accessibility in the study area, the distribution pattern of electoral polling units having a voting strength above 500 registered voters was plotted on a scatter plot, and the findings were interpreted in terms of voter accessibility.

The electoral polling units with voting strength above 500 registered voters were queried. A total of 256 electoral polling units had voting strength exceeding 500 registered voters. The navigations of electoral polling units were executed by enabling geocoding of their corresponding geospatial data, in both single and multiple ways. In terms of voter accessibility, Figure 4 provided three major insights. It showed the clustering patterns of electoral polling units that have voting strength exceeding 500 registered voters, electoral polling units with overcrowding potential, and accessibility gaps.

i. Clustering Patterns: The electoral polling units with high voting strength appeared to be clustering in particular areas, implying a likelihood of densely populated urban or semi-urban areas. In terms of voter accessibility, the concentration of electoral polling units in clustered areas may be relatively convenient for voters to access.

ii. Potential Overcrowding: It could be suggested, based on Figure 4, that the fewer electoral polling units with high voting strength may experience long queues and delays, thereby creating inconvenience and potentially impeding voter turnout.

iii. Accessibility Gaps: In the few sparsely distributed electoral polling units with high-voting strength in the less populated areas, the voters would have to cover longer distances to access that poll. This would dissuade electoral participation and complicate voter apathy

According to Figure 5 on voter accessibility analysis, the Hotspots of High Voter Density, represented by the red areas, denoted places where multiple electoral polling units with high-voting strength were closely congested. This showed that the areas were probably urban centres or densely populated neighbourhoods. The Sparse Areas, representing some areas with fewer polling units with high voting strength, confirmed potential accessibility challenges for voters in the regions. Finally, the Potential Congestion Zones, representing the densest clusters, might experience logistical tussle such as long wait times and overcrowding during elections.

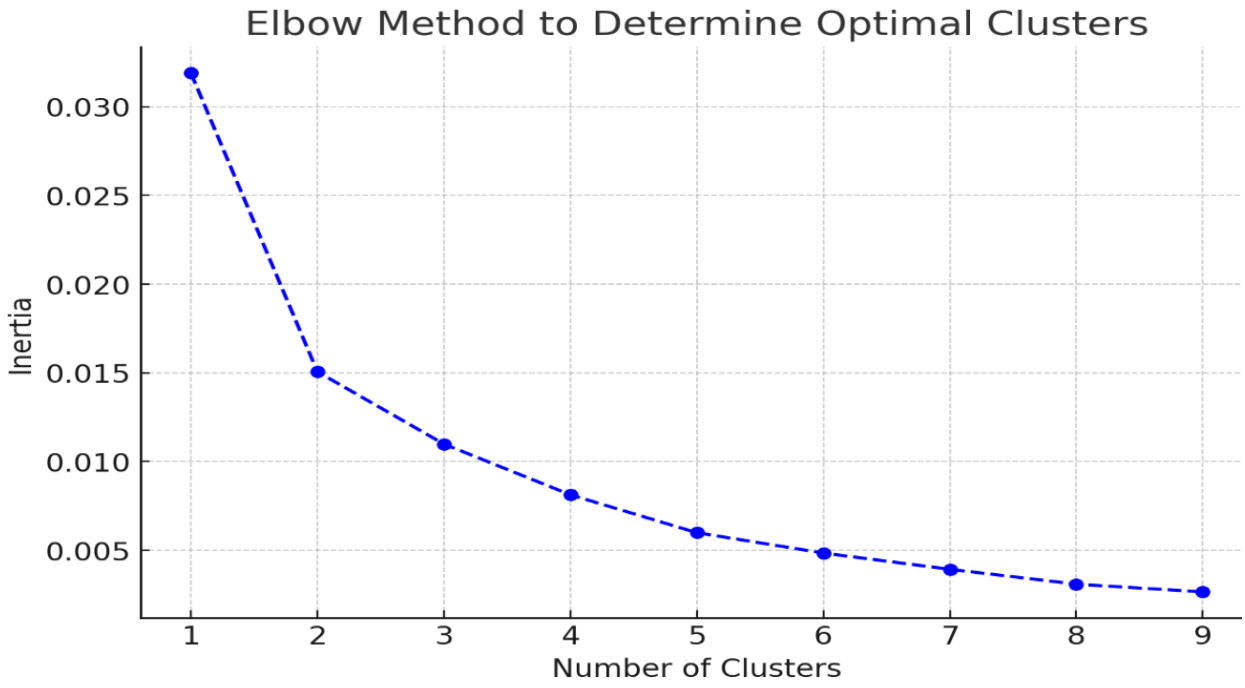


Figure 6: Elbow method determining optimal clusters

In order to identify the optimal distribution of electoral polling units in the study area, a clustering analysis was conducted. This was done to find groups of electoral polling stations with more than 500 registered voters, revealing areas that were either underserved or overcrowded. The K-Means Clustering Algorithm segmented the electoral polling units by location.

To find the optimal number of clusters, the Elbow Method Graph was plotted (Figure 6). This is achieved by identifying the elbow point where the inertia begins to decrease at a slower rate. The best clustering number was chosen, and k-means clustering was performed to visualise the electoral polling unit distribution.

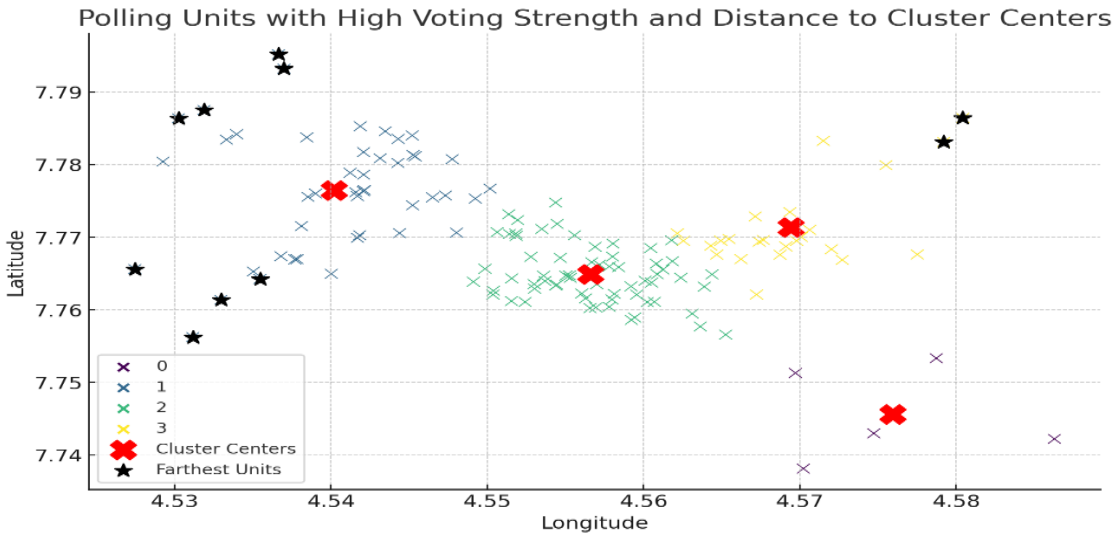


Figure 7: Clustering of electoral polling units with voting strength above 500 registered voters

The following results, as shown in Figure 7, were figured out from the clustering analysis

i. Distinct Clusters: The fact that the electoral polling units with high voting strength were grouped into four key clusters, depicted the natural voting distribution patterns.

ii. Cluster Centres (Red X markers): These represented the central locations of each cluster. These marks could be useful in the electoral logistical planning and assignment of additional voting or polling resources.

iii. Dispersed vs. Densely Packed Areas: It was noted that some clusters were more re more compact that others. This signifies better electoral polling unit accessibility. Other clusters were more spread out, suggesting a need for better or additional electoral polling units

The distance analysis was done to identify underserved areas and recommend electoral polling unit optimisation. This was done by analysing the distances between the electoral polling units and their cluster centres to check for potential voter accessibility challenges. This was done to help identify the underserved areas where the electoral polling units were far from the cluster centres. The distances were computed to do this, and the farthest electoral polling units from their respective centres were highlighted. The outcome is visualised in Figure 8. Based on the distance analysis, the following are the findings on the underserved electoral polling units, as shown in Figure 8.

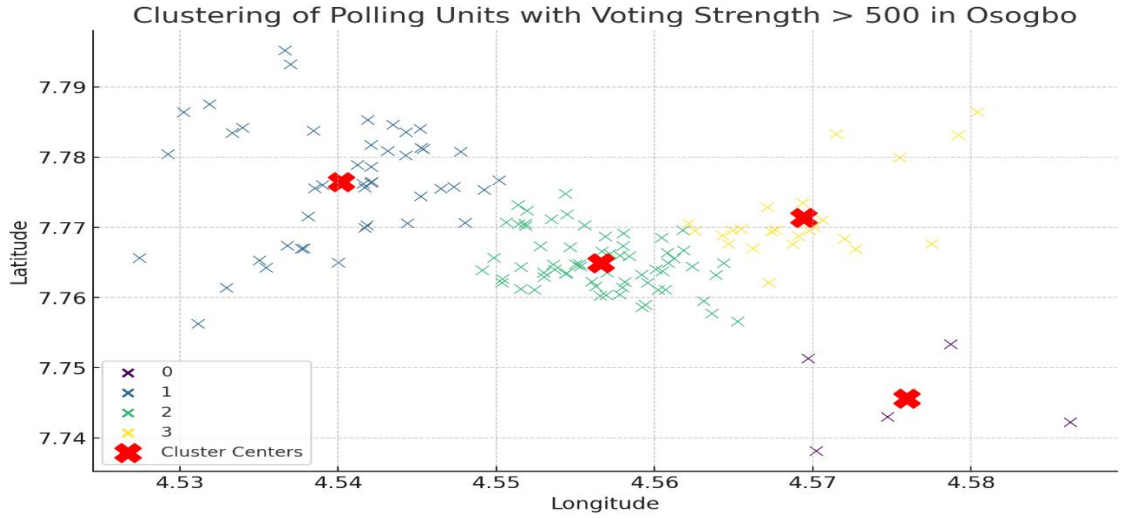


Figure 8: The electoral polling units with high voting strength and distance to cluster centres

i. Polling units farthest from cluster centres: The black stars on the scatter plot signify the electoral polling units that are significantly farther from their respective cluster centres. They may pose voter accessibility challenges.
ii. Potential accessibility challenges: The electorates in these areas may need to walk longer distances. These may lead to lower voter turnout and logistical issues during elections.
iii. Polling units with the longest distances are:
    a. Oba Iyiola Oyewale Govt Pry School, Ajagbe Area (522 registered voters)
    b. Gbadebo Street, Behind A.U.D Pry School I & II (969 and 899 registered voters)
    c. Open Space Beside Jerry Paul Filling Station (729 registered voters)

4.0 Conclusion

This study established that the electoral polling unit distribution pattern in the Osogbo Local Government Area is clustered. It also identified Oba Iyiola Oyewale Govt Pry School, Ajagbe Area (522 registered voters), Gbadebo Street, Behind A.U.D Pry School I & II (969 and 899 registered voters) and Open Space Beside Jerry Paul Filling Station (729 registered voters) as the electoral polling unit with the longest distance.
The study, therefore, recommends increasing polling Units: Adding more electoral polling units closer to long-distance areas should be considered to reduce voter congestion and optimise polling management on election day. A better road network and improved road infrastructure should be considered to better aid voter access to the polls. The deployment of extra election staff and election materials to the distant electoral polling units may prevent delays on election days.

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