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GEOSPATIAL ANALYSIS OF URBAN MORPHOLOGY AND REAL ESTATE MARKET IN MINNA, NIGERIA

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Abstract

This complexity and uncontrolled transformation of urban morphology is one of the major challenges of urban areas of the global south. There are many literatures on urban morphology, where few captured how urban form determines aspects of real estate market. This paper adopted Geographic Information System (GIS) in assessing the urban morphology and real estate market in Minna, Nigeria. All 21 professional Estate Surveyors and Valuers in the study area were sampled for rent data collection, while the urban form was assessed using satellite imageries. The data collected were analysed using descriptive analysis and spatial analysis. The relationship between the urban morphology and real estate market was analysed using Geographically Weighted Regression (GWR). The study reveals a clear spatial variation in the rental value of two-bedroom apartments across neighbourhoods, the values range from ₦250,000 to ₦200,000. The study also found that rental value variation among neighbourhoods in the study area is closely associated with differences in urban morphology, particularly density, land use mix, and accessibility. The GWR density beta spatial pattern shows a clear spatial variation in the influence of density on rental value across the neighbourhoods of the study area, with local coefficients ranging from -18,098.41 to 49,010.09. The strongest positive effects are concentrated in the central neighbourhoods, where the beta values fall within 26,077.50 to 49,010.09. The study concludes that the physical configuration of urban neighbourhoods is a significant determinant of rental values in Minna. It was recommended that neighbourhoods with relatively low rental values should be targeted for physical and environmental improvement.

Keywords: Real Estate Market, Urban Morphology, Geographic Information System, Geospatial Modelling, Neighbourhood

1. Introduction

The increasing rate of urban populations is one of the challenges faced by many cities worldwide (Zarocostas, 2022), particularly, in the global south (Gu *et al*., 2021; Mohammed, 2021). The population of the world as at year 2000 was 6.1 billion and increased to 7.8 billion in the year 2020 (Chen *et al*., 2022; Gu *et al*., 2021), where the population of the urban areas increased from 46.69% of the world population in the year 2000 to 56.15% in the year 2020 with a net urban population growth of 1.5 billion (Molotoks *et al*., 2021; Chen *et al*., 2022).

The world population is projected to reach 10 billion in the year 2050 (Gu *et al*., 2021), where the sub-Saharan Africa is expected to account for the most of the increase in the world's population throughout the century with about 40% increase projected for the year 2050 (Gu *et al*., 2021; United Nations Department of Economic and Social Affairs, 2022), and the larger share of the populations are in the urban areas (Smit, 2021). The increasing population has transformed the global landscape (Profiroiu *et al*., 2020), with consequential effects, including the alteration of natural resources (Maja and Ayano, 2021), land use change (Molotoks *et al*., 2021), pollution (Vinod Kumar, 2017), climate change (Molotoks *et al*., 2021) and alteration of urban form (Chen *et al*., 2022; Folke *et al*., 2021), among others.

The real estate market is one of the major contributor to the global economy (Huy *et al*., 2021), it is determine by several factors including the physical building structures, micro and macroeconomic indicators, environmental and neighbourhood structures, among others (Mohammed *et al*., 2021). The activities of the real estate market have also been influenced by urban form (Antoniucci and Marella, 2018; Mohammed, 2021; Xiao, 2017).

In Nigeria, cities have neighbourhoods with different urban forms laid out, those representing the new urbanist development neighbourhoods considered as the government-reserved areas (GRAs) which are mainly zoned for residential purpose and the old city neighbourhoods at the city core considered as areas of conventional development, and the commercial hub with mix-land uses (Alabi, 2021). Nigerian cities have undergone significant urban development and rapid spatial expansion in decades. For example, in Kano, significant changes was observed in the last three centuries in the city's traditional building materials, roofing styles, street forms, distribution of ponds, and green and open spaces. The population pressure on urban land has also been a major driving force behind the unfolding changes (Barau *et al*., 2015). In Akure,

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there is an evidence of strong relationship between urban form and socioeconomic activities of the city (Alabi, 2021).

Minna which is a century old city in the north central region of Nigeria has undergone significant urban development and rapid spatial expansion in recent years, primarily driven by a substantial influx of people migrating from rural and countryside areas over the past three decades (Dalil *et al*., 2013; Morenikeji *et al*., 2018). However, the most significant expansion occurred after year 2010, which significantly impacted the transformation of the city's urban form (Owoeye *et al*., 2023). This expansion is reflected in the significant neighbourhood increase by the random building of many residential apartments in different parts of the city (Popoola et al., 2015).

In the year 2004, only 25 neighbourhoods existed in Minna (Sanusi, 2008), whereas, in 2024, this number increased to 66, indicating more than 50% urban growth in just 20 years. This continuous urban transformation in Minna continues to shape the physical configuration and gives the city an unstable urban fabric. These changes have affected economic activities of the city (Popoola et al., 2016). Also, this trend may have significant impact on the real estate market, particularly on the real property values. However, the impacts may vary across the neighbourhoods and crate a complex urban physical configuration.

This complexity and uncontrolled transformation of urban form is one of the major challenges of urban areas, particularly, in the global south (Yen et al., 2019). These problems persists across the global south, particularly, in the African cities, where the urban form determines the level of wellbeing of the urban dwellers (Smit, 2021). In Nigeria, quality of life is measured by the type and quality of neighbourhoods of residence, including type and condition of housing, planning, street pattern, population density, among others (Dzukogi et al., 2022). This attracted the attention of researchers to investigate how the urban physical structure affects human activities, where several studies have been conducted in that regards (Fathi et al., 2020; Juan et al., 2021). Little have been done on how urban morphology shapes the activities of real estate market and yet, without comprehensiveness. Also, the extent to which different aspects of urban morphology determine the real estate market and submarkets is yet to be established. It is on this backdrop that this research adopted Geographic Information System (GIS) in assessing the urban morphology and real estate market in Minna, Nigeria. The specific objectives include; identification of the physical configuration of urban neighbourhoods, assessing the rental values of real estate properties an Model spatial relationships between the physical configuration of urban neighbourhoods and rental values of real estate properties in the study area.

2. Methodology

2.1 The study area

Minna, the study area, is the state capital of Niger State in Nigeria, lies approximately on latitude 9.583555° North and Longitude 6.546316° East. However, the town has transformed from a small traditional settlement to an urban centre with modern facilities and amenities. The study covers the entire 66 neighbourhoods of Minna as at the year 2024. These neighbourhoods are; 123 Quarters, Abdulsalam quarters, Albishiri, Anguwan Biri, Anguwan Daji, Bahago, Bajago, Barikin Saleh, Barikin Saleh Extension, Bosso Estate, Bosso Estate Extension, Bosso Low-cost, Bosso Town North, Bosso Town South, Bovi, Chanchaga, Darulsalam A, Darulsalam B, Dutsen Kura Gwari, Dutsen Kura Gwari Extension, Dutsen Kura Hausa, Fadikpe, Fadikpe Extension, F-layout, FMBN housing estate, Gbeganu, Gbeganu Extension, GRA, Gurara, Hayi Gwari, Kafin Tela, Kafin Tela Extension, Keteran Gwari, Kpakungu, Kwangila, Limawa, M. I. Wushishi housing estate, Maitumbi North, Maitumbi South, Makera, Mandela, Morris, New Shango, Oduoye quarters, Old Airport Quarters, Old Shango, Paida, Railway quarters, Sabon Gari, Sabon Titi, Sauka Kahuta, Sauka Kahuta Extension, Shanu Village, Soje A, Soje B, Talba housing estate, Tayi Village, Tudun Fulani, Tudun Wada North, Tudun Wada South, Tunga A, Tunga B, Tungan Goro, Type-B quarters, Upper base and Zarumai (see Figure 1).

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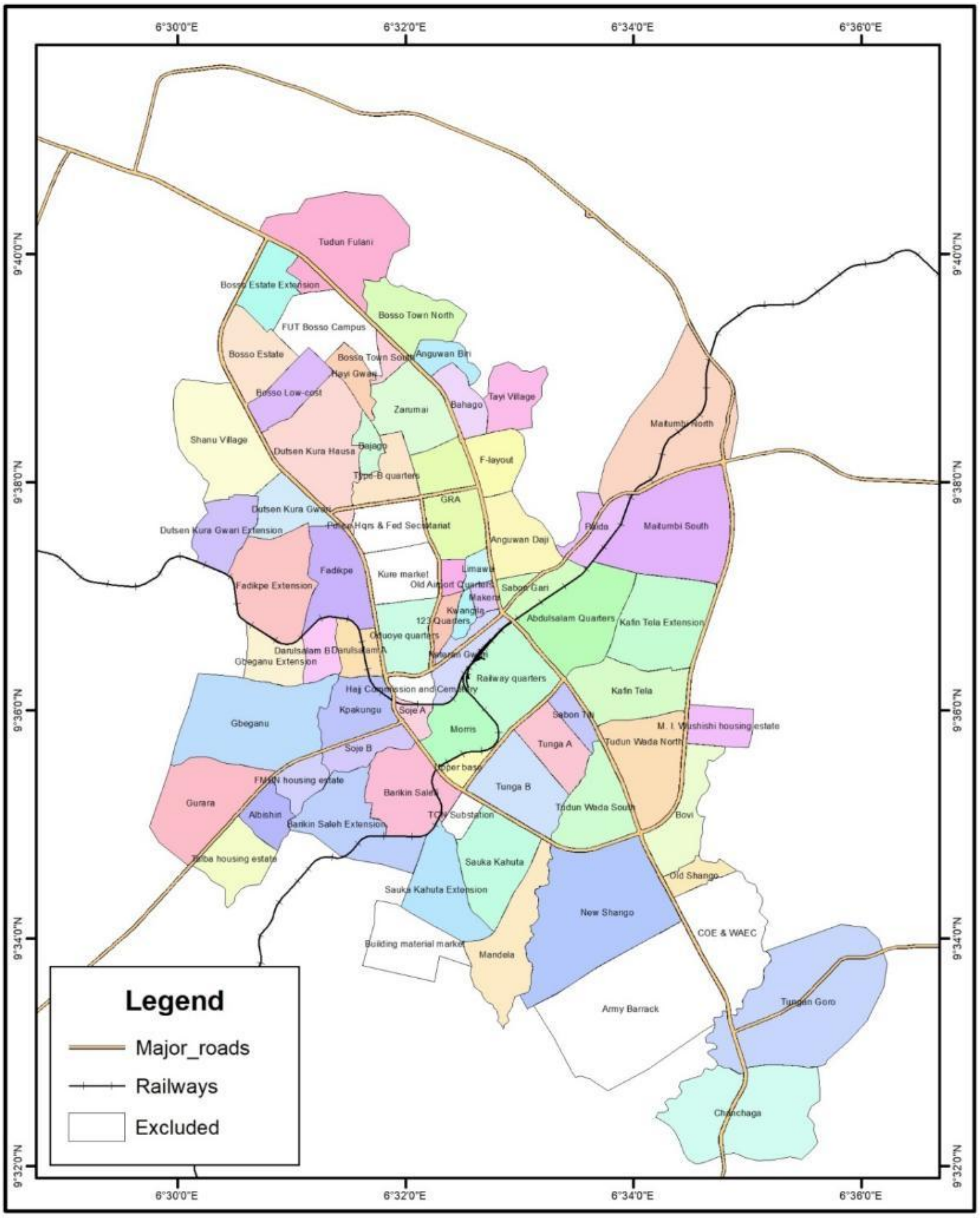

Figure 1: Minna, the study area

2.2 Sampling

Minna was considered based on number properties managed by professional estate surveyors and valuers firms in the major 66 residential neighbourhoods. The population of this research work include a total of 21 estate surveying and valuers firms in Minna and household heads of the residential rental properties managed by professional estate surveyors in the neighbourhoods.

2.3 Data and analysis

This study adopted quantitative research design approach. The required data for this were collected through structured questionnaire to urban residents, practicing estate surveyors and valuers in the study area. Satellite imageries data were collected for the study area using current Google satellite image. The study area was demarcated using property submarkets. All data needed for this study were geographically referenced (i.e. latitude and longitude). Data collected were analysed base on the nature of data. The physical configuration of the neighbourhoods were analysed quantitatively and presented spatially using maps. The spatial patterns of rental values were analysed using maps. The relationship between urban morphology and rental values of residential properties were analysed using Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR) through ArcGIS 10.8 Desktop software package.

3. Results and Findings

3.1 Physical configuration of urban neighbourhoods in the study area

Findings of this study in Table 1 revealed the physical configuration of urban neighbourhoods in Minna. Table 1 reveals a clearly differentiated pattern in the physical configuration of neighbourhoods in the study area, indicating that residential structure of the city is shaped by distinct morphological types defined by variations in density, land use mix, and accessibility. The findings indicate that the most dominant urban form is the high-density neighbourhood category, which comprises 24 of the 66 neighbourhoods, representing 36.4% of the total. Neighbourhoods such as Anguwan Biri, Chanchaga, Kpakungu, Kwangila, Limawa, Sabon Gari, Railway Quarters, and Tudun Fulani typify this category, as they are characterized by high population, building, and housing densities, small lot sizes, a land use structure dominated by 68% residential use, and relatively weak accessibility conditions marked by low street connectivity, high dendritic pattern, and 9% transport land use. This pattern suggests a compact and intensely built urban environment with limited spatial openness and a less integrated circulation system.

The results further show that 17 neighbourhoods (25.8%) fall within the medium-density category, represented by places such as Barikin Saleh Extension, Bosso Low-cost, Darulsalam B, Maitumbi North, Mandela, New Shango, Paida, Sabon Titi, and Zarumai. These neighbourhoods display moderate values across the three density indicators, medium lot sizes,

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and a more balanced land use composition of 80% residential, 10% public institutional, 7% natural environmental, and 3% industrial land use. Their accessibility profile is also moderate, with medium street connectivity and dendritic pattern.

In contrast, 14 neighbourhoods (21.2%) are identified as low-density planned estates, including 123 Quarters, Abdulsalam Quarters, Bosso Estate, Bosso Estate Extension, F-layout, FMBN Housing Estate, GRA, Talba Housing Estate, Type-B Quarters, and Upper Base. These areas are distinguished by low population, building, and housing densities, large lot sizes, relatively higher proportions of public institutional and natural environmental land uses, and better accessibility conditions, particularly high street connectivity and low dendritic street pattern. This configuration reflects a more organized and formally planned residential environment with greater spatial order and better internal movement structure.

Another group, comprising 11 neighbourhoods (16.7%), includes areas such as Albishiri, Bahago, Gbeganu, Gurara, Kafin Tela, Maitumbi South, Shanu Village, Tayi Village, and Tungan Goro. These neighbourhoods are notable for low population and building density, slightly higher housing density, large lot sizes, and the highest proportion of natural environmental land use (30%), combined with weak accessibility characteristics. This suggests relatively dispersed and less intensively developed neighbourhood environments, possibly reflecting peripheral or semi-open residential forms.

Table 1: Estimated Physical Configuration of Neighbourhoods in Minna

Neighbourhood	**Density**					**Land use mix**					**Accessibility**		
	Pop. density	Bldg. density	Housing density	Lot size		Res. **LU** %	Public inst. **LU** %	Natural env. **LU** %	Industrial **LU** %		Street conn.	Dendritic pattern	Transport **LU** %
123 Quarters	1	1	1	3		75	14	10	1		3	1	8
Abdulsalam Quarters	1	1	1	3		75	14	10	1		3	1	8
Albishiri	1	1	2	3		58	7	30	2		1	3	3
Anguwan Biri	3	3	3	1		68	8	5	5		1	3	9
Anguwan Daji	3	3	3	1		68	8	5	5		1	3	9
Bahago	1	1	2	3		58	7	30	2		1	3	3
Bajago	3	3	3	1		68	8	5	5		1	3	9
Barikin Saleh	3	3	3	1		68	8	5	5		1	3	9
Barikin Saleh Extension	2	2	2	2		80	10	7	3		2	2	6
Bosso Estate	1	1	1	3		75	14	10	1		3	1	8
Bosso Estate Extension	1	1	1	3		75	14	10	1		3	1	8
Bosso Low-cost	2	2	2	2		80	10	7	3		2	2	6
Bosso Town North	3	3	3	1		68	8	5	5		1	3	9
Bosso Town South	3	3	3	1		68	8	5	5		1	3	9
Bovi	1	1	2	3		58	7	30	2		1	3	3
Chanchaga	3	3	3	1		68	8	5	5		1	3	9
Darulsalam A	1	1	2	3		58	7	30	2		1	3	3
Darulsalam B	2	2	2	2		80	10	7	3		2	2	6
Dutsen Kura Gwari	3	3	3	1		68	8	5	5		1	3	9
Dutsen Kura Gwari Extension	2	2	2	2		80	10	7	3		2	2	6
Dutsen Kura Hausa	3	3	3	1		68	8	5	5		1	3	9
Fadikpe	3	3	3	1		68	8	5	5		1	3	9
Fadikpe Extension	2	2	2	2		80	10	7	3		2	2	6
F-layout	1	1	1	3		75	14	10	1		3	1	8
FMBN Housing Estate	1	1	1	3		75	14	10	1		3	1	8
Gbeganu	1	1	2	3		58	7	30	2		1	3	3
Gbeganu Extension	2	2	2	2		80	10	7	3		2	2	6
GRA	1	1	1	3		75	14	10	1		3	1	8
Gurara	1	1	2	3		58	7	30	2		1	3	3
Hayi Gwari	3	3	3	1		68	8	5	5		1	3	9
Kafin Tela	1	1	2	3		58	7	30	2		1	3	3
Kafin Tela Extension	2	2	2	2		80	10	7	3		2	2	6
Keteran Gwari	3	3	3	1		68	8	5	5		1	3	9
Kpakungu	3	3	3	1		68	8	5	5		1	3	9
Kwangila	3	3	3	1		68	8	5	5		1	3	9
Limawa	3	3	3	1		68	8	5	5		1	3	9

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M. I. Wushishi Housing Estate	1	1	1	3		75	14	10	1		3	1	8
Maitumbi North	2	2	2	2		80	10	7	3		2	2	6
Maitumbi South	1	1	2	3		58	7	30	2		1	3	3
Makera	3	3	3	1		68	8	5	5		1	3	9
Mandela	2	2	2	2		80	10	7	3		2	2	6
Morris	1	1	1	3		75	14	10	1		3	1	8
New Shango	2	2	2	2		80	10	7	3		2	2	6
Oduoye Quarters	1	1	1	3		75	14	10	1		3	1	8
Old Airport Quarters	1	1	1	3		75	14	10	1		3	1	8
Old Shango	3	3	3	1		68	8	5	5		1	3	9
Paida	2	2	2	2		80	10	7	3		2	2	6
Railway Quarters	3	3	3	1		68	8	5	5		1	3	9
Sabon Gari	3	3	3	1		68	8	5	5		1	3	9
Sabon Titi	2	2	2	2		80	10	7	3		2	2	6
Sauka Kahuta	3	3	3	1		68	8	5	5		1	3	9
Sauka Kahuta Extension	3	3	3	1		68	8	5	5		1	3	9
Shanu Village	1	1	2	3		58	7	30	2		1	3	3
Soje A	2	2	2	2		80	10	7	3		2	2	6
Soje B	3	3	3	1		68	8	5	5		1	3	9
Talba Housing Estate	1	1	1	3		75	14	10	1		3	1	8
Tayi Village	1	1	2	3		58	7	30	2		1	3	3
Tudun Fulani	3	3	3	1		68	8	5	5		1	3	9
Tudun Wada North	3	3	3	1		68	8	5	5		1	3	9
Tudun Wada South	2	2	2	2		80	10	7	3		2	2	6
Tunga A	2	2	2	2		80	10	7	3		2	2	6
Tunga B	2	2	2	2		80	10	7	3		2	2	6
Tungan Goro	1	1	2	3		58	7	30	2		1	3	3
Type-B Quarters	1	1	1	3		75	14	10	1		3	1	8
Upper Base	1	1	1	3		75	14	10	1		3	1	8
Zarumai	2	2	2	2		80	10	7	3		2	2	6

Note: Population density, building density, housing density, street connectivity, and dendritic pattern are coded as 1 = low, 2 = medium, and 3 = high. Lot size is coded as 1 = small, 2 = medium, and 3 = large.

The spatial pattern in Figure 2 reveal a clear spatial heterogeneity in the physical structure of the neighbourhoods, with significant variations in population density, building density, housing density, and lot size across the study area. Figure 2(a) shows the spatial pattern of population density. The finding revealed that high population concentration is distributed in several clusters, particularly within the more built-up parts of the study area, while lower population density occurs mostly at some peripheral sections. This pattern indicates that population is concentrated in selected neighbourhoods rather than evenly spread across the city. The moderate-density zones appear to form transition belts between the high-density core areas and the lower-density outskirts, suggesting gradual changes in settlement intensity rather than abrupt spatial breaks.

A closely related pattern is observed in the spatial pattern of building density in Figure 2(b). Areas with high building density largely correspond to neighbourhoods already showing high population density, implying that these locations are not only more populated but are also physically more compact in terms of structures per unit area. In contrast, neighbourhoods with low building density are fewer in built structures and are likely to have more open spaces, lower site coverage, or less intensive development. The similarity between the population and building density surfaces therefore points to a strong relationship between demographic concentration and the compactness of the built environment.

The spatial analysis of housing density in Figure 2(c) also reflects this spatial pattern, although its pattern appears slightly more mixed than those of population and building density. High housing density in some neighbourhoods indicates areas where residential units are more concentrated, which may reflect multi-household compounds, closely spaced dwelling units, or generally compact residential layouts. Medium-density neighbourhoods are widely distributed, showing that much of the study area falls within an intermediate residential form rather than at the extremes. In contrast, the lot size spatial pattern in Figure 2(d) indicates an inverse spatial logic. Neighbourhoods classified in the higher lot-size category are generally associated with lower density conditions, while areas with lower lot-size values tend to coincide with the more compact and congested parts of the city.

The neighbourhood structure of the study area is shaped by a strong interaction between land subdivision and residential concentration. This finding confirms that variation in physical configuration is a major basis for neighbourhood differentiation within the study area and provides evidence of contrasting residential environments ranging from compact, intensely occupied neighbourhoods to more spacious and less congested ones.

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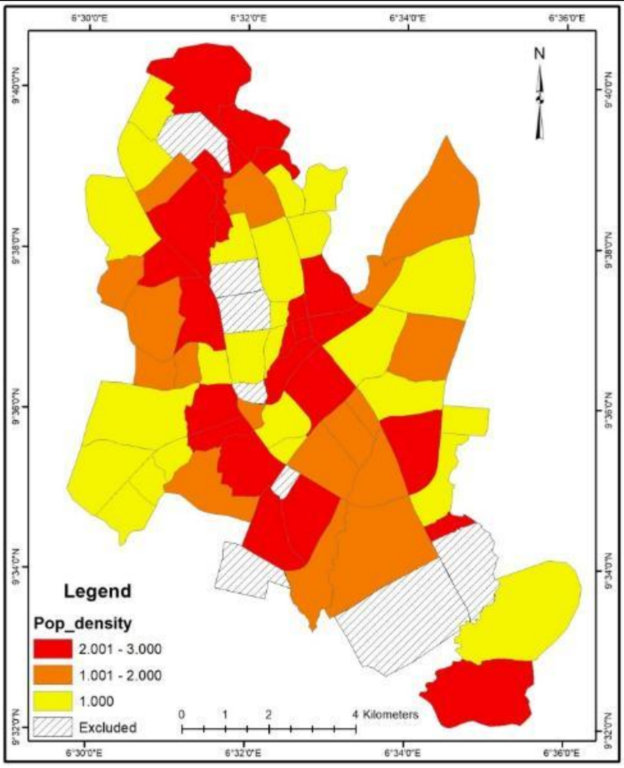
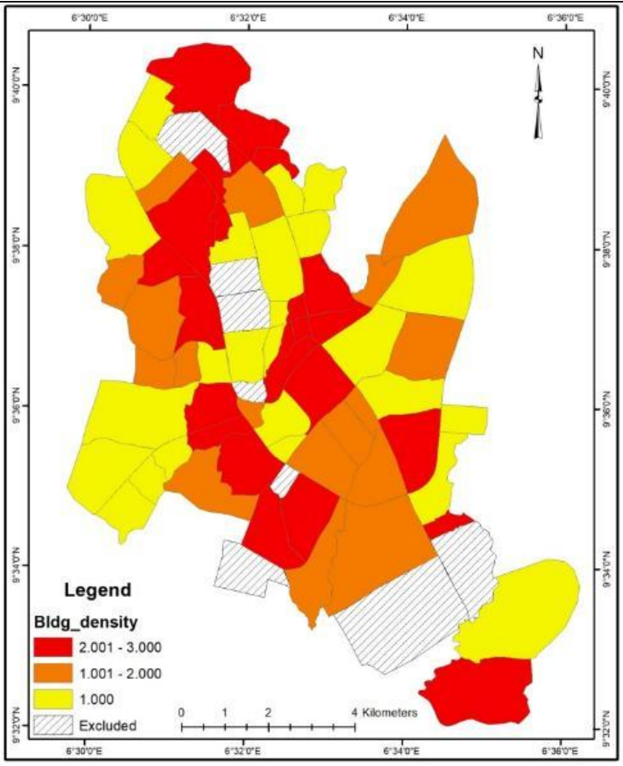
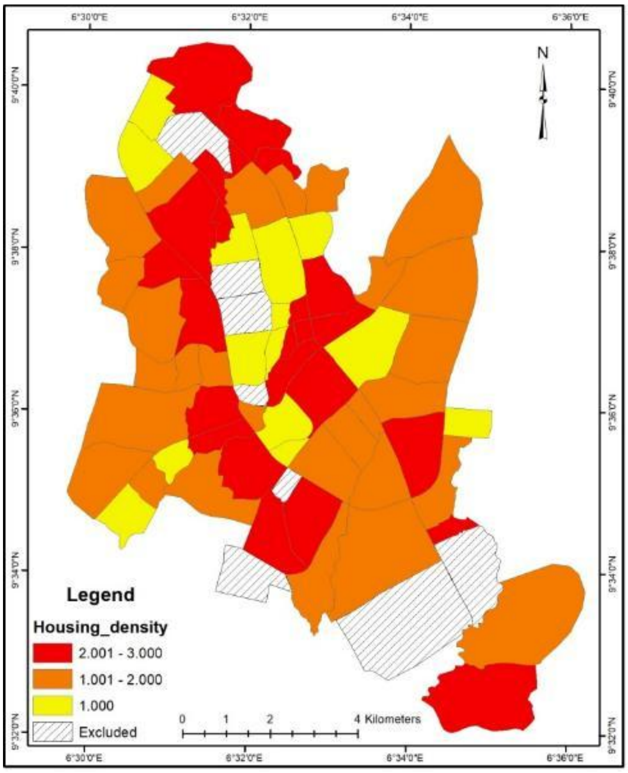


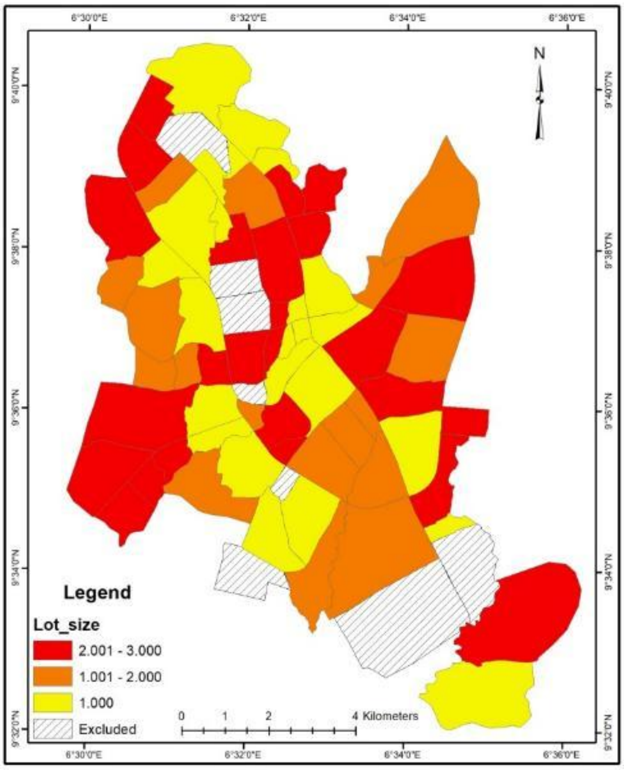
a) Population density



b) Building density



c) Housing density



d) Lot size

Figure 2: Spatial pattern of density as physical configuration of the study area

The spatial pattern of land use in Figure 3(a) shows a clear spatial variation in neighbourhood structure across the study area. Residential land use remains the dominant land use category in most neighbourhoods, while public institutional, natural environment, and industrial uses are distributed more unevenly. The residential land use pattern indicates that a large proportion of the neighbourhoods fall within the moderate to high residential use categories. In several parts of the study area, residential land occupies the largest share of available land, confirming that housing is the principal urban function. Areas with very high residential land use appear to be more strongly built up and likely more compact in form, while neighbourhoods with lower residential percentages may have a greater presence of other competing land uses such as public institutions, industry, or open land.

The public institutional land use pattern in Figure 3(b) shows a more scattered pattern. Public institutional use is present across the city, but it is not dominant in most neighbourhoods. Only a few areas record relatively high proportions, while many neighbourhoods fall within the lower and middle categories. The natural environment land use pattern in Figure 3(c) reveals that natural land cover is not uniformly distributed. Some neighbourhoods record relatively high proportions of natural environment, while others have very little.

The industrial land use pattern in Figure 3(d) shows that industrial land use generally occupies the smallest proportion of land across most neighbourhoods. Although a few neighbourhoods have relatively higher industrial percentages, the overall pattern suggests that industry is limited and concentrated in selected locations rather than spread widely throughout the study area.

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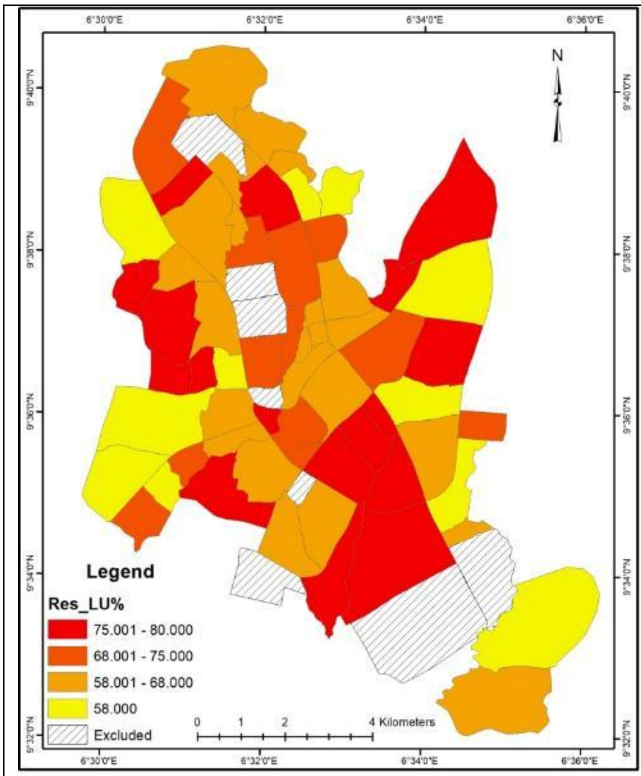
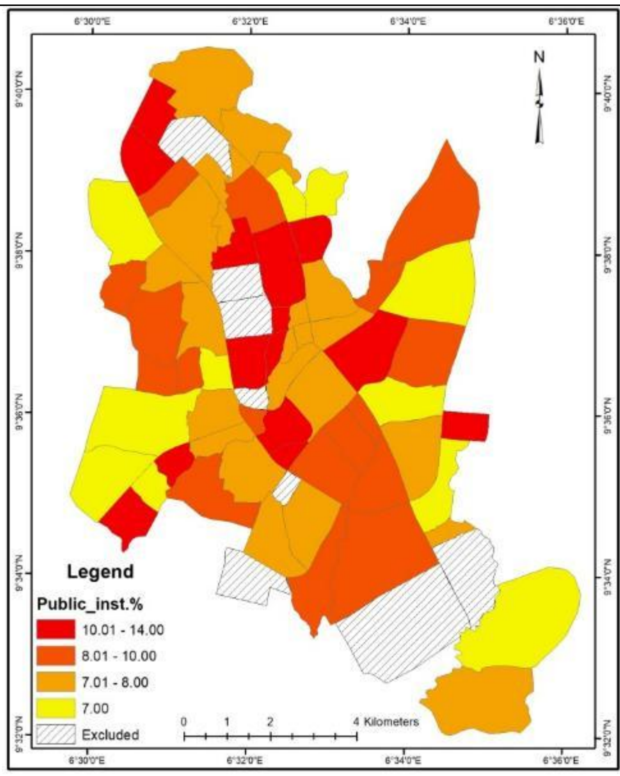
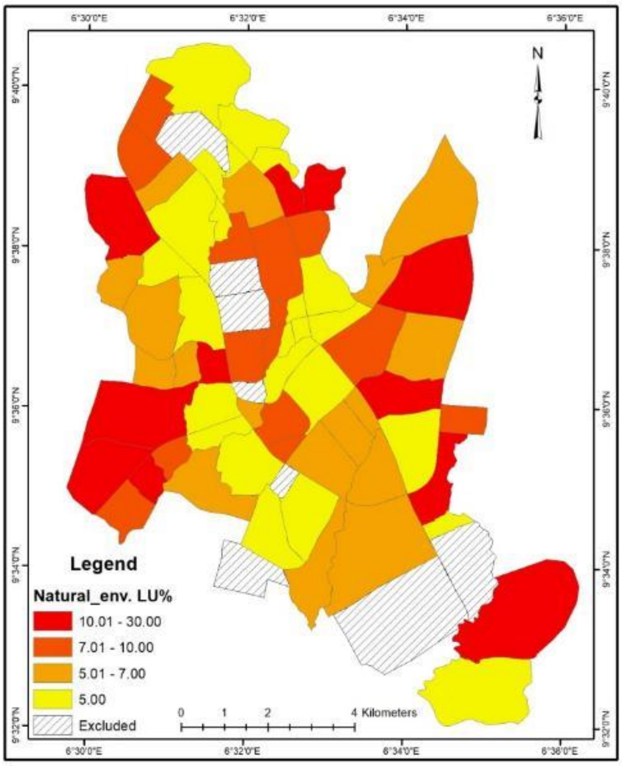


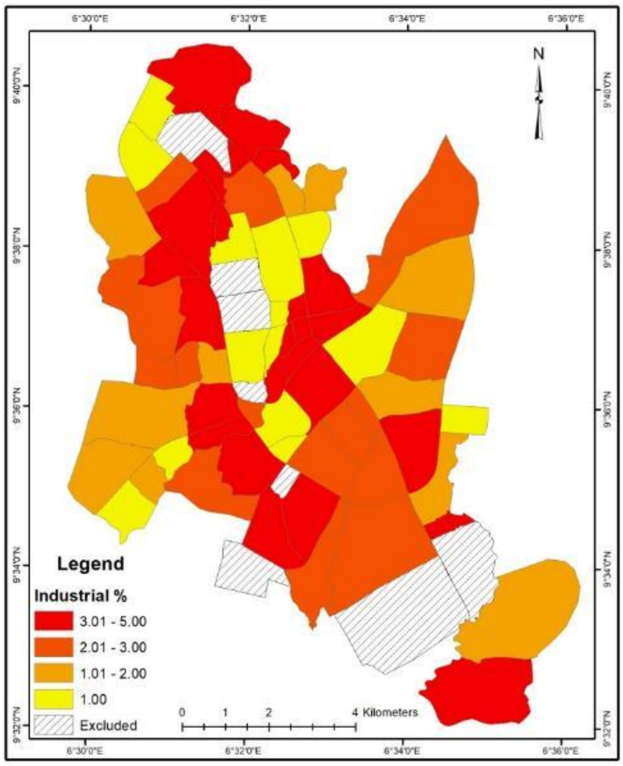
a) Percentage of Residential Land Use



b) Percentage of Public Institutional Land Use



c) Percentage of Natural Environment Land Use



d) Percentage of Industrial Land Use

Figure 3: Spatial pattern of land use mix as physical configuration of the study area

The accessibility spatial pattern in Figure 4 reveals clear spatial variation in the road structure of neighbourhoods across the study area. The pattern shown by street connectivity, dendritic street form, and transport land use suggests that neighbourhood accessibility is uneven and that not all parts of the city are equally integrated in terms of movement and circulation. The street connectivity pattern in Figure 4(a) shows that highly connected neighbourhoods are fewer and are mainly concentrated in selected parts of the study area, while many other neighbourhoods fall within the low to moderate categories. This indicates that only some areas have well-linked street networks with stronger internal and external movement connections. In contrast, many neighbourhoods appear to have weaker street interconnections, which may reduce ease of movement, route choice, and general accessibility. This pattern suggests that the city does not have a uniformly connected street system, but rather a fragmented structure in which some neighbourhoods are better served than others.

The dendritic pattern in Figure 4(b) presents a different but related picture. High dendritic values are more widespread across the study area, indicating that many neighbourhoods are organised around branching road systems. Such a pattern is often associated with hierarchical street layouts, where major access roads feed into smaller local roads, with fewer direct links between neighbourhood streets. This means that although roads may exist within these areas, their arrangement may not support high permeability or direct movement. The transport land use pattern in Figure 4(c) further supports this interpretation. A considerable number of neighbourhoods fall within the moderate to high transport land use categories, showing that a noticeable proportion of urban land is devoted to roads and movement corridors. However, the existence of transport land does not automatically translate into strong street connectivity.

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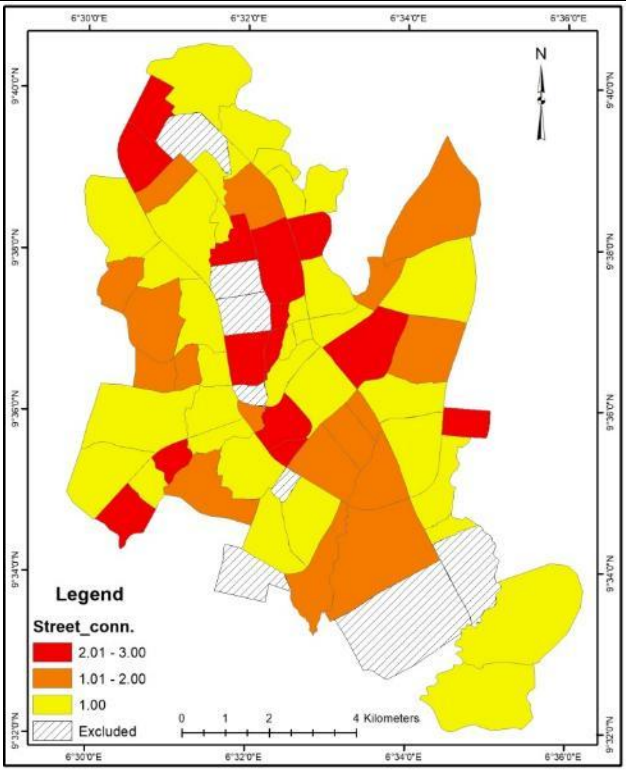
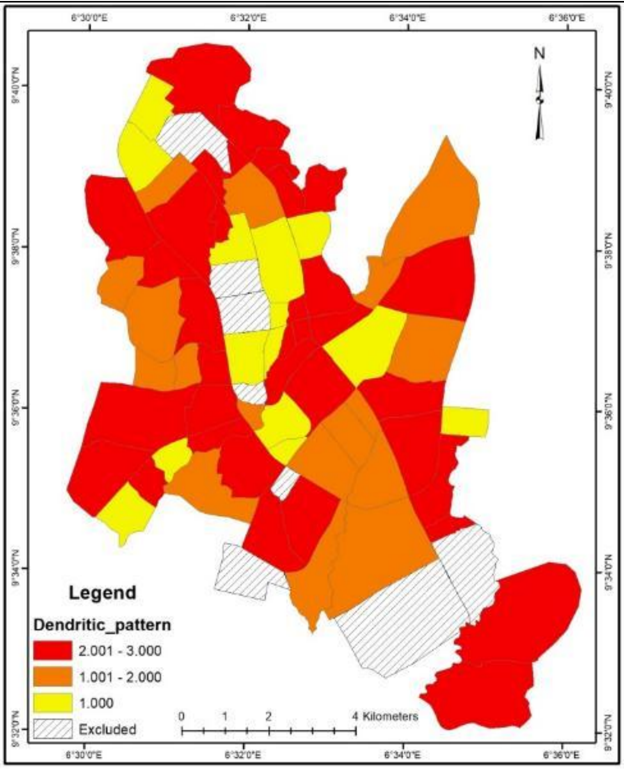
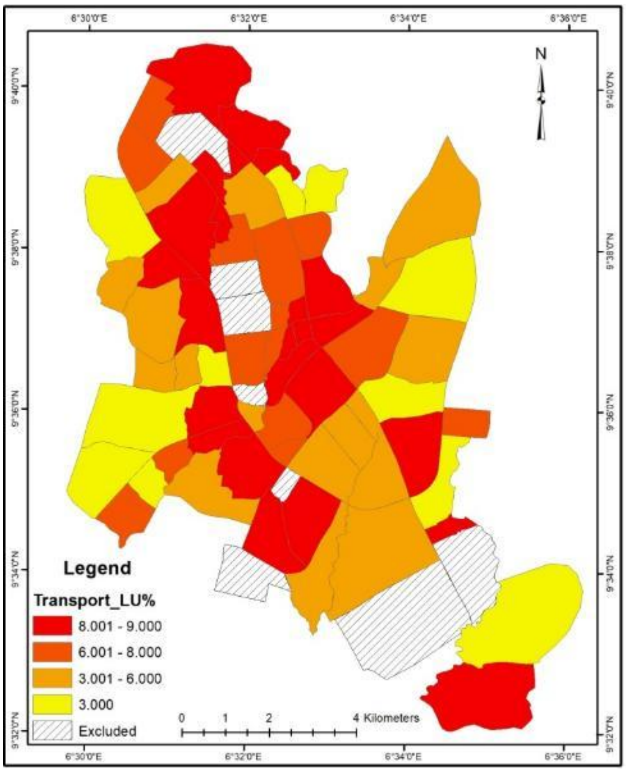


a) Street connectivity



b) Dendritic street pattern



c) Percentage of transport land use

Figure 4: Spatial pattern of accessibility as physical configuration of the study area

3.2 Rental values of real estate properties in the study area

Table 2 reveals a clear spatial variation in the rental value of two-bedroom apartments across neighbourhoods in Minna in 2025. The values range from ₦250,000 in Darulsalam A to ₦450,000 in Abdulsalam Quarters, Dutsen Kura Hausa, FMBN Housing Estate, Morris, Oduoye Quarters, and Type-B Quarters, giving a wide rental gap of ₦200,000 between the least and most expensive neighbourhoods. This indicates that rental housing values in the study area are far from uniform and are strongly differentiated by neighbourhood characteristics.

The finding further shows that the upper segment of the rental market is concentrated in planned, accessible, and relatively prestigious neighbourhoods. Areas such as GRA (₦440,000), Bosso Estate Extension (₦435,000), F-Layout (₦435,000), M. I. Wushishi Housing Estate (₦435,000), Tudun Wada South (₦435,000), Tunga A (₦430,000), Barikin Saleh Extension (₦430,000), Old Shango (₦425,000), and Zarumai (₦425,000), all fall within the higher rental bracket. The clustering of high values in these neighbourhoods suggests that tenants are willing to pay more for locations perceived to offer better housing quality, improved infrastructure, enhanced accessibility, and a more favourable residential environment.

By contrast, the lowest rental values are found in neighbourhoods such as Darulsalam A (₦250,000), Limawa (₦265,000), Albishiri (₦280,000), Kwangila (₦280,000), Keteran Gwari (₦285,000), Maitumbi South (₦285,000), and Kafin Tela (₦305,000). These comparatively lower values imply that such neighbourhoods may be less attractive in terms of building quality, environmental condition, service provision, accessibility, or neighbourhood status. Their lower rents may also reflect weaker demand relative to the more expensive parts of Minna.

Another notable pattern is that some extension or estate neighbourhoods tend to attract higher rents than their older or adjoining counterparts. For example, Barikin Saleh Extension (₦430,000) is higher than Barikin Saleh (₦415,000), Bosso Estate Extension (₦435,000) is higher than Bosso Estate (₦420,000), and Dutsen Kura Gwari Extension (₦425,000) is higher than Dutsen Kura Gwari (₦415,000). This may suggest that newer or more recently developed residential areas enjoy a rental premium, likely due to better planning, newer housing stock, and improved neighbourhood appeal.

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Table 2: Rental Value of Two-bedroom Apartment in the Study Area 2025

S/N	Neighbourhood	Rental Value (₦)		S/N	Neighbourhood	Rental Value (₦)
1	123 Quarters	420,000		34	Kpakungu	375,000
2	Abdulsalam Quarters	450,000		35	Kwangila	280,000
3	Albishiri	280,000		36	Limawa	265,000
4	Anguwan Biri	385,000		37	M. I. Wushishi housing estate	435,000
5	Anguwan Daji	335,000		38	Maitumbi North	370,000
6	Bahago	335,000		39	Maitumbi South	285,000
7	Bajago	345,000		40	Makera	375,000
8	Barikin Saleh	415,000		41	Mandela	395,000
9	Barikin Saleh Extension	430,000		42	Morris	450,000
10	Bosso Estate	420,000		43	New Shango	395,000
11	Bosso Estate Extension	435,000		44	Oduoye Quarters	450,000
12	Bosso Low-cost	420,000		45	Old Airport Quarters	420,000
13	Bosso Town North	370,000		46	Old Shango	425,000
14	Bosso Town South	355,000		47	Paida	380,000
15	Bovi	420,000		48	Railway Quarters	350,000
16	Chanchaga	350,000		49	Sabon Gari	345,000
17	Darulsalam A	250,000		50	Sabon Titi	405,000
18	Darulsalam B	420,000		51	Sauka Kahuta	380,000
19	Dutsen Kura Gwari	415,000		52	Sauka Kahuta Extension	415,000
20	Dutsen Kura Gwari Extension	415,000		53	Shanu Village	335,000
21	Dutsen Kura Hausa	450,000		54	Soje A	395,000
22	Fadikpe	375,000		55	Soje B	375,000
23	Fadikpe Extension	370,000		56	Talba housing estate	420,000
24	F-layout	435,000		57	Tayi Village	365,000
25	FMBN housing estate	450,000		58	Tudun Fulani	420,000
26	Gbeganu	410,000		59	Tudun Wada North	340,000
27	Gbeganu Extension	405,000		60	Tudun Wada South	435,000
28	GRA	440,000		61	Tunga A	430,000
29	Gurara	365,000		62	Tunga B	405,000
30	Hayi Gwari	375,000		63	Tungan Goro	385,000
31	Kafin Tela	305,000		64	Type-B Quarters	450,000
32	Kafin Tela Extension	400,000		65	Upper Base	420,000
33	Keteran Gwari	285,000		66	Zarumai	425,000

The spatial pattern of two-bedroom rental value for 2025 in Figure 5 shows a clear spatial variation in rental prices across the neighbourhoods in the study area. Rental values are not evenly distributed; rather, they appear to cluster into high-, medium-, and low-value zones. The highest rental class (₦425,001 – ₦450,000) is concentrated in selected neighbourhoods, indicating areas of stronger housing demand and greater residential desirability. These neighbourhoods likely possess more favourable physical and locational characteristics, such as better housing quality, improved accessibility, stronger neighbourhood image, or a higher level of urban services.

A second group of neighbourhoods falls within the upper-middle rental range (₦385,001 – ₦425,000). These areas are also prominent across the map and appear to form transitional zones between the highest-value neighbourhoods and the lower-value areas. The lower rental categories, particularly ₦250,000 – ₦305,000 and ₦305,001 – ₦385,000, are found in fewer but distinct parts of the study area. These neighbourhoods may reflect less intense housing demand, weaker accessibility, lower-quality infrastructure, or a less attractive residential environment when compared with the high-rent zones. Their presence confirms that the housing market within the study area is socially and spatially differentiated.

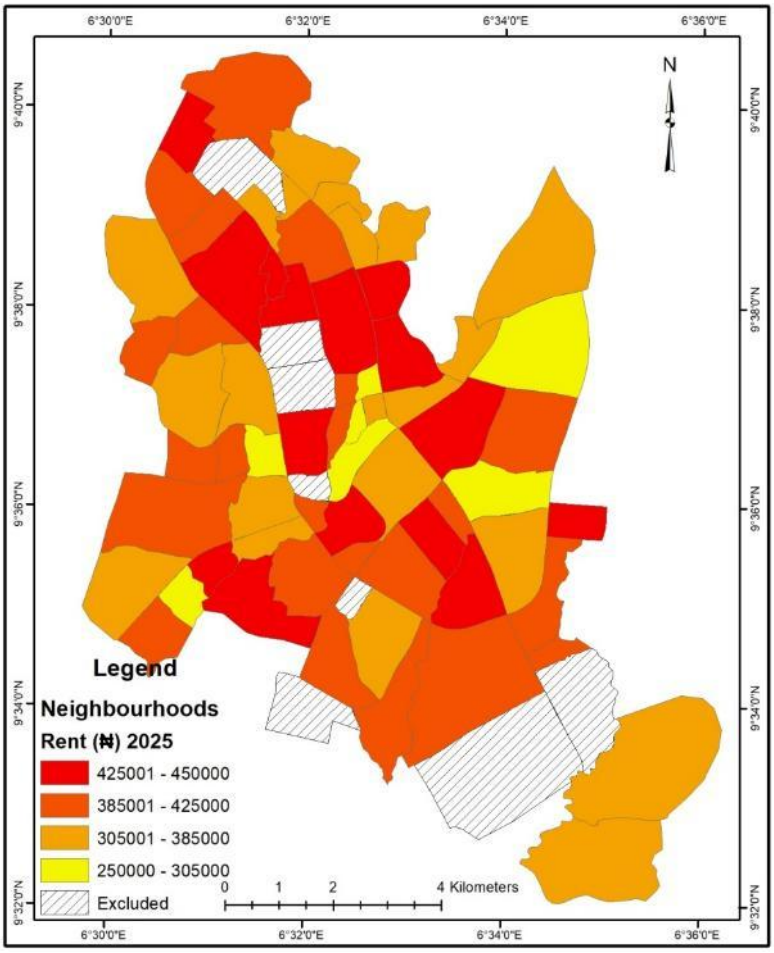

Figure 5: Spatial pattern of two-bedroom rental values in the study area

3.3 Modelling spatial relationships between the physical configuration of urban neighbourhoods and rental values

Table 3 presents the global OLS model, which serves as the baseline for analysing the GWR results on the relationship between the physical configuration of urban neighbourhoods and

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rental values. The findings show that, at the global level, land use mix and accessibility exert statistically significant positive effects on rental value, while density does not have a significant influence. Specifically, land use mix has a coefficient of 23,329.012 with a p-value of 0.001, indicating that neighbourhoods with more favourable land use composition tend to record higher rental values. Similarly, accessibility has the strongest positive effect, with a coefficient of 47,793.445 and a p-value of 0.000, suggesting that improvements in accessibility are associated with substantial increases in rental values. The 95% confidence intervals for both variables remain entirely positive, further confirming the robustness of their effects. In contrast, density has a small positive coefficient of 5,363.249, but its p-value of 0.841 shows that this relationship is not statistically significant, while its confidence interval crosses zero, indicating uncertainty in its effect. The intercept is also not statistically significant.

In substantive terms, the global model suggests that rental value variation is explained more by how neighbourhood land uses are arranged and how accessible such areas are than by density alone. This means that neighbourhoods with better connectivity, transport advantage, and a more supportive land use structure are more likely to command higher rents. However, the non-significance of density in the global OLS model also implies that its effect may not be uniform across space. This provides a strong justification for the use of GWR, since GWR is better suited to reveal whether the influence of density, land use mix, and accessibility varies from one neighbourhood to another rather than remaining constant across the entire study area.

Table 3: Global OLS model result for the relationships between the physical configuration of urban neighbourhoods and rental values

Global OLS coefficients	Coefficient	Std_Error	t_stat	p_value	CI_2.5%	CI_97.5%
Intercept	-347086.80	220226.58	-1.57604	0.1201	-787313.46	93139.86
Density	5363.249	26541.347	0.202	0.841	-47692.147	58418.645
Land use mix	23329.012	6871.461	3.395	0.001	9593.157	37064.866
Accessibility	47793.445	8388.380	5.698	0.000	31025.312	64561.579

Table 4 shows that the GWR model provides a better fit than the global OLS model in explaining the relationship between the physical configuration of urban neighbourhoods and rental values. While the global OLS model produced an R^2 of 0.409, the GWR model improved this to a pseudo R^2 of 0.556, indicating that the local model explains a substantially larger proportion of the variation in rental values. The global OLS adjusted R^2 of 0.381 further suggests only a moderate explanatory power when spatial variation is ignored. In addition, the

GWR model recorded lower error values, with RMSE decreasing from 38,182.658 to 33,095.356 and MAE reducing from 27,330.139 to 24,722.175. These improvements indicate that the GWR predictions are closer to the observed rental values than those produced by the OLS model.

The bandwidth result also provides important insight into the spatial process underlying rental value variation. The GWR bandwidth of 48 nearest neighbours and mean bandwidth distance of about 6,045.240 m suggest that the local relationships are influenced by conditions within a fairly broad spatial neighbourhood rather than by only immediate adjacent areas. Substantively, this means that the effects of density, land use mix, and accessibility on rental values are not spatially constant across Minna, and allowing these relationships to vary locally improves model performance. This comparison confirms that GWR is more appropriate than OLS for modelling rental values in relation to urban morphology, because it captures the spatial heterogeneity embedded in neighbourhood-level housing market behaviour.

Table 4: Comparison of the OLS and GWR model fits for the relationships between the physical configuration of urban neighbourhoods and rental values

	Global OLS	GWR
R^2	0.409224031	0.556
Adjusted_R^2	0.380638097	
RMSE	38182.65752	33095.356
MAE	27330.13867	24722.175
Bandwidth_k_neighbors		48.000
Bandwidth_mean_m		6045.240

The GWR model for the relationship between physical configuration of urban neighbourhoods and rental value is presented in Figure 6. The spatial pattern of the GWR residuals in Figure 6(a) indicates that the relationship between rental value and physical configuration of urban neighbourhoods in Minna is not entirely uniform across space, although the model appears to have explained a substantial part of the variation. Residual values range from about -85,739 to 82,050, with most neighbourhoods falling within the intermediate classes, while only a few areas record extreme positive or negative residuals. This suggests that the GWR model has captured much of the spatial effect of the morphology variables, but some local discrepancies remain. The positive residual zones (shown in pink and part of yellow) represent areas where actual rental values are higher than predicted, implying that factors beyond density, land use mix, and accessibility may be elevating rents in those neighbourhoods. Conversely, the negative residual zones (shown in cyan and purple) indicate areas where the model

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overpredicted rental values, suggesting that urban morphology alone does not fully translate into higher rents there.

The GWR density beta spatial pattern in Figure 6(b) shows a clear spatial variation in the influence of density on rental value across the neighbourhoods of the study area, with local coefficients ranging from -18,098.41 to 49,010.09. The strongest positive effects are concentrated in the central neighbourhoods, where the beta values fall within 26,077.50 to 49,010.09, indicating that increases in density in these areas are associated with substantial increases in rental value. A wider belt of surrounding neighbourhoods falls within the moderately positive range of 13,213.80 to 26,077.49, showing that density still contributes positively to rent, though less strongly. By contrast, some peripheral areas, especially toward the eastern and southeastern parts of the city, record weak or negative coefficients, with values ranging from -2,108.92 to 13,213.79 and -18,098.41 to -2,108.93. This means that in those locations, higher density adds little to rental value and may even reduce it, possibly because density there is linked more to congestion and lower residential appeal than to urban advantage.

The GWR land use mix beta spatial pattern in Figure 6(c) shows that the effect of land use mix on rental value is positive across all neighbourhoods of the study area, although the strength of that effect varies spatially. Local coefficients range from 16,365.46 to 47,598.60, indicating that land use mix consistently contributes to higher rental values, but more strongly in some neighbourhoods than others. The strongest positive influence occurs in the central part of the city, where beta values fall within 35,993.01 to 47,598.60, suggesting that neighbourhoods with a more favourable mix of residential, institutional, environmental, and supporting land uses command higher rental premiums in these locations. A broader surrounding zone records coefficients of 28,311.99 to 35,993.00, while other neighbourhoods fall within the moderate range of 23,657.00 to 28,311.98. The lowest but still positive coefficients, ranging from 16,365.46 to 23,656.99, are concentrated mainly toward the outer northern, eastern, southeastern, and far southern parts of the study area. This pattern suggests that land use mix has its greatest rental effect in the urban core and nearby neighbourhoods, where functional diversity likely enhances convenience and attractiveness, while its influence weakens toward the periphery.

The GWR accessibility beta spatial pattern in Figure 6(d) shows that accessibility has a consistently positive effect on rental value across the study area, although the strength of this effect varies from one neighbourhood to another. The local coefficients range from 29,089.82

to 79,343.44, indicating that better accessibility is associated with higher rental values throughout the study area, but with stronger influence in some locations. The highest accessibility effects are concentrated in the central neighbourhoods, where beta values fall within 62,951.16 to 79,343.44, suggesting that accessibility commands the greatest rental premium in the urban core. A surrounding belt of neighbourhoods records coefficients of 54,726.05 to 62,951.15, showing a still strong but slightly lower effect. Further outward, many areas fall within the moderate range of 43,202.80 to 54,726.04, while the lowest positive coefficients, ranging from 29,089.82 to 43,202.79, are mainly located in the southeastern and far eastern parts of the city. This pattern suggests that accessibility contributes most strongly to rental value in the more central and functionally integrated parts of the study area, while its influence weakens toward the periphery.

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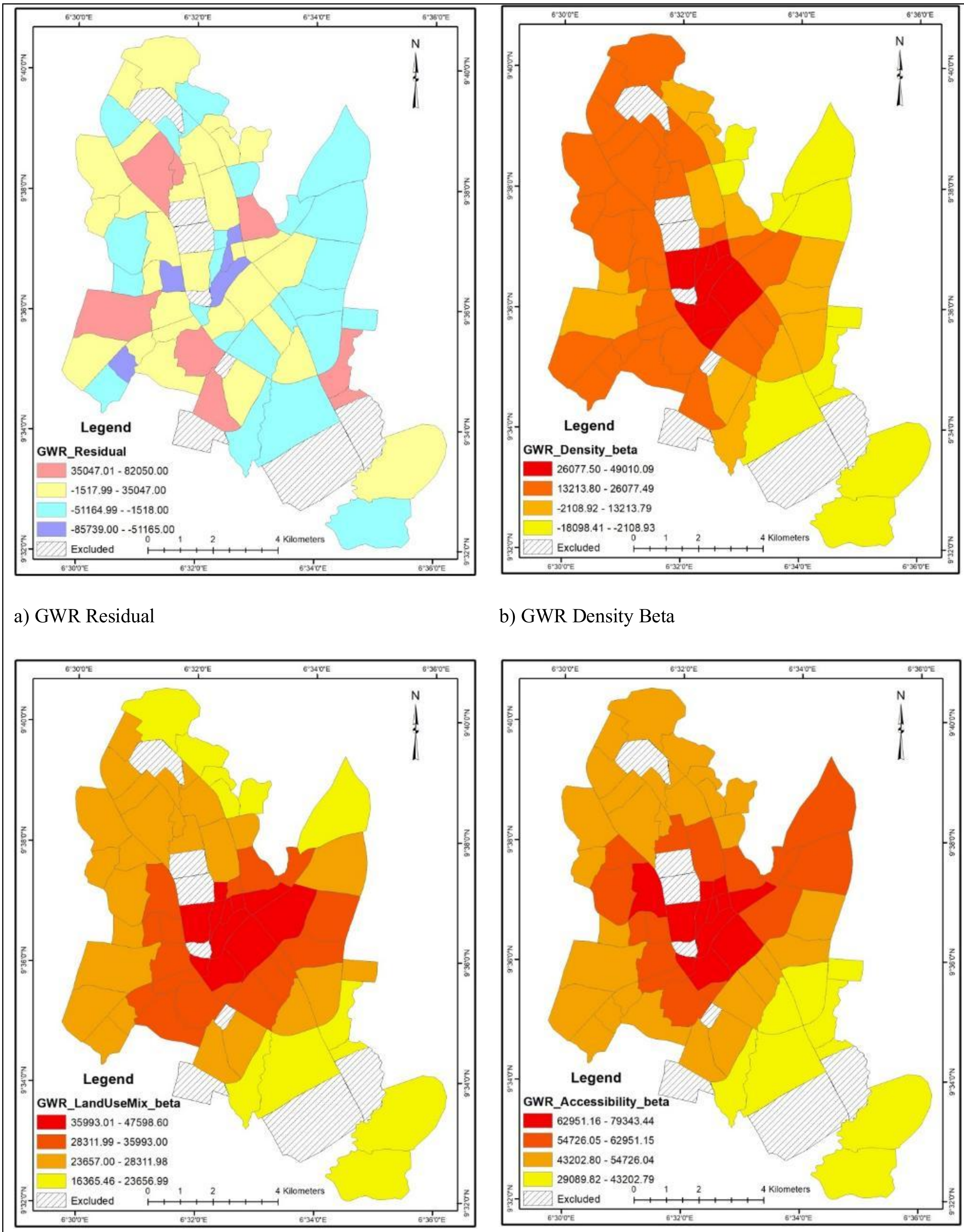

a) GWR Residual

b) GWR Density Beta

c) GWR Land Use Mix Beta

d) GWR Accessibility Beta

Figure 6: GWR Model for the Relationship between Urban Morphology and Rental Value

4. Conclusion and Recommendations

This study has shown that rental value variation among neighbourhoods in the study area is closely associated with differences in urban morphology, particularly density, land use mix, and accessibility. The findings revealed that the city is composed of distinct neighbourhood forms, with high-density neighbourhoods constituting the dominant pattern, while medium-density areas, low-density planned estates, and more environmentally open neighbourhoods also exist as important urban types. Rental values were found to vary widely across the study area, confirming that the housing market is spatially differentiated rather than uniform. At the descriptive level, higher rents were concentrated in more planned, accessible, and prestigious neighbourhoods, whereas lower rents were associated with less attractive and less integrated areas. More importantly, the modelling results established that land use mix and accessibility have significant positive effects on rental value, while density was not significant in the global model. However, the GWR model demonstrated that these relationships vary spatially across the city and provided a better fit than the OLS model, confirming the existence of spatial heterogeneity in the real estate market. The study concludes that the physical configuration of urban neighbourhoods is a significant determinant of rental values in Minna, but its influence is not spatially uniform, with accessibility emerging as the strongest and most consistent predictor, followed by land use mix, while the effect of density depends on local neighbourhood context.

The study therefore recommended the following:

i. Neighbourhoods with relatively low rental values should be targeted for physical and environmental improvement, especially in terms of housing quality, road condition, security, electricity, water supply, and general infrastructure provision.
ii. The positive features observed in high-value neighbourhoods, such as better street organization, improved accessibility, orderly land use arrangement, and quality infrastructure, should be integrated into future residential layouts and urban expansion schemes.
iii. Housing and urban policies should move beyond city-wide generalizations and focus more on neighbourhood-specific conditions, since the determinants of rental value are not spatially uniform across the study area.
iv. Researchers and urban managers should make greater use of spatial analytical models such as Geographically Weighted Regression, since the study has shown that the

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influence of urban morphology on rental values varies from one neighbourhood to another.

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