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THIESSEN MAPPING OF SPATIAL FEATURES INFLUENCE ON COMMERCIAL REAL ESTATE INVESTMENT IN IKEJA, LAGOS STATE

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ABSTRACT

Purpose: This study uses Thiessen polygons to examine the spatial influence of key spatial features on commercial real estate investment viability in Ikeja, Lagos.

Methodology: Data were obtained from 141 estate surveying and valuation firms and 143 appraised commercial properties across seven commercial operational sectors of Ikeja. Spatial factors were identified and ranked through weighted mean score analysis and their interrelationships were examined through Kendall's tau-b correlation analysis. Thiessen polygon maps were generated in ArcGIS 10.2 for five spatial features; bus stations, Ikeja Mall, Murtala Muhammad International Airport, Alausa Secretariat, and Ikeja Government Reserved Area (GRA).

Findings: The results show that closeness to building line, proximity to major roads, and proximity to bus stations are the three most influential spatial determinants of commercial real estate investment viability in the study area. Kendall's tau-b analysis revealed a strong and significant correlation between proximity to bus stations and proximity to major roads ($\tau = .712$, $p < .05$), confirming spatial collinearity that informed the selection of representative variables for Thiessen polygon mapping. The Thiessen analysis of 22 bus stations generated polygons of varying spatial influence extents, with coefficients of influence, which was also found for other spatial features identified in the study.

Research Limitations/Implication: The geographical scope of this study is limited to Ikeja, Lagos, and different spatial features might be influential in other parts of Nigeria. The contribution to knowledge is that this study established the methodical advancement of quantifying spatial differences in real estate investment viability appraisal.

Practical Implication: It is recommended that stakeholders like Estate Surveyors and Valuers should quantitatively incorporate weights of spatial features in commercial real estate investment viability appraisal in Lagos, Nigeria

Originality: This study showed that spatial features exert a mappable, structured and quantifiable spatial influence on the viability of commercial real estate investment in the study area.

Keywords: Commercial Real Estate, Spatial influence, Spatial features, Thiessen Polygon, Viability Appraisal

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1. INTRODUCTION

The spatial undertone of commercial real estate investment has long been recognized in theory but its operationalisation remains grossly inadequate in appraisal practice, particularly in developing countries. The viability of direct real estate investment is fundamentally location-dependent, where properties can be similar physically in terms of construction quality, age, and floor area but can yield substantially different returns due to varying spatial relationships with commercial spatial attractors, institutional anchors, service nodes and transport infrastructure (Mashiri & Karam, 2019; Ping, *et al.,* 2019; Bello & Binuyo, 2020; Alao, *et al.,* 2022). The spatial heterogeneity that is embedded in commercial property markets requires analytical tools that can be able to map, quantify, and integrate spatial influence into real estate investment viability frameworks. Ikeja, Lagos is a major commercial centre in Lagos state and one of the most active direct commercial real estate investment markets in Nigeria. The spatial structure of the Ikeja commercial market is shaped by major spatial features like road networks, operational sectors, bus station proximities, major retail anchors, and institutional centres. These spatial features exhibit a zone of influence on their surrounding commercial properties. The nature and extent of the influence have the possibility of variation with distance and spatial differentials, in a pattern that conventional discounted cash flow (DCF) viability appraisal models have not explicitly captured (Udoudoh & Ekpo, 2018; Appau, 2020).

Nevertheless, Thiessen polygon analysis, also recognized as Voronoi tessellation, presents a geometrically operationalised method suitable for the delineation of spatial zones of influences of spatial features across a space (Okabe, *et al.,* 2000). In this tessellation, each of the polygons in the decomposition gives a defined area that is spatially close to its generating point than any other point on the geographic space in the data set. In the application of this to commercial real estate investment appraisals, Thiessen polygon mapping offers the capacity for an explicit delineation of the spatial zones within which each of the spatial features (landmarks) like transportation nodes, retail hub, or institutional node exhibit their primary spatial influence on the viability of surrounding commercial property viability. Consequently, commercial real estate properties that are within the polygon of each of the identified spatial features are then assigned spatial proximity coefficient of the point spatial feature that generated the polygon. This provides a spatially explicit and quantifiable measure of locational influence for integration into commercial real estate investment analytical model.

However, despite the proven capability of the Thiessen mapping in spatial analysis in different domains like hydrology (Thiessen, 1811), urban planning (Boots, 1986), and environmental science (Mishra & Parasat, 2021), the application of Thiessen polygon analysis to commercial real estate investment viability appraisal has not been explored. A real-estate related study of Lahor (2007) applied multi-criteria evaluation GIS techniques to analyse spatial factors in real estate investment values in Stockholm but did not explicitly employ Thiessen polygon analysis, which could present the additional input of generating normalized spatial influence than mere visual mapping. This study directly addresses this analytical gap by providing a methodological contribution to the spatially-explicit real estate studies by demonstrating that Thiessen polygon can provide a rigorous pre-processing spatial analytics tool for commercial real estate investment viability appraisal. The normalized proximity weights that are generated by the Thiessen polygon tessellation provides spatially explicit coefficients, giving a replicable framework that is applicable to other Nigerian and African commercial real estate environments.

This study therefore applies Thiessen polygon map analysis to examine and quantify the spatial influence of key locational features on commercial real estate investment viability in Ikeja, Lagos. In this, the identified spatial features are ranked on their influence on commercial real estate investment viability in Ikeja, Lagos and Thiessen polygon maps are generated for the representative spatial features which can help in the context of commercial real estate investment decision-making in the study area.

2. LITERATURE REVIEW

2.1. Spatial Factors in Commercial Real Estate Investment

In property research literature, the influence of spatial features has been given some attention on commercial real estate values and investment performance. For example, Cheng and Roulac (2007) established that the application of differing distances and spatial statistics is necessary in commercial real estate investment assessment, a methodological position that has underpinned subsequent spatial real estate studies. This opinion was reinforced in Miller (2020) that applied spatial differentiation statistics to commercial real estate investment appraisal. Owning to spatial relationship connotation of direct real estate investment, the theoretical foundation that underpins the spatial analytics is derived from Tobler's First Law of Geography (1974), which states that near things are more related than distant things, implying that spatial proximity to valued features generates measurable premium effects on commercial property performance.

Gao and Asami (2005) examined the influence of spatial features on land and housing prices in Japan. The study compared global regression with Geographically Weighted Regression (GWR) to identify spatial factors including distance to the nearest station, proximity to the city centre, and proximity to parks. While the study was limited to residential land in a developed country context, the methodological contribution of using residual analysis to expose spatial omissions in global regression models is directly relevant to commercial real estate investment studies in Nigerian commercial real estate investment context. As spatial data infrastructure in Nigeria also differs substantially from that of East Asian markets where Gao and Asami (2005) was conducted.

The study of Lahor (2007) identified factors such as distance to main roads, transport accessibility and proximities to water bodies as significant spatial features that affect real estate investment values. The study of Lahor (2007) used GIS map analysis to visually depict the spatial features' influence, setting a methodical precedent that can be used for the Thiessen polygon map analysis which is deployed in this current study to also generate the proximity coefficients. Hayunga and Pace (2010) also applied spatial statistics specifically on real estate assessment where it was demonstrated that spatial autocorrelation in commercial property values systematically reflect location influence patterns that require the introduction of spatially explicit analytical methods.

Mingzhao, *et al.* (2018) applied network analysis to determine the influence of transport facility proximities on real estate investment potentials. Findings from the study established that transport hub accessibility is a significant spatial determinant of real estate investment performance. The study of Bello and Binuyo (2020) conducted on rental property valuation around Federal University of Technology, Akure, demonstrated spatial non-stationarity in real estate values in a Nigerian context through GWR, inferring that the spatial influence of locational factors could varies across the commercial real estate market in ways that uniform financial appraisal cannot address.

Some key spatial factors identified in the literature as influencing commercial real estate investment values in urban contexts include proximity to transport nodes (Saidu, *et al.* 2025; Mingzhao *et al.*, 2018), commercial clustering density (Jayaraman, *et al.*, 2013), distance to major city centre commercial hub (Gao & Asami, 2005) and distance to major retail hub (Loyer, 2010). The operationalisation of these factors as quantifiable spatial variables, rather than qualitative appraiser judgments, is the defining methodological challenge that Thiessen polygon analysis addresses in this study.

The application of Thiessen polygon analysis to commercial real estate investment viability appraisal in Ikeja, a sub-Saharan commercial real estate market is novel and fills a research gap in the real estate investment appraisal literature. Through this application, spatial influence of market area delineations identified in previous studies like Choi and Usery (2004), Longley, *et al*, (2005) in real estate market can be decomposed. This provides coefficients that can serve as quantitative spatial input feature that can be used for further geostatistical analytics, related to real estate investment appraisal.

2.2. Conventional Commercial Real Estate Investment Appraisal

The common conventional method for commercial real estate investment viability appraisal in Nigeria centres on Discounted Cash Flow (DCF) methods. More usually, the Net Present Value (NPV) method is used, which discounts projected future net cash flows at the investor's target rate of return to determine present investment worth (Udoudoh & Ekpo, 2018). A positive NPV indicates a viable investment, while a negative NPV signals that the investment fails to meet the required return threshold (Udoudoh & Ekpo, 2018). There is also the Internal Rate of Return (IRR) which identifies the discount rate at which the present value of expected cash flows equals the initial investment outlay, enabling comparison with target returns.

The study of Akinbogun, *et al.* (2017) applied Monte Carlo simulation to address the limitation of single-point estimates in conventional DCF analysis, generating probability distribution for NPV outcomes. Like most other conventional real estate investment appraisal studies, Akinbogun, *et al.* (2017) treated location as an implicit adjustment rather than an explicit quantifiable spatial variable. Also, the study of Nnamani (2017) documented that estate surveying and valuation firms rarely apply the relatively sophisticated techniques, rather relying more on subjective judgment that are informed by professional experience rather than systematic explicit analysis which spatial analytics might require. These studies underscore the methodical gap that spatially enriched analytics, like Thiessen polygon analysis can afford. The inability to explicitly process the spatial configuration of the commercial property markets portends a structural limitation of most of the conventional methods of commercial real estate investment appraisal. As it is established in the study of Appau (2020), retail concentration and other factors like institutional centres, are fundamental determinants of streams of income and capital appreciation that can drive viability results. However, the exclusion of these spatial characteristics from the analytical framework of the existing real estate investment viability appraisal provides a leeway for the introduction of systematic bias into viability predictions, leading to possible 'misestimation' patterns

2.3. GIS in Real Estate Analysis

There has been the application of Geographic Information System (GIS) in real estate-related research since the early 1900s, which provide analytical capabilities for the management of spatial data, proximity analysis, spatial interpolation, and thematic mapping of property market phenomena (Belay, 2012).. The study of Subasinghe, *et al.* (2016) also demonstrated that GIS and remote sensing provided indispensable tools for incorporating the geographical configuration of urban space into real estate analysis. In the context of commercial real estate, where urban space is continuously shaped and reshaped by economic activity patterns and infrastructure development (Ramos, 2019), GIS-based spatial analysis provides the methodological means to capture dynamic locational influences that static conventional financial models cannot depict.

3. METHODOLOGY

This study is carried out in Ikeja, the capital of Lagos State, Nigeria, situated in the north-central part of Lagos between coordinates 534852.71°E, 736000.00°N and 542856.50°E, 736011.605°N. In line with Oni (2010), Ikeja is organized into seven commercial operational sectors(i) North-central residential-commercial zone; (ii) WEMPCO-ACME-Lateef Jakande industrial corridor; (iii) Adeniyi Jones-Oba Akran-Awolowo Way mixed-use sector; (iv) Secretariat Road-Oregun Road-7-Up Road eastern sector; (v) Ola Ayeni Road-Opebi Road-Allen Avenue-Toyin Street commercial concentration; (vi) Government Residential Area and institutional zone; and (vii) Murtala Muhammad International Airport sector. The key spatial features used in the study are Ikeja City Mall (the major retail attractor), Murtala Muhammad International Airport, the Alausa State Secretariat, Ikeja Government Reserved Area (GRA), and 21 identified major bus stations. These constitute the primary spatial features analysed through Thiessen polygon mapping in this study. Other spatial features considered are proximity to building line, proximity to major roads, proximity to high vehicular traffic volume and vertical location of the commercial space.

3.1. Research Design, Population and Sampling

The quantitative research design is adopted for this study. It used the cross-sectional survey methodology where 432 registered estate surveying and valuation firms in Lagos State as shown in the NIESV Directory (2025) were taken as the study population and the sampling frame. To determine the sample size, the Yamane's (1967) formula at 95% confidence level and $p \leq 0.05$ significance level was adopted. This formula is given as:

$$n = \frac{N}{1 + N(e)^2} \qquad \dots \textit{Equation } 1$$

Where; n = the required minimum/optimal sample size, N = the population size, and e = level of precision or limit of error.

From this, a sample size of 207 was derived for the estate surveying firms. To elicit data from this sample, simple random sampling technique was applied.

3.2. Data Collection

Two structured questionnaires were administered to the respondents (Estate surveying and valuation firms). The first obtained commercial real estate viability data including initial construction cost, target annual rent, annual incurable expenses, discount rate, and investment holding period for properties in Ikeja appraised between 2015 and 2025 as well as the coordinate location of the properties. The second questionnaire was on rating the spatial factors in commercial real estate investment viability appraisal, using a seven-point Likert scale ranging from "No Importance" (1) to "Utmost Importance" (7). Google Earth imagery was georeferenced and digitized using ArcGIS 10.2, for spatial feature identification and verification, and Google Maps data for road network and point-of-interest analysis were also carried out on the ArcGIS 10.2 software. The spatial features mapped through Thiessen polygon analysis in this study are: (i) 21 major bus stops across Ikeja metropolis, serving as the primary transport node layer; (ii) Ikeja City Mall as the major retail attractor; (iii) Murtala Muhammad International Airport; (iv) Alausa State Secretariat; and (v) Ikeja GRA. Each feature was geocoded and incorporated into the ArcGIS 10.2 spatial analysis environment.

3.3. Analytical Methods

Weighted Mean Score (WMS): This was used to rank spatial factors by their importance to commercial real estate investment viability in the study area as assessed by the appraisers

$$\text{Weighted Mean Score (WMS)} = \frac{7n_7+6n_6+5n_5+4n_4+3n_3+2n_2+1n_1}{n_7+n_6+n_5+n_4+n_3+n_2+n_1} \qquad \dots \text{ Equation 2}$$

Where; n_7 = number of responses for utmost importance, n_6 = number of responses for very important. n_5 = number of responses for Important, n_4 = number of responses for moderately important, n_3 = number of responses for slightly important, n_2= number of responses for low importance, and n_1= number of responses for No Importance.

Kendall's Tau-b Correlation Analysis**:** This was applied to examine the interrelationships among the identified spatial factors and assess collinear pairs that could inflate model results. The Kendall tau-b coefficient is given as:

$$\tau = 1 - \frac{2\,x\,[d_{\Delta}\ (\mathcal{P}_1, \mathcal{P}_2)]}{N(N-1)} \qquad \dots \text{ Equation 3}$$

The parameteter, $\mathcal{P}$ = a set of N objects, d_{Δ} = change in distance between the set of objects, N = objects occurrence, and $\boldsymbol{\tau}$ = Kendall's Tau coefficient. Kendall's tau-b takes values from -1 to +1, where positive values indicate that the ranks of both variables increase together.

Thiessen Polygon Spatial Analysis**:** This was implemented in ArcGIS 10.2 environment to delineate the spatial zones of influence of each spatial feature. The geometry is constructed by triangulating all input points into an irregular network and generating perpendicular bisectors for each triangle edge, forming polygon edge while polygon vertices are located at bisector intersections. The normalized proximity weight assigned to each commercial property within a polygon is:

$$P_{ave} = \frac{\Sigma A_1 P}{\Sigma A_1} \qquad \dots Equation\ 4$$

Where ΣA_1 = A = total area of the point, P = data point

Properties assigned a coefficient of 1 are fully within the sphere of influence of the nearest spatial feature node; a coefficient of 0 indicates no direct spatial influence from any node in that layer within the study extent.

4. PRESENTATION AND DICUSSION OF RESULTS

4.1. Questionnaire Administration

From the questionnaire administration, the retrieval yielded 141 responses from estate surveying firms (68.1%) out of the 207 questionnaire administered to the respondents on the rating of the spatial factors and 143 on appraised property datasets (69.1%). These retrieval rates exceed the 60% minimum for survey reliability (Babbie, 2007).

4.2. Spatial Factors Influencing Commercial Real Estate Investment Viability in Ikeja, Lagos

Table 1 reveals the weighted mean scores and rankings of spatial factors influencing commercial real estate investment viability in Ikeja, as assessed by 141 estate surveying and valuation professionals.

Table 1: Weighted Mean Scores and Rankings of Spatial Factors

Spatial Factor	WMS	SD	Rank
Closeness to building line / frontage	6.22	.6640	1st
Proximity to major roads	5.83	1.1210	2nd
Proximity to bus stations	5.60	.7660	3rd
Proximity to Alausa Secretariat	5.50	1.2370	4th
Proximity to Ikeja Mall	5.34	.9650	5th
Vertical Location of the commercial space	5.10	.7300	6th
Distance from high vehicular Traffic	5.04	.6870	7th
Proximity to Ikeja GRA	4.84	.8600	8th
Proximity to Airport	4.82	.8590	9th

The results in Table 1 reveal a clear hierarchy of spatial influence where closeness to the building line or frontage of the building emerged as the most influential spatial determinant of commercial real estate investment viability, with a WMS of 6.22 out of a maximum of 7.00. This finding shows that there is a fundamental logic undergirding the visibility and accessibility in the commercial property market, where commercial properties that have direct road frontage enjoy maximum exposure to pedestrian and vehicular traffic flows, which enhance commercial patronage and the potential of rental income. The result shows that proximity to major roads ranked second with weighted mean score of 5.83, which confirms the importance of accessibility as a major determinant of commercial property investment decisions. This result is in alignment with the study of Mingzhao, *et al*., (2018) on the centrality of transport accessibility in commercial real estate investment performance and also Oni (2009) on the importance of arterial road network in organizing commercial activities in Ikeja, Lagos. Proximity to bus stations ranked third (WMS = 5.60), which shows that access to public transportation is an important spatial determinant in the Ikeja commercial market. At the lower end of the rankings, distance from high vehicular traffic (WMS = 5.04), Proximity to Ikeja GRA (WMS = 4.84), proximity to airport (WMS = 4.45), and proximity to Airport (WMS =

4.82) were all rated as important but less dominant than accessibility-related factors on the higher end of the Table.

4.3. Kendall's Tau-b Correlation Analysis of Spatial Factors

Kendall's Tau-b correlation analysis was conducted to examine inter-correlations among the spatial features. Statistically significant correlations were discovered between some spatial features shown in Table 2 above, while others do not have statistically significant correlations. From the Table 2, the strongest and most statistically significant correlation is between proximity to bus stations and proximity to major roads ($\tau = .712$, $p < .050$). This indicates that the two factors are spatially co-located in the Ikeja market. It implies that commercial properties near major bus stations are also near major roads, creating a mutually reinforcing transport accessibility premium. This shows that the two factors are spatially co-located in the Ikeja market. This strong correlation has an important methodological implication that both variables cannot be used simultaneously in further spatial analyses without risk of multicollinearity and over-inflation of result.

Table 2: Significant Kendall's Tau-b Correlations Among Spatial Factors

Spatial Factor Pair	Interpretation	τ Value	p-value
Proximity to bus stations × Proximity to major roads	Strong positive – co-located transport features	.712	< .050
Proximity to major roads × Proximity to Ikeja Mall	Moderate positive – road-retail synergy	.225	< .010
Proximity to building line × Proximity to Ikeja Mall	Positive – frontage-retail clustering	.165	< .050
Distance to traffic × Proximity to major roads	Modest positive – road exposure externalities	.078	< .050

The correlation between proximity to major roads and proximity to Ikeja Mall ($\tau = .225$, $p < .010$) also reveals commercial synergies between road accessibility and proximity to the major retail attractor. The identified correlation between the proximity to building line and proximity to Ikeja Mall ($\tau = .225$, $p < .010$) suggest a relationship between frontage accessibility and retail agglomeration, which implies that the most commercially exposed properties in the study area have clustering around major retail anchor. Based on the correlation analysis, the following variable selection was applied for Thiessen polygon analysis: proximity to bus stations was selected as the representative variable for the transport accessibility cluster (representing both bus stops and major roads due to their strong collinearity), while proximity to Ikeja Mall was selected as the representative variable for the retail-road accessibility cluster. Airport proximity, Alausa Secretariat proximity, and Ikeja GRA proximity were analysed as independent spatial features given their low correlations with other variables.

4.4. Thiessen Polygon Analysis of Bus Station Spatial Influence

Following the identification of bus station proximity as the representative transport accessibility variable, Thiessen polygon analysis was applied to the 21 major bus stations identified across the Ikeja study area. The tessellation generated 21 polygons of varying size, shape, and commercial property capture, reflecting the uneven spatial distribution of bus station infrastructure across the study area as shown in Figure 1.

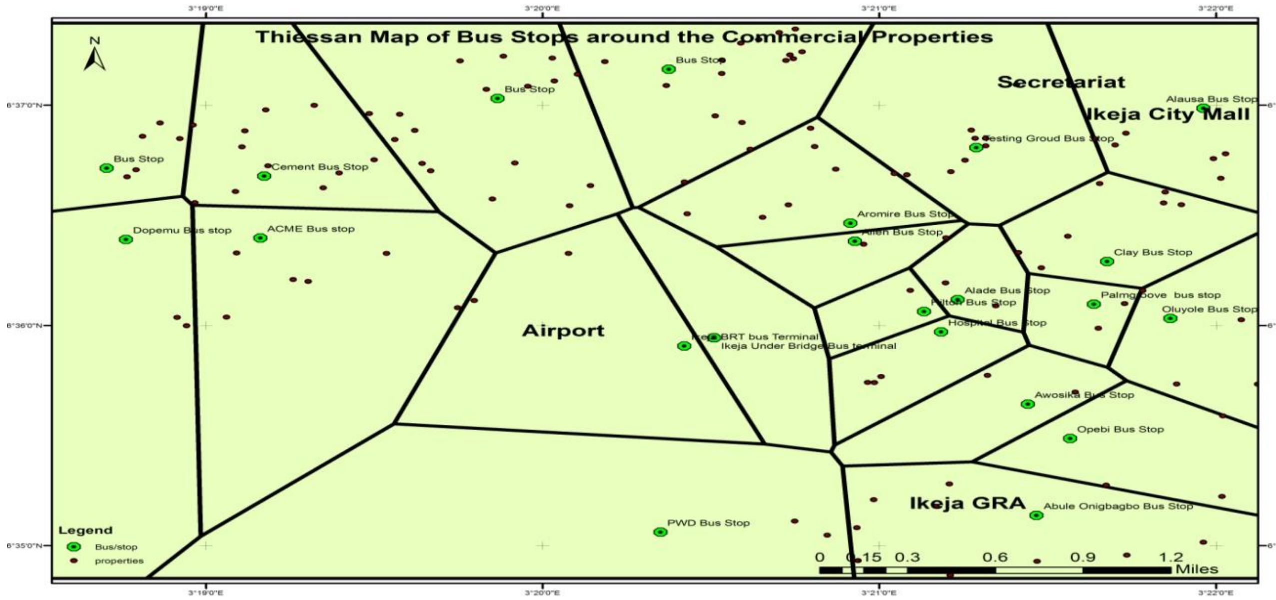

Figure 1. Thiessen polygon analysis of the influence of Bus Stations as Spatial Factors

The Thiessen map in Figure 1 with coefficients shown in Appendix I reveal several important spatial patterns of the bus stations polygons. The shown polygons in the Figure have substantial variation in their spatial extent, where larger polygons imply bus stations that have wider zone of influence as a result of lower competition from neighbouring bus stations and smaller polygon reflect bus station in high density transport clusters where competing stations are in close proximity. This has implications on investment as commercial properties that are located within the larger polygons have primary benefits of the accessibility effect of the bus station while properties that are in small polygons with clustered stations areas have shared accessibility experience from multiple proximate stations. In the polygons created around the bus stations, the number of commercial properties that are captured within each polygon vary, where the largest polygons in the peripheral sectors capture fewer commercial properties despite their larger spatial extent, while densest commercial sector (Allen Avenue, Toyin Street, Opebi area) generate multiple small, tightly packed polygons that reflect the high concentration of spatially influential bus stations in this commercial hub. Although, the Thiessen map does not show overlapping gradient of each commercial property from the spatial feature in the polygons, the weights of the effects of the spatial features are estimated for other commercial properties outside the polygons and are shown in Appendix I.

From the coefficients generated in Appendix I, commercial properties that have proximity weights close to 1.0 have effective co-locations with their nearest bus stations and enjoy maximum transport accessibility premiums. Properties that have proximity coefficients less than 0.50 are at the fringes of their respective bus station influence zones, potentially facing relative accessibility disadvantage that could comparatively reduce their commercial viability, with respect to that bus stations. These varying spatial influence coefficients can be further integrated with conventional real estate investment appraisal models, quantifying the influence of the bus stations. This spatial differentiation that might be treated uniformly by conventional appraisal methods is the location undertone that the Thiessen polygon analysis has made visible and quantifiable. The Thiessen mapping result corroborates the findings of Mingzhao *et al*. (2018) on the spatial influence of transport hubs on real estate investment potentials, while extending their network-analysis methodology with the Thiessen polygon approach that explicitly assigns spatial influence coefficients to individual properties. Unlike Lahor's (2007) multi-criteria evaluation technique, which produced visual maps of spatial factor influence without generating property-specific influence coefficients, the Thiessen analysis in this study produces quantitative spatial weights.

2.1.Thiessen Polygon Analysis of Other Spatial features

3. Figure 2 with coefficients in Appendix II, present the Thiessen map for the remaining four spatial features analysed which are Ikeja City Mall, Murtala Muhammad International Airport, Alausa Secretariat, and Ikeja GRA. Unlike the bus station analysis where 21 generating points created a fine-grained polygon mosaic, each of these four features generates a single polygon whose extent delineates the zone within which that feature exerts its primary spatial influence relative to the three other features in the group.

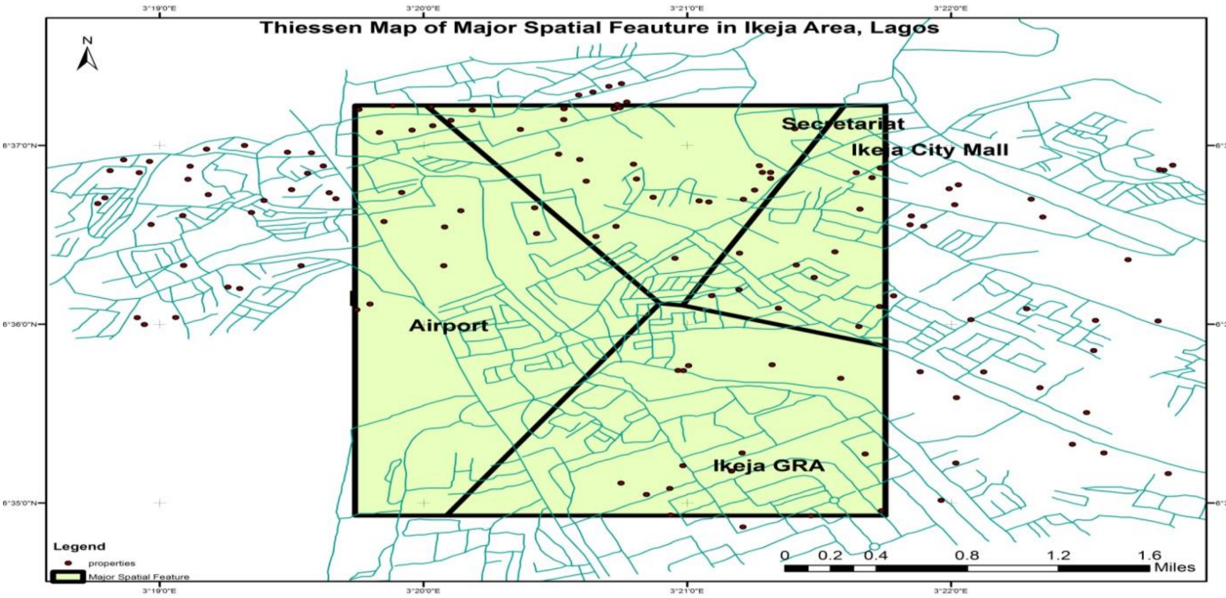

Figure 2. Thiessen Map for the infleunce of other spatial Factors

The Ikeja City Mall polygon, as the dominant commercial attractor in the study area, captures the largest share of identified commercial properties in the densest commercial sector of Ikeja. This is consistent with the WMS ranking results, where Ikeja Mall proximity ranked fifth among all spatial factors (WMS = 5.34), and with the significant correlation between the Mall proximity and major road proximity ($\tau = .225$, $p < .010$) that confirms the commercial concentration of high-value properties around this spatial feature.

The Murtala Muhammad International Airport polygon encompasses a substantial portion of the study area, reflecting the airport's spatial influence on commercial properties in the northern portions of the metropolis. While airport proximity ranked ninth in the WMS analysis (WMS = 4.82), the Thiessen map reveals that its spatial influence zone is disproportionately large relative to the relatively modest importance rating, indicating that the airport exerts a broader but less commercially intense spatial influence than transport-related factors. The pattern found out from this is partly consistent with findings by Cohen and Brown (2013) in the study of airport influence on commercial property values in Vancouver which found that airport proximity generates mixed effects. These include accessibility benefits for businesses requiring frequent international connectivity offset by environmental externalities for standard retail and service commercial uses. The Thiessen map analysis of these spatial factors also generated coefficients of influence which range from 0 to 1 in their strength of influence the viability of the commercial properties. These coefficients shown in Appendix II can be geostatistically modelled to spatially enhance commercial real estate investment viability appraisal.

4. Conclusion and Recommendations

The results of this study have shown that the presence of significant spatial features in a commercial property market has quantifiable, structured and spatially heterogeneous implications on the commercial real estate investment viability in the study area. This operation has been substantiated through the use of Thiessen polygon mapping that shows a possibility of quantifying and delineating these spatial influences. The weighted mean score analysis of the responses from the professional appraisers discovered that closeness to building line, proximity to major roads, and proximity to bus stations are the three most influential spatial determinants of the viability of commercial real estate investment in the study area. The Kendall's tau-b analysis showed a strong spatial collinearity between proximities to bus station and major roads, informing a methodologically sound variable selection for polygon analysis.

The Theissen polygon analysis of major bus stations within the study area generated spatial polygons with varying extents of influence and commercial real estate property capture. This demonstrated that commercial real estate investments in the study area are not uniformly served by transport nodes and that their viability is differentially affected by their position within or beyond the influence of specific bus station zones. The Theissen analysis for Ikeja Mall, Airport, Alausa Secretariat and Ikeja GRA further revealed that the geographic extent of spatial influence and the intensity of spatial influence, as perceptually appraised by the appraisers, are not always congruent, which is a distinction that the existing conventional appraisal techniques do not capture.

The results of this Thiessen analysis in this study confirms that despite professional awareness of spatial factor importance, explicit integration of spatial data into conventional commercial real estate investment viability appraisal in Ikeja has remained perceptual rather than analytical. This emphasizes methodical gap that the incorporation of Thiessen polygon analysis would help bridge.

From the findings of this study, it is recommended that estate surveying and valuation firms across Nigeria can incorporate Thiessen polygon spatial analysis into their commercial real estate investment viability appraisal workflows. This is implementable within the environment of many GIS software that are accessible to practitioners, to produce spatial influence coefficients that can directly augment the DCF analysis. This can be enhanced through professional training programmes like MCPDs by NIESV and ESVARBON which should include GIS-based spatial analysis modules to build this competency across the profession.

Thiessen polygon analytical framework shown in this study should be replicated in other major Nigerian commercial real estate markets, including Abuja, Port Harcourt, Kano, and Ibadan. This will facilitate comparative analysis of the spatial influence structures across different commercial property markets. It will further advance empirical evidence on the generalisability of the influence of spatial factor hierarchy identified in Ikeja.

5. Limitation of the Study

This study is geographically limited to Ikeja, Lagos which might have introduced bias in the choice of spatial features. Influential spatial features in other urban centres in the country might be different and their choice should be peculiar to specific study areas. While the Thiessen polygon analysis could attribute spatial weights to estimate the relationships between the spatial features and the commercial properties, it did not identify the gradient of the distance between the spatial features and the commercial properties. This creates the need for merging the Thiessen Polygon mapping with other spatial analytics like proximity mapping to identify the gradients of the weights in further research.

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APPENDIX I - BUS STATION COEFFICIENTS FOR THE FIRST 28 COMMERCIAL PROPERTIES

PPTY ID	FID	Long	Lati	BUS0	BUS1	BUS2	BUS3	BUS4	BUS5	BUS6	BUS7	BUS8	BUS9	BUS10	BUS11
0	0	6.625176	3.337586	0.031738	0.34046	0.028623	0.027318	0.022255	0.021078	0.021	0.019247	0.018049	0.012441	0.009268	0.005394
1	1	6.654623	3.359407	0.031919	0.03286	0.029818	0.028585	0.021786	0.022027	0.022278	0.020552	0.017023	0.013597	0.010257	0.008505
2	2	6.616115	3.364808	0.031458	0.035272	0.027218	0.025856	0.022959	0.020192	0.019718	0.018009	0.019533	0.011906	0.009437	0.003475
3	3	6.652151	3.364384	0.03239	0.03239	0.027106	0.025719	0.024984	0.020861	0.019999	0.018427	0.022283	0.013505	0.011926	0.006221
4	4	6.5923	3.309627	0.031797	0.03827	0.025541	0.02417	0.025777	0.020354	0.019126	0.017791	0.023981	0.014519	0.013985	0.009475
5	5	6.639664	3.359774	0.030245	0.037298	0.023644	0.022289	0.024922	0.01896	0.017589	0.016387	0.023619	0.014035	0.014076	0.010471
6	6	6.59586	3.294915	0.029371	0.036092	0.023058	0.021687	0.023656	0.017971	0.016697	0.015401	0.022181	0.012615	0.012532	0.008942
7	7	6.600842	3.348992	0.029667	0.037235	0.022725	0.021397	0.025012	0.018609	0.017108	0.016058	0.024117	0.014551	0.015004	0.011984
8	8	6.599956	3.316527	0.027223	0.032915	0.021849	0.020463	0.020379	0.01568	0.014753	0.013208	0.01836	0.008973	0.008396	0.005029
9	9	6.617124	3.344173	0.025494	0.031101	0.020344	0.018962	0.018566	0.013959	0.013111	0.011523	0.01664	0.007185	0.0069	0.00493
10	10	6.647219	3.358391	0.02635	0.028939	0.023538	0.022271	0.016935	0.015853	0.015942	0.014199	0.013017	0.007261	0.00396	0.00414
11	11	6.612238	3.310656	0.029071	0.029404	0.027687	0.026525	0.018675	0.019824	0.020333	0.018671	0.013713	0.011882	0.008702	0.00929
12	12	6.626629	3.334514	0.037477	0.033587	0.038498	0.037556	0.026784	0.030894	0.031905	0.030454	0.021541	0.024371	0.021614	0.022605
13	13	6.652057	3.338085	0.033342	0.030248	0.034069	0.033108	0.022589	0.026429	0.027421	0.025965	0.01729	0.019915	0.017229	0.018697
14	14	6.618529	3.312768	0.031449	0.028852	0.031975	0.030999	0.020676	0.024307	0.025279	0.023815	0.015352	0.017766	0.015114	0.016851
15	15	6.610543	3.316289	0.031476	0.027524	0.032958	0.032097	0.020862	0.025562	0.026744	0.025419	0.015717	0.019936	0.017645	0.020107
16	16	6.637844	3.330553	0.029807	0.026341	0.031094	0.030216	0.019131	0.023659	0.024826	0.023494	0.013927	0.018027	0.015791	0.018499
17	17	6.650761	3.335489	0.026103	0.023224	0.027375	0.026519	0.015397	0.020014	0.021247	0.01998	0.010176	0.014929	0.013103	0.016783
18	18	6.627484	3.35212	0.022683	0.021058	0.023563	0.022688	0.011907	0.016166	0.017408	0.016166	0.006583	0.01148	0.010158	0.014786
19	19	6.611011	3.332876	0.031617	0.028535	0.027135	0.010114	0.023696	0.023311	0.023522	0.022517	0.013021	0.015807	0.016777	0.015339
20	20	6.590082	3.317314	0.020457	0.020919	0.020229	0.01925	0.009894	0.012576	0.013655	0.012311	0.004972	0.007521	0.006694	0.012125
21	21	6.663418	3.352927	0.019145	0.022407	0.016961	0.015799	0.010014	0.009103	0.00965	0.008061	0.0073	0.002521	0.003522	0.009528
22	22	6.610338	3.299649	0.017248	0.022873	0.013378	0.012095	0.010458	0.005919	0.005764	0.004019	0.01003	0.002953	0.00629	0.010873
23	23	6.623161	3.349554	0.01795	0.025823	0.011706	0.01032	0.014175	0.006943	0.005353	0.004496	0.014984	0.00756	0.01047	0.013031
24	24	6.613745	3.362407	0.018482	0.026391	0.012124	0.01074	0.014721	0.007509	0.005908	0.005062	0.015442	0.007772	0.010578	0.01287
25	25	6.621196	3.303314	0.018567	0.026591	0.012086	0.010706	0.014978	0.00769	0.006046	0.005279	0.015756	0.008101	0.010888	0.013088
26	26	6.593958	3.347842	0.012014	0.018151	0.00954	0.008519	0.006456	0.001938	0.003577	0.003347	0.008704	0.007609	0.010697	0.015991
27	27	6.641031	3.369295	0.014953	0.017453	0.014636	0.013742	0.005078	0.007293	0.008726	0.007794	0.003646	0.006719	0.008459	0.014489

PPTY ID	FID	Long	Lati	BUS12	BUS13	BUS14	BUS15	BUS16	BUS17	BUS18	BUS19	BUS20	BUS21
0	0	6.625176	3.337586	0.043214	0.046539	0.05146	0.04916	0.055015	0.058389	0.02316	0.027038	0.026237	0.019065
1	1	6.654623	3.359407	0.044526	0.04847	0.054134	0.052055	0.058054	0.061233	0.026888	0.029686	0.028742	0.018817
2	2	6.616115	3.364808	0.041472	0.044057	0.048115	0.045581	0.051267	0.05484	0.01878	0.023894	0.02328	0.01966
3	3	6.652151	3.364384	0.040757	0.042483	0.045465	0.04264	0.048077	0.051901	0.014718	0.021785	0.02144	0.021707
4	4	6.5923	3.309627	0.038349	0.039265	0.04137	0.038356	0.043634	0.047597	0.010014	0.018377	0.018302	0.022643
5	5	6.639664	3.359774	0.036127	0.036863	0.038934	0.03596	0.041303	0.045209	0.008257	0.01597	0.015951	0.021904
6	6	6.59586	3.294915	0.035933	0.037045	0.039622	0.036782	0.042254	0.046045	0.00973	0.016196	0.01602	0.020587
7	7	6.600842	3.348992	0.03477	0.035214	0.037043	0.034041	0.039374	0.043287	0.006694	0.01434	0.014439	0.022114
8	8	6.599956	3.316527	0.035629	0.037735	0.041605	0.039125	0.044896	0.048376	0.013775	0.017392	0.016829	0.017179
9	9	6.617124	3.344173	0.034329	0.036766	0.041158	0.038857	0.044766	0.048079	0.014757	0.016772	0.016062	0.015373
10	10	6.647219	3.358391	0.038215	0.04201	0.047809	0.045865	0.051972	0.054996	0.022353	0.023399	0.022389	0.013711
11	11	6.612238	3.310656	0.042375	0.046834	0.05326	0.051466	0.057639	0.060546	0.027928	0.028954	0.02786	0.015871
12	12	6.626629	3.334514	0.052681	0.058276	0.065864	0.06439	0.070696	0.073332	0.041255	0.041909	0.04069	0.025134
13	13	6.652057	3.338085	0.048333	0.053821	0.06138	0.059934	0.066261	0.068859	0.037342	0.037471	0.036235	0.020778
14	14	6.618529	3.312768	0.046293	0.051704	0.059224	0.057783	0.064116	0.066704	0.035445	0.035326	0.034085	0.018751
15	15	6.610543	3.316289	0.046903	0.052799	0.060944	0.059745	0.066171	0.068529	0.038544	0.037447	0.036124	0.019459
16	16	6.637844	3.330553	0.04511	0.050927	0.05902	0.057816	0.064245	0.066602	0.036821	0.035526	0.034199	0.017618
17	17	6.650761	3.335489	0.041358	0.047216	0.05548	0.054388	0.06086	0.063101	0.034512	0.032236	0.030863	0.013879
18	18	6.627484	3.35212	0.037656	0.043396	0.051645	0.050595	0.057086	0.059278	0.022683	0.021058	0.023563	0.022688
19	19	6.611011	3.332876	0.00782	0.009703	0.00776	0.011915	0.037964	0.043206	0.050822	0.04952	0.055927	0.058357
20	20	6.590082	3.317314	0.034636	0.039962	0.047836	0.046685	0.053151	0.055428	0.027903	0.024544	0.023159	0.007295
21	21	6.663418	3.352927	0.03166	0.036221	0.04336	0.041996	0.048398	0.05086	0.02311	0.019672	0.018346	0.006715
22	22	6.610338	3.299649	0.028036	0.032056	0.038861	0.03747	0.043876	0.046341	0.020073	0.015179	0.013829	0.007531
23	23	6.623161	3.349554	0.025521	0.028343	0.034104	0.032467	0.038795	0.041453	0.016065	0.010015	0.008768	0.011868
24	24	6.613745	3.362407	0.025806	0.028465	0.034013	0.032303	0.038599	0.041322	0.015501	0.009809	0.00862	0.012379
25	25	6.621196	3.303314	0.025668	0.02824	0.033713	0.031986	0.038277	0.041012	0.015282	0.009487	0.008313	0.012669
26	26	6.593958	3.347842	0.024139	0.02923	0.037525	0.036764	0.04335	0.045228	0.023849	0.015716	0.014147	0.004862
27	27	6.641031	3.369295	0.028928	0.034455	0.042877	0.042045	0.048608	0.050568	0.026607	0.020546	0.019035	0.001835

APPENDIXII - SPATIAL FEATURES FOR THE FIRST 28 COMMERCIAL PROPERTIES

PPTY ID	FID	Long	Lati	AIRPORT	IKEJA MALL	IKEJA GRA	ALAUSA
0	0	6.625176	3.337586	0.034311	0.032289	0.011594	0.035301
1	1	6.654623	3.359407	0.037311	0.031846	0.015151	0.035305
2	2	6.616115	3.364808	0.030679	0.03271	0.007537	0.035164
3	3	6.652151	3.364384	0.027774	0.034273	0.004949	0.036171
4	4	6.5923	3.309627	0.02359	0.03433	0.003754	0.03559
5	5	6.639664	3.359774	0.021164	0.03305	0.003778	0.034022
6	6	6.59586	3.294915	0.021916	0.032003	0.002206	0.033161
7	7	6.600842	3.348992	0.024236	0.02932	0.002046	0.031013
8	8	6.599956	3.316527	0.024035	0.027522	0.003623	0.02928
9	9	6.617124	3.344173	0.024035	0.027522	0.003623	0.02928
10	10	6.647219	3.358391	0.03125	0.026934	0.010556	0.029905
11	11	6.612238	3.310656	0.036948	0.028672	0.016059	0.032337
12	12	6.626629	3.334514	0.050123	0.03538	0.029399	0.039983
13	13	6.652057	3.338085	0.045727	0.031523	0.025473	0.035993
14	14	6.618529	3.312768	0.043597	0.02981	0.023591	0.034188
15	15	6.610543	3.316289	0.045852	0.029268	0.026752	0.033903
16	16	6.637844	3.330553	0.043938	0.027771	0.025073	0.032328
17	17	6.650761	3.335489	0.04071	0.024229	0.023006	0.028699
18	18	6.627484	3.35212	0.037038	0.021242	0.020466	0.02548
19	19	6.611011	3.332876	0.033037	0.019869	0.017109	0.023607
20	20	6.590082	3.317314	0.033037	0.019869	0.017109	0.023607
21	21	6.663418	3.352927	0.028114	0.019846	0.012963	0.022696
22	22	6.610338	3.299649	0.023657	0.019087	0.011712	0.021001
23	23	6.623161	3.349554	0.018427	0.021005	0.010824	0.021721
24	24	6.613745	3.362407	0.018158	0.021566	0.010402	0.022248
25	25	6.621196	3.303314	0.017827	0.021715	0.010456	0.022325
26	26	6.593958	3.347842	0.024156	0.013894	0.016822	0.015744
27	27	6.641031	3.369295	0.029075	0.015058	0.017474	0.018294