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Mapping the Spatial Distribution of Socio-economic Facilities in Asaba Delta State

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Abstract
This study examined the spatial distribution of socio-economic facilities within Asaba, Delta State, Nigeria, employing geospatial techniques to assess patterns of clustering, randomness, or dispersion. The analysis focused on seven categories of facilities: financial, educational, leisure, transportation, religious, health, and security. Spatial analysis was conducted using the Average Nearest Neighbor (ANN) tool in a Geographic Information System (GIS) environment to quantify spatial relationships among facility locations. Results indicated that financial, health, transportation, and security facilities exhibit statistically significant dispersion, implying strategic locational decisions. Leisure facilities displayed a clustered pattern, suggesting the influence of socio-cultural demand zones. Conversely, educational and religious facilities revealed random distributions, reflecting unregulated development or varied community-level initiatives. Overall, the integration of all facilities revealed a general pattern of randomness. These findings underscore the uneven spatial logic underpinning infrastructure planning in Asaba and highlight the need for integrative urban development strategies to ensure equitable service provision.

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1. Introduction
Urban planning and infrastructure development in rapidly growing cities face persistent challenges regarding spatial equity and resource distribution. The equitable arrangement of socio-economic amenities constitutes a central component of sustainable urban development, as uneven distribution often leads to exclusionary outcomes for vulnerable populations (Nicoletti *et al*., 2022) [6]. Geographic Information Systems (GIS) have emerged as powerful instruments for diagnosing spatial disparities, enabling the visualization and quantification of both concentration and service gaps (Siqueira-Gay *et al*., 2019) [9].

Studies within the Nigerian context underscore significant intra-urban variation in facility accessibility. For example, accessibility to emergency obstetric care in major Nigerian cities demonstrates disparities correlated with wealth quintiles (Wong *et al*., 2024) [10]. Research on medium-sized cities such as Ilesa has likewise revealed uneven distributions of health facilities, which impede equitable access to essential services (Adetunji, 2013) [1]. Similarly, analyses of market distributions in cities like Akure identified spatial randomness and established correlations between locational patterns and household mobility behaviors (Adetunji, 2021) [2]. Facility clustering often aligns with social and commercial demand zones. Leisure amenities and transportation nodes tend to aggregate around central business districts and major road networks (Siqueira-Gay *et al*., 2019) [9]. Comparable tendencies have been documented in Lagos and Delta State more broadly, where urban expansion and land-use dynamics have shaped socio-spatial patterns (MDPI, 2022). In Asaba, mapping of street networks and drainage channels using GIS techniques has highlighted the spatial logic that underpins urban infrastructure (Ojiako *et al*., 2018; GJETA, 2024) [7, 3].

Despite notable advancements in spatial analysis applications, few empirical studies have integrated multi-sectoral facility categories within a single urban locality. Evaluating financial, educational, leisure, transport, religious, health, and security facilities in a unified spatial framework remains rare in Nigeria, particularly for capital cities such as Asaba.

The city's rapid growth—exceeding half a million residents—and strategic position along the Niger River make it an ideal candidate for such comprehensive study.

The present research addresses this critical gap by mapping and analyzing the spatial distribution of seven socio-economic facility categories within Asaba. Objectives include determining whether each category exhibits clustering, randomness, or dispersion, assessing statistical significance using Nearest Neighbor analysis, and interpreting the locational logic underpinning these patterns. Such evaluation has significant implications for urban governance and infrastructure planning in similar secondary cities experiencing rapid demographic and economic transformation (Ossai & Oliha, 2023) [8]; (IIARD, 2025).

This research contributes to scholarship on urban spatial equity by integrating multi-sectoral facility analysis within a GIS framework in a developing world context. Insights derived may inform the formulation of evidence-based spatial policies and support equitable development strategies in Asaba and comparable urban environments. Geospatial evaluation of socio-economic facility distribution thus becomes instrumental in remedying service gaps and promoting inclusive urban growth.

2. Materials and Methods

2.1 Description of the Study Area

Asaba, the capital city of Delta State, Nigeria, lies within the southern part of the country along the western banks of the River Niger. It is geographically positioned between latitudes 6°10′ and 6°15′ North and longitudes 6°40′ and 6°45′ East. The city occupies a strategic location as a regional hub for administration, commerce, and transportation. Asaba exhibits a typical humid tropical climate characterized by a wet season (April to October) and a dry season (November to March), with annual rainfall exceeding 1,800 mm and average temperatures ranging from 24°C to 32°C. The city has experienced significant urban growth due to administrative centralization, commercial expansion, and population influx, which has led to uneven development in socio-economic infrastructure distribution.

2.2 Data Sources and Types

This study utilized both primary and secondary geospatial datasets. The primary data consisted of geographic coordinates and attribute information of socio-economic facilities. These facilities were categorized into seven thematic groups: financial institutions (banks, ATMs), educational facilities (primary, secondary schools, and tertiary institutions), leisure centers (recreational parks, hotels, event venues), transportation facilities (motor parks, bus terminals, major transport junctions), religious centers (churches and mosques), healthcare facilities (hospitals, clinics, primary health centers), and security infrastructure (police stations, fire service units, and civil defense posts).

The acquisition of facility data involved the use of Global Positioning System (GPS) devices (Garmin eTrex 30x) to collect the precise spatial coordinates. Field surveys were conducted with handheld GPS receivers to geo-locate the facilities and gather attribute data such as facility type, capacity, and operational status.

Secondary data included high-resolution base maps of Asaba obtained from the Delta State Ministry of Lands and Surveys. These base maps were used to delineate administrative boundaries, road networks, and hydrological features. Satellite imagery from Google Earth Pro was also employed for cross-validation of facility locations and urban structure.

2.3 Hardware and Software Requirements

The hardware components included a high-performance workstation configured with an Intel i7 processor, 32 GB RAM, and a 2 TB SSD drive, suitable for intensive spatial data processing. GPS receivers and mobile Android devices were used for field data acquisition. The software environment consisted of:

1. ArcGIS 10.8 (Esri Inc.) for spatial analysis and cartographic visualization.
2. Microsoft Excel 2019 for data tabulation and preprocessing.
3. Google Earth Pro for pre-field reconnaissance and coordinate verification.
4. QGIS 3.28 for additional spatial processing and validation of GIS outputs.

2.4 Methodological Framework

The methodological framework followed a systematic sequence of data collection, processing, spatial analysis, and interpretation.

2.4.1 Geospatial Data Collection and Digitization

All field data were geo-referenced using the World Geodetic System 1984 (WGS 84) datum and projected to Universal Transverse Mercator (UTM) Zone 31N. The GPS points collected were exported and compiled into a geodatabase. Each facility was digitized as a point feature and attributed according to its category, name, and functional status.

2.4.2 Spatial Pattern Analysis Using Nearest Neighbor Statistics

The spatial distribution of the mapped facilities was analyzed using the Average Nearest Neighbor (ANN) tool in ArcGIS. This statistical tool measures the distance between each feature and its closest neighboring feature, then compares this observed average distance to the expected average distance in a hypothetical random distribution.

The ANN ratio is calculated using the following formula:

$$\text{ANN Ratio} = \frac{\text{Observed Mean Distance}}{\text{Expected Mean Distance}}$$

Where:

The observed mean distance is the average of all nearest neighbor distances among actual facility locations.

The expected mean distance is computed based on a Poisson distribution, assuming complete spatial randomness (CSR) and uniform distribution within the study boundary.

The statistical significance of the observed pattern was evaluated using z-scores and p-values. The interpretation of ANN results follows this framework:

ANN ratio < 1, with statistically significant z-score: Clustered

ANN ratio ≈ 1, with statistically insignificant z-score: Random

ANN ratio > 1, with statistically significant z-score: Dispersed

2.4.3 Spatial Visualization and Mapping

The spatial patterns were visualized using graduated symbol and thematic point maps. Each facility category was mapped individually and then collectively to assess both disaggregated and cumulative spatial structures. Thematic maps were classified using equal interval classification and overlaid on base layers to evaluate proximity to major roads, urban centers, and other spatial determinants.

3. Results

2.5 Spatial Distribution of Financial Facilities in Asaba Delta State

The spatial distribution of financial facilities in Asaba was calculated by employing average nearest neighbor analysis. Average Nearest Neighbor analysis measured the distance between each feature centroid and its nearest neighbor's centroid location. It then averaged all these nearest neighbor distances. If the averaged distance is less than the average for a hypothetical random distribution, the distribution of the features being analyzed is considered clustered. If the averaged distance is greater than a hypothetical random distribution, the features considered dispersed. The average nearest neighbor ratio is calculated as the observed average distance divided by the expected average distance (with expected average distance being based on a hypothetical random distribution with the same number of features covering the same total area).

The results gave an observed mean distance of 548.3893m, expected mean distance of 8.2704m, nearest neighbor ratio of 66.307579, p-value and z-score of 0.000 and 819.27 respectively. This indicated that the spatial distribution of the financial facilities were dispersed and given the z-score of 819.27, and p-value of 0.000 at confidence level of 99%, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance, meaning that the locations of these financial facilities were strategically located along the major expressway instead of random occurrence, see Figure 1.

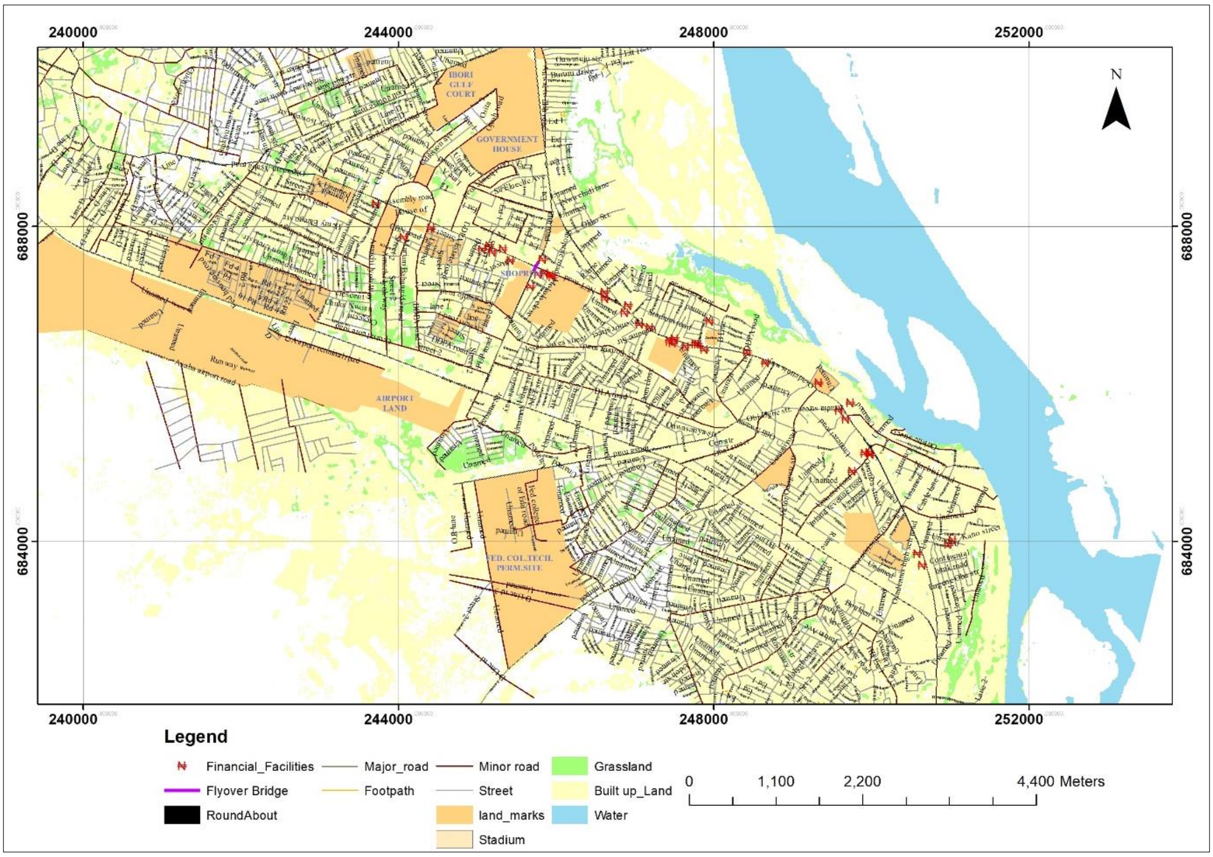

Fig 1: Spatial Distribution of Financial Facilities in Asaba

2.6 Spatial Distribution of Educational Facilities in Asaba Delta State

The spatial distribution results of educational facilities gave an observed mean distance of 365.0555m, expected mean distance of 406.1366m, nearest neighbor ratio of 0.898849, p-value and z-score of -1.340667and 0.180028 respectively. This indicated that the spatial distribution of the educational facilities was randomly distributed and given the z-score of -1.340667and p-value of 0.180028 at confidence level of 82%, the pattern does not appear to be significantly different than random, meaning that the locations of these educational facilities were of random occurrence, see Figure 2.

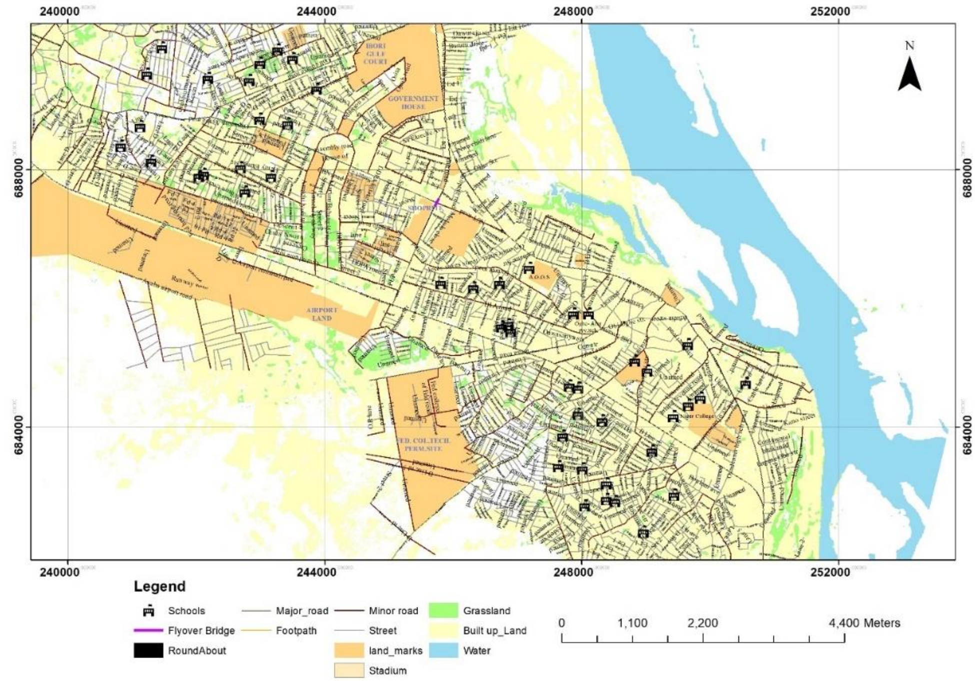

Fig 2: Spatial Distribution of Educational Facilities in Asaba

2.7 Spatial Distribution of Leisure Facilities in Asaba Delta State

The spatial distribution results of leisure facilities gave an observed mean distance of 454.2770m, expected mean distance of 534.4175m, nearest neighbor ratio of 0.850041, p-value and z-score of 0.059944 and -1.881208 respectively. This indicated that the spatial distribution of the leisure facilities were clustered and given the z-score of -1.881208, and p-value of 0.059944 at significant level of 0.05, there is a less than 10% likelihood that this clustered pattern could be the result of random chance., meaning that the clustering of the locations of these leisure facilities were not randomly occurring, see Figure 3.

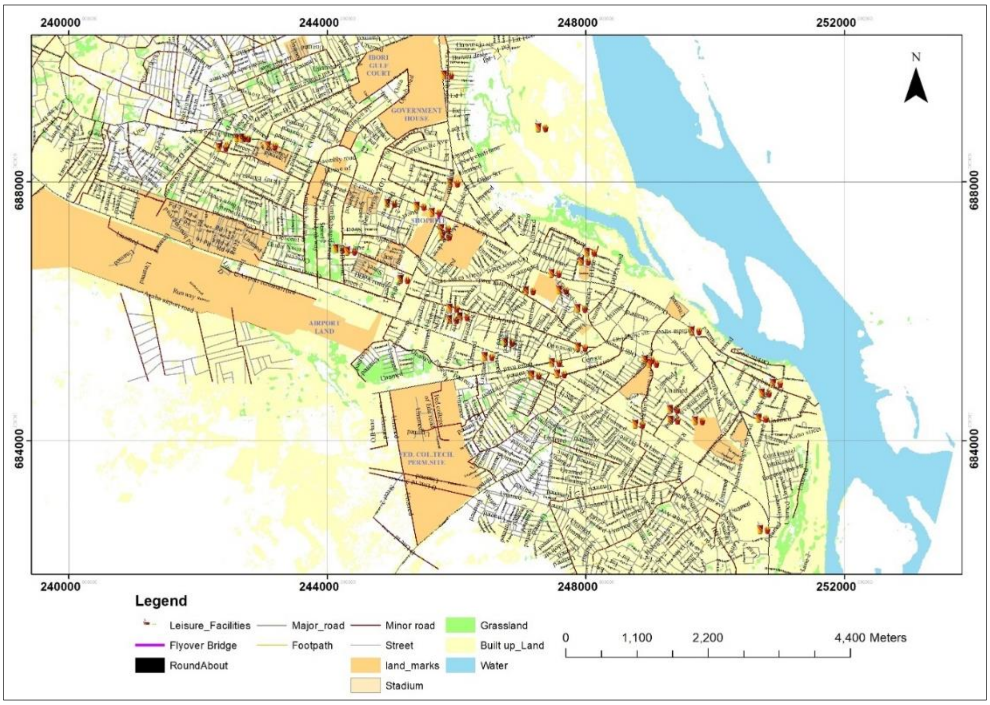

Fig 3: Spatial Distribution of Leisure Facilities in Asaba

2.8 Spatial Distribution of Transportation Facilities in Asaba Delta State

The spatial distribution results of transportation facilities gave an observed mean distance of 529.5722m, expected mean distance of 699.2427m, nearest neighbor ratio of 0.757351, p-value and z-score of 0.000116 and 3.853979 respectively. This indicated that the spatial distribution of the transportation facilities were dispersed and given the z-score of -1.856818, and p-value of 0.063337 at significant level of 0.10%, there is a less than 10% likelihood that this clustered pattern could be the result of random chance, meaning that the locations of these transportation facilities were strategically clustered at the roadsides, see Figure 4.

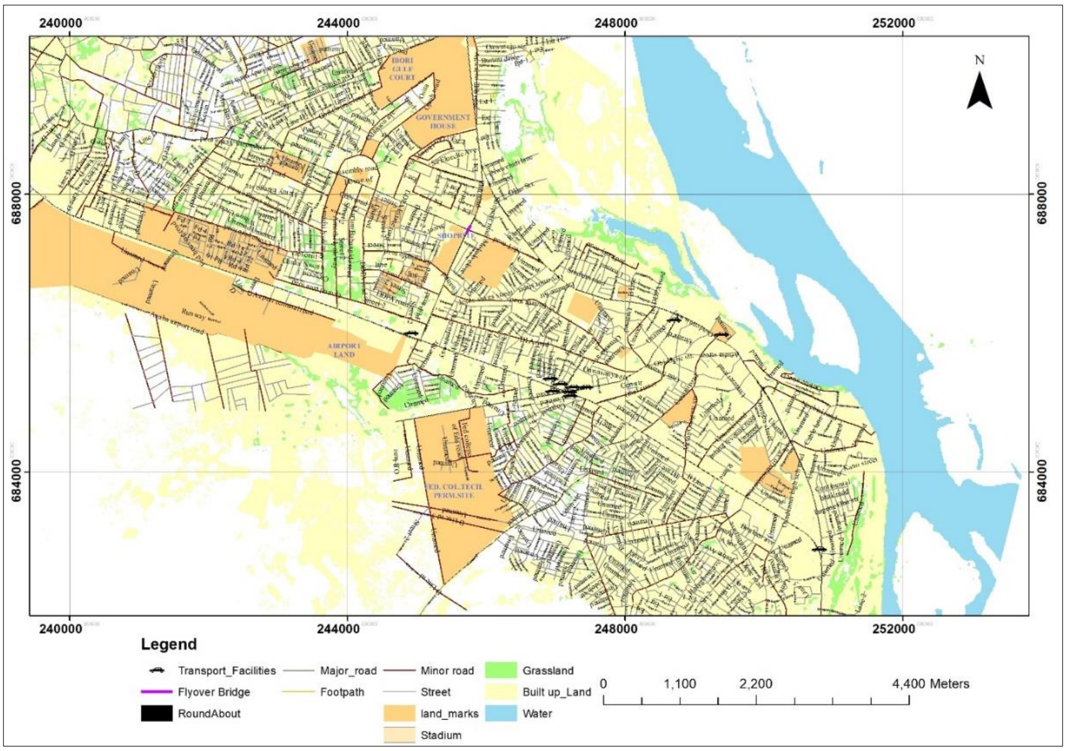

Fig 5: Spatial Distribution of Transportation Facilities in Asaba

2.9 Spatial Distribution of Religious Facilities in Asaba Delta State

The spatial distribution results of religious facilities gave an observed mean distance of 665.1922m, expected mean distance of 648.6065m, nearest neighbor ratio of 1.025571, p-value and z-score of 0.831144 and 0.213235 respectively. This indicated that the spatial distribution of the religious facilities was random and given the z-score of 0.213235, and p-value of 0.831144 at confidence level of 99%, the pattern does not appear to be significantly different than random., meaning that the locations of these religious facilities were of random occurrence, see Figure 6.

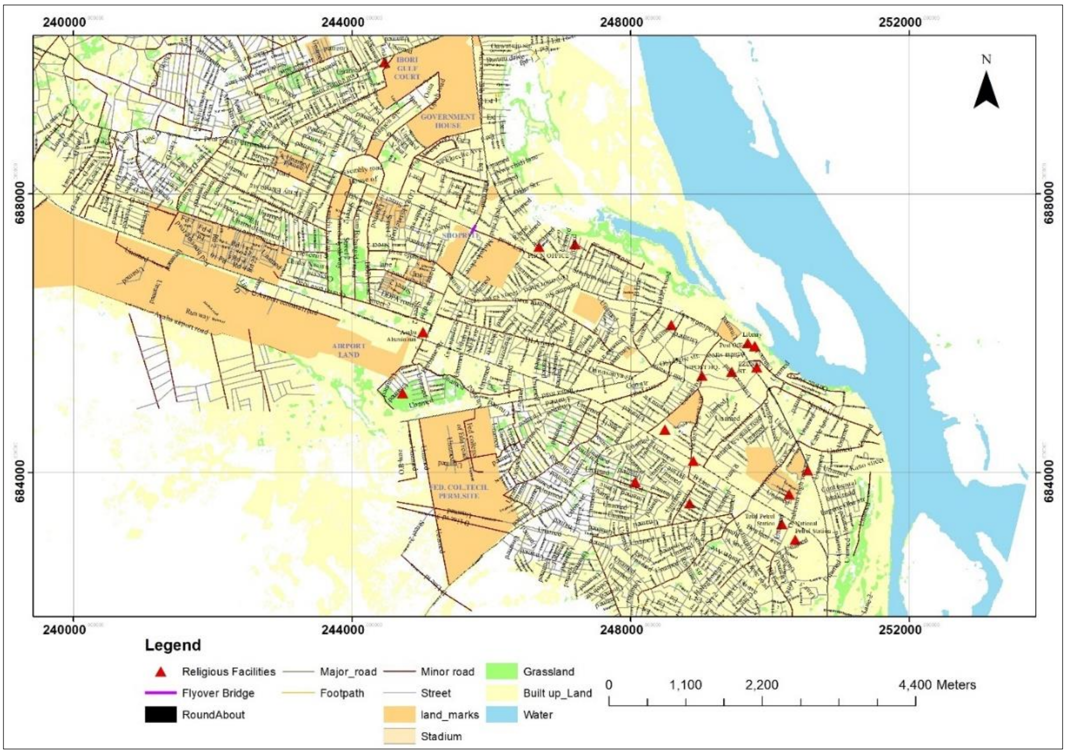

Fig 6: Spatial Distribution of Religious Facilities

2.10 Spatial Distribution of Health Facilities in Asaba Delta State

The spatial distribution results of Health facilities gave an observed mean distance of 33340.9907m, expected mean distance of 5980.9488m, nearest neighbor ratio of 5.574532, p-value and z-score of 0.000 and 33.894028 respectively. This indicated that the spatial distribution of the Health facilities were dispersed and given the z-score of 33.894028, and p-value of 0.0000 at confidence level of 99%, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance, meaning that the locations of these Health facilities were strategically located instead of random occurrence, see Figure 7.

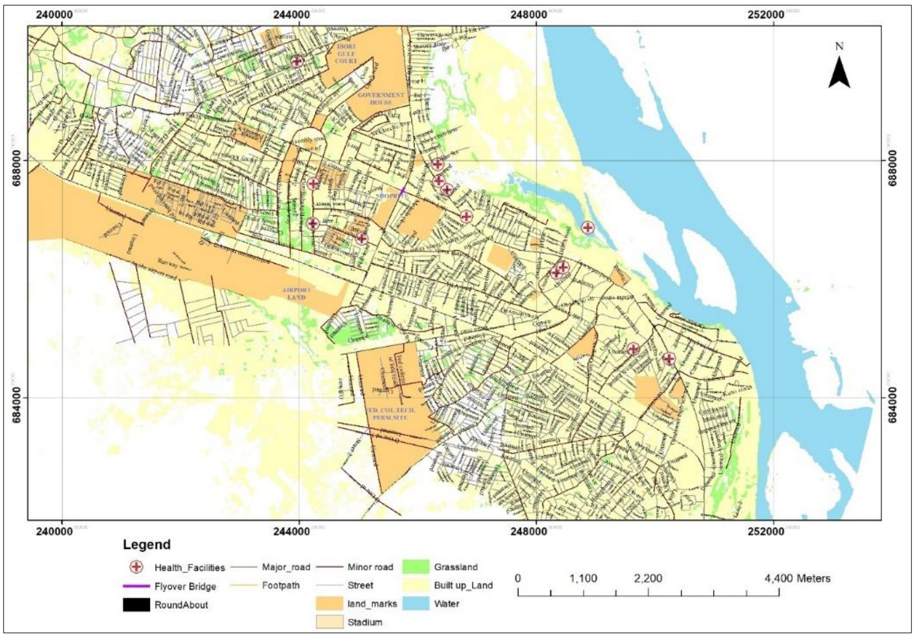

Fig 7: Spatial Distribution of Health Facilities

2.11 Spatial Distribution of Security Facilities in Asaba Delta State

The spatial distribution results of security facilities gave an observed mean distance of 1263.9971m, expected mean distance of 773.7375m, nearest neighbor ratio of 1.633625, p-value and z-score of 0.002986 and 2.969197 respectively. This indicated that the spatial distribution of the security facilities were dispersed and given the z-score of 2.969197, and p-value of 0.002986 at confidence level of 99%, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance, meaning that the locations of these security facilities were located at strategic points instead of random occurrence, see Figure 8.

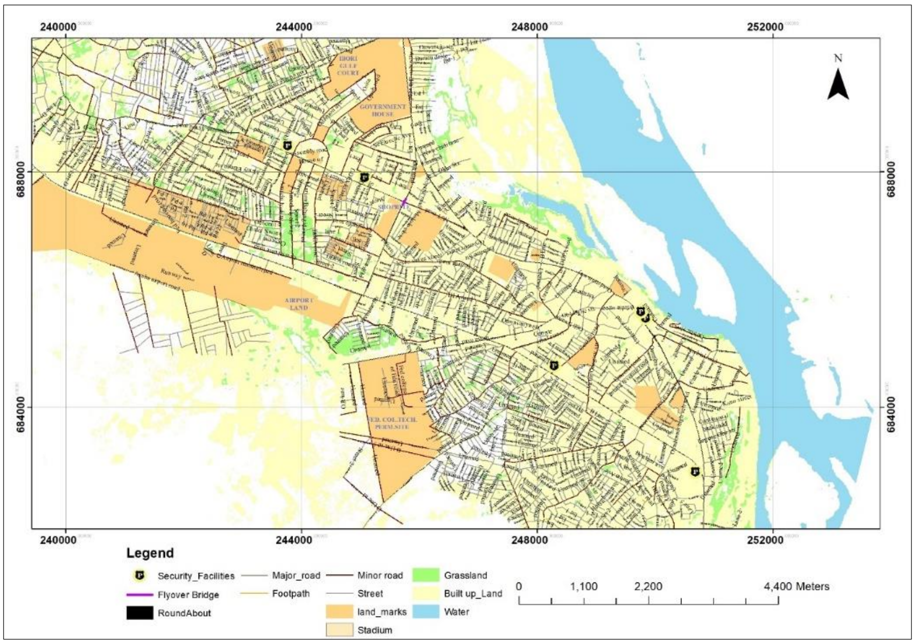

Fig 8: Spatial Distribution of Security Facilities

2.12 Summary of the Spatial Distribution of Socio-economic Facilities in Asaba Delta State

The overall spatial distribution results of the socio-economic facilities gave an observed mean distance of 2785.1665m between facilities, expected mean distance of 2671.0804m, nearest neighbor ratio of 1.042712, p-value and z-score of 0.260039 and 1.126299 respectively. This indicated that the spatial distribution of the socio-economic facilities were randomly distributed and given the z-score of 1.126299, and p-value of 0.260039 at confidence level of 99%, the pattern of distribution of the facilities does not appear to be significantly different than random, meaning that the overall locations of these facilities were of random occurrence if the facilities are grouped together, see Figure 9.

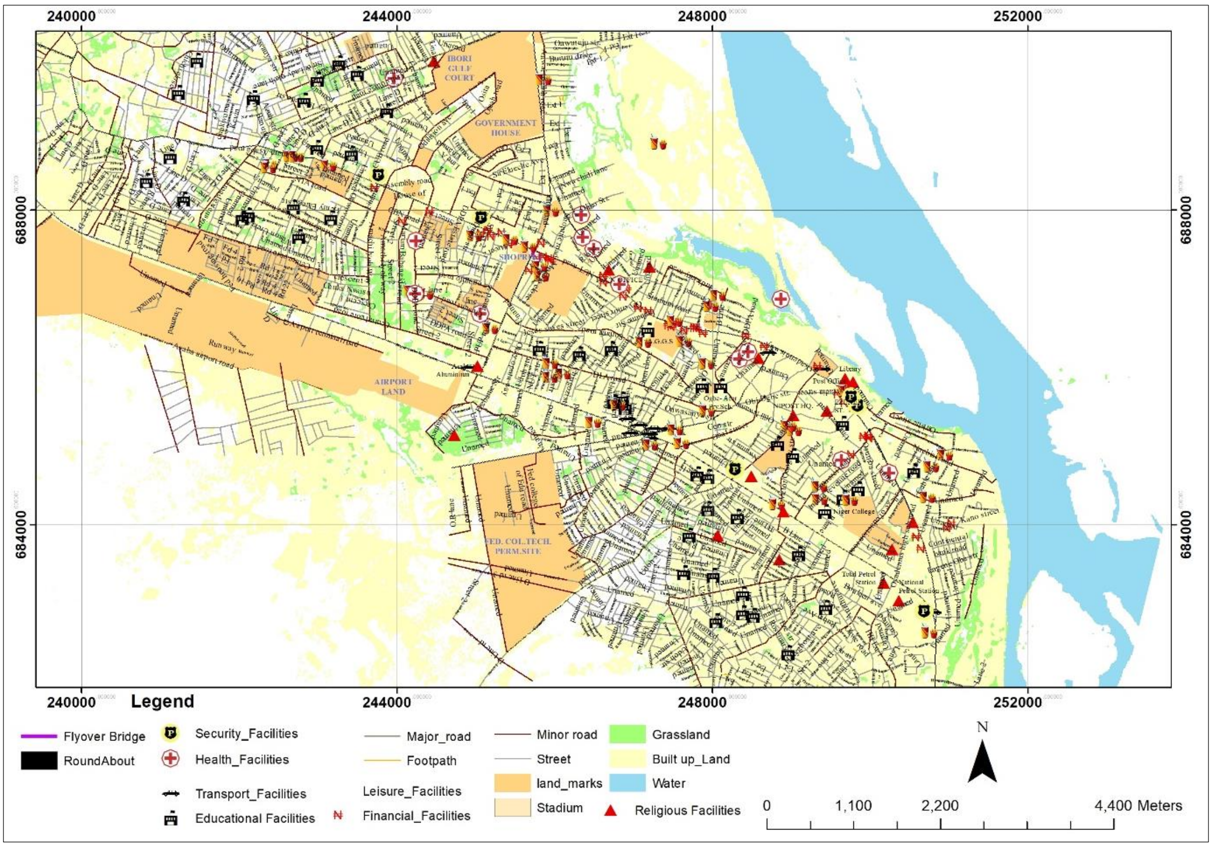

Fig 9: Spatial Distribution of Socio-economic Facilities in Asaba

In summary, the overall results of the analysis of spatial distribution of the socio-economic facilities indicated that the facilities were randomly distributed and given the z-score of 1.126299, and p-value of 0.260039 at confidence level of 99%, the pattern of distribution of the facilities does not appear to be significantly different than random.

When analyzed individually, the results indicated that the spatial distribution of the financial facilities were dispersed and given the z-score of 819.27, and p-value of 0.000 at confidence level of 99%, there is a less than 1% likelihood that this dispersed pattern could be the result of random chance, meaning that the locations of these financial facilities were strategically located.

For educational facilities, the results indicated that its spatial distribution was of random occurrence and given the z-score of -1.340667and p-value of 0.180028 at confidence level of 82%, the pattern does not appear to be significantly different than random.

For leisure facilities, the results indicated that its spatial distribution were clustered and given the z-score of -1.881208, and p-value of 0.059944 at significant level of 0.05, there is a less than 10% likelihood that this clustered pattern could be the result of random chance., meaning that the clustering of the locations of these leisure facilities were not randomly occurring.

For transportation facilities, the results indicated that its spatial distribution were dispersed and there is a less than 10% likelihood that this clustered pattern could be the result of random chance, meaning that the locations of these transportation facilities were strategically clustered at the roadsides.

For religious facilities, the results indicated that its spatial distribution was random and the pattern does not appear to be significantly different than random., meaning that the locations of these religious facilities were just random occurrence.

For Health facilities, the results indicated that its spatial distribution were dispersed and there is a less than 1% likelihood that this dispersed pattern could be the result of random chance, meaning that the locations of these Health facilities were strategically located instead of random occurrence.

And lastly, the results for the distribution of security facilities indicated that the security facilities were dispersed and there is a less than 1% likelihood that this dispersed pattern could be the result of random chance, meaning that the locations of these security facilities were located at strategic points instead of random occurrence. This means that financial facilities, transportation facilities, health facilities, leisure facilities and security facilities were the only strategically positioned facilities, the positioning of the rest of the facilities like religion and educational were just at random occurrence.

The findings from this analysis underscore a critical planning paradox. While some facilities, notably financial, transportation, security, and health services, demonstrate evidence of strategic planning, others like educational and religious facilities follow a decentralized or unregulated growth pattern. This spatial inconsistency has practical implications for service accessibility, land-use efficiency, and spatial equity. For instance, random or clustered distributions may result in spatial redundancies or service voids, undermining the efficiency of resource allocation.

Urban planners, policy-makers, and development agencies must adopt a more integrative geospatial planning framework to address these disparities. Facility siting decisions should be guided by demographic demand modeling, accessibility analysis, and multi-sector spatial congruence to ensure optimized urban service delivery.

3. Conclusion

This study examined the spatial distribution patterns of socio-economic facilities in Asaba, Delta State, employing geospatial techniques and the Average Nearest Neighbor (ANN) statistical model to evaluate the locational logic and spatial arrangement of key infrastructure categories. The facilities analyzed included financial institutions, educational establishments, leisure centers, transportation hubs, religious institutions, healthcare facilities, and security installations. Each of these categories plays a distinct role in the urban system, influencing socio-economic interactions, accessibility, and quality of life within the city.

The results demonstrated significant variability in the spatial arrangement of different facility types. Financial, healthcare, and security facilities were found to exhibit dispersed patterns, suggesting that their placement was influenced by planning considerations aimed at optimizing spatial coverage and accessibility. The dispersed arrangement of health and security infrastructure, in particular, underscores an attempt to ensure that essential services are equitably distributed across the city landscape, thereby promoting resilience and public safety.

Conversely, educational and religious facilities were characterized by random spatial distributions, indicating limited central oversight in their siting. These facilities tend to emerge based on localized demand, community initiative, or private investment without a formal spatial plan. While this organic growth model can be advantageous in meeting immediate local needs, it also increases the risk of uneven service provision, potential redundancy in high-density zones, and under-provision in peripheral or underserved areas.

Leisure and transportation facilities exhibited clustered spatial distributions, with the clustering of leisure amenities reflecting commercial agglomeration tendencies in central business districts and socially active corridors. The clustering of transportation nodes along major roadways and entry points into the city further reflects their functional dependence on high mobility corridors, consistent with transport planning norms. However, this clustering may exclude residents in less-connected areas and necessitates the introduction of supporting intra-city transportation infrastructure.

When all socio-economic facilities were analyzed collectively, the resultant spatial pattern approached randomness. This indicates a lack of integrated spatial coordination across the various infrastructure categories. Such randomness can lead to infrastructural inefficiencies, overlapping service jurisdictions, and service access inequalities, particularly in rapidly growing urban centers like Asaba.

The study reinforces the value of geospatial analysis in diagnosing the spatial health of urban infrastructure systems. The findings suggest that while some sectors exhibit evidence of strategic planning, others are developing in an unregulated spatial context. This imbalance necessitates an urgent policy shift toward comprehensive spatial planning that is evidence-based, participatory, and supported by geospatial data infrastructure.

For sustainable urban development, future urban infrastructure planning in Asaba should adopt a multi-sectoral geospatial decision-support framework that integrates land use planning, demographic projections, and facility access modeling. Spatial equity, service efficiency, and resilience must become guiding principles in the deployment of socio-economic infrastructure to address the growing complexity and dynamism of urban growth in the city. Moreover, the institutionalization of GIS in urban governance processes will enhance the ability of planners to monitor, evaluate, and reallocate resources in ways that support inclusive and balanced urban development.

4. References

1. Adetunji MA. Spatial distribution pattern and accessibility of urban population to health facilities in Southwestern Nigeria: The case study of Ilesa. Mediterr J Soc Sci. 2013;4(3):123–31. Available from: https://www.researchgate.net/publication/272709422
2. Adetunji MA. The impact of geo-spatial distribution of markets on household travel patterns in Akure Metropolis, Nigeria. Hasanuddin Econ Bus Rev. 2021;5(2):113–25. Available from: https://www.researchgate.net/publication/355794977
3. GJETA. Mapping and analysis of urban drainage system in Asaba Metropolis using remote sensing and GIS. Glob J Eng Technol Adv. 2024;10(3):72–85. Available from: https://gjeta.com/sites/default/files/GJETA-2024-0030.pdf
4. IIARD. GIS-based assessment of the spatial pattern and accessibility of health facilities in Nigeria. Int J Health Pharm Res. 2025;10(5):1–17. Available from: https://www.iiardjournals.org/get/IJHPR/VOL.%2010%20NO.%205%202025/GIS-BASED%20ASSESSMENT%20OF%20THE%20SPATIAL%201-17.pdf
5. MDPI. Analysis of the spatial pattern of urban expansion in African cities. Land. 2022;11(3):558. Available from: https://doi.org/10.3390/land11030558
6. Nicoletti L, Sirenko M, Verma T. Disadvantaged communities have lower access to urban infrastructure. arXiv. 2022. Available from: https://arxiv.org/abs/2203.13784
7. Ojiako JC, Igbokwe EC, Ossai EN. Application of GIS and remote sensing for analysis of Asaba urban street network. Int J Adv Stud Res Educ. 2018;5(2):45–53. Available from: https://www.academia.edu/35890386
8. Ossai EN, Oliha AO. The integral role of surveyors in the development and management of smart cities: A case study of Asaba, Delta State, Nigeria. J Urban Reg Innov.

2023;9(1):65–78. Available from: https://www.researchgate.net/publication/377329415
9. Siqueira-Gay J, Giannotti MA, Sester M. Learning about spatial inequalities: Capturing heterogeneity in urban environments. arXiv. 2019. Available from: https://arxiv.org/abs/1908.00625
10. Wong KLM, Banke-Thomas A, Olubodun T, Wright KD, Ameh CA. Socio-spatial equity analysis of comprehensive emergency obstetric care accessibility in urban Nigeria. Commun Med. 2024;4:58. Available from: https://doi.org/10.1038/s43856-024-00458-2