

Socio-Spatial Dynamics of Urban Residential Land Use in Agartala City, India: A GIS-Based Analysis of Housing Typology, Land Value Gradients, and Infrastructure Disparities

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Abstract

Urban residential land use constitutes the most extensive component of metropolitan spatial structure, yet its internal differentiation in mid-sized cities of emerging economies remains underexplored. This study investigates the socio-spatial configuration of residential land use in Agartala City, the capital of Tripura State, India, integrating primary household survey data from 990 systematically sampled dwellings with GIS-based cartographic analysis, cadastral records, and secondary census data. Four residential typologies are delineated—high-class reinforced concrete (RCC) structures, intermediate semi-permanent housing, mixed low-income dwellings, and dilapidated settlements—and their spatial distributions are mapped across the municipal wards. Statistical analyses, including descriptive profiling, chi-square independence tests, and Spearman rank correlation, reveal significant associations between housing quality, residential distance from the Central Business District (CBD), and access to infrastructure. Quantitative findings demonstrate that land values exhibit a pronounced negative gradient with increasing distance from the urban core ($r = -0.81$, $p < 0.001$), while infrastructure adequacy scores display a parallel attenuation pattern. The residential fabric of Agartala City conforms most closely to the Multiple Nuclei Model of urban land use rather than classical concentric or sector configurations, reflecting the compounded influence of post-partition migration, rapid urbanisation, and topographically constrained expansion within the Haora River–Kata Khal floodplain system. Peripheral localities exhibit acute deficiencies in piped water supply, road connectivity, drainage infrastructure, and solid waste management. The study concludes with evidence-based recommendations for decentralised service provision, vertical densification, and ecologically sensitive urban planning to ensure long-term residential sustainability in Agartala.

1. Introduction

The spatial organisation of residential land use is a foundational determinant of urban morphology, social equity, and environmental sustainability. Housing one of the three elemental necessities of human existence alongside food and clothing extends beyond mere physical shelter to encompass the broader socio-economic context in which households fulfil their daily requirements (Maslow, 1954; Knox & McCarthy, 2012). Within the framework of urban land use, residential areas typically occupy the largest share of metropolitan territory and simultaneously reflect, and reinforce, the socio-economic stratification of urban populations (Singh, 1980; Carter, 1995).

The configuration of residential space is shaped by a complex interplay of physical geography, transportation networks, accessibility to employment and services, land market dynamics, and public planning interventions (Northam, 1975; Pacione, 2009). In rapidly urbanising developing economies, these determinants interact with additional pressures including unregulated migration, informal settlement formation, and constrained fiscal capacity of municipal governments, producing residential landscapes that frequently deviate from patterns predicted by classical land use theory (Lambin et al., 2003; Seto et al., 2012; Batty, 2013).

Agartala, the capital and primate city of Tripura in northeastern India, represents a compelling case study for examining these dynamics. As one of the fastest-growing urban centres in the northeast Indian subregion (Das & Dutta, 2020), Agartala has undergone substantial spatial transformation driven by successive waves of cross-border migration, post-independence administrative growth, and more recent infrastructural investment (Mitra & Santra, 2020). Its residential land use expanded from approximately 588 hectares in 1991 to nearly 2,915 hectares by 2011 (Census of India, 2011; JNNURM, 2006), representing a near five-fold increase over two decades. Despite this rapid transformation, the internal spatial structure of residential land use in Agartala has received limited systematic scholarly attention.

Earlier scholarship has established that urban land values exhibit positive spatial autocorrelation, with residential land prices demonstrating stronger clustering behaviour than either commercial or industrial values (Liu et al., 2006). Research from sub-Saharan African cities has demonstrated that spatial factors—including road accessibility, distance to commercial nodes, and neighbourhood income composition—exert independent and measurable effects on residential land prices (Bhanjee & Zhang, 2018; Msuya et al., 2021; Marandu et al., 2024). Evidence from Southeast Asian contexts further underscores the relationship between urban cluster formation and intra-urban price variation (Gamal et al., 2024). These findings converge on a consistent empirical regularity: residential land values exhibit a negative distance–value gradient from the urban core, modulated by local accessibility conditions and the spatial distribution of economic functions.

The present study addresses three interrelated research objectives. First, it documents and maps the typological diversity of residential land use across the 49 municipal wards of Agartala, classifying dwellings according to structural quality and socio-economic character. Second, it analyses the spatial gradient of land values in relation to distance from the Central Business District (CBD) and proximity to transportation infrastructure. Third, it evaluates the adequacy and spatial distribution of key urban infrastructure services—including drinking water, road connectivity, drainage, and solid waste management—across residential categories. In pursuing these objectives, the study deploys both GIS-based spatial analysis and inferential statistical techniques, addressing a methodological gap in existing Indian urban geography research on mid-sized northeastern cities.

The conceptual framework draws upon the classical urban land use models of Burgess (1925), Hoyt (1939), and Harris and Ullman (1945), as well as their subsequent modifications by Vance (1964), Mann (1965), and Kearsley (1983), to evaluate whether the residential spatial structure of Agartala conforms to any established theoretical configuration or manifests a locally distinctive pattern shaped by its unique demographic history, topographic setting, and developmental trajectory.

2. Study Area

Agartala City is situated in the extreme western sector of Tripura State, occupying the geographic coordinates 23°45'N to 23°55'N latitude and 91°15'E to 91°20'E longitude (Fig. 1). The city's municipal extent has progressively expanded from an initial area of approximately 62 km² to the current boundary

of 76.504 km², encompassing 49 administrative wards following the most recent boundary revision (Mitra & Santra, 2020). As recorded in the 2011 Census of India, the city's population stood at approximately 400,004 persons, yielding a population density of 6,451 persons per square kilometre (Census of India, 2011).

Physiographically, Agartala occupies a synclinal floodplain valley defined by the Haora River and the Kata Khal drainage corridor, imparting a characteristic saucer-shaped (basin) topography to the urban landscape (Bhattacharya, 2013). This low-lying configuration renders substantial portions of the city susceptible to seasonal waterlogging during the monsoon period, constituting a persistent environmental and planning challenge (Tripura State Action Plan on Climate Change, 2012). The local topography is informally described using the binary terminology of Tilla (elevated upland areas) and Lunga (seasonally inundated lowland areas), which has historically exerted a decisive influence on patterns of residential settlement and land valuation.

Administratively, the city is bounded to the west by the international frontier with Bangladesh, to the east by Jirania Revenue District Block, to the north by Mohanpur Revenue District Block, and to the south by Dukli Revenue District Block (Census of India, 2011). Transportation connectivity is provided by National Highway-44 (re-designated NH-8) linking Agartala to Silchar, Guwahati, and Shillong, and by the Northeast Frontier Railway (Government of Tripura, 2018). The city functions as the principal administrative, commercial, educational, and cultural hub of Tripura State.

3. Methodology

The study adopted a mixed-methods research design integrating primary field investigation with secondary spatial and demographic data. Primary data were generated through a structured household survey of 990 dwellings, selected through systematic random sampling across all 49 municipal wards. Ward-level sample sizes were allocated proportionally to ward population, ensuring spatial representativeness. The survey instrument captured information on housing material typology, dwelling area, household income category, tenure status, and perceived adequacy of nine infrastructure services.

Secondary data were obtained from the Agartala Municipal Corporation (AMC), the Directorate of the Census of India (2011), the Settlement Office (cadastral records), the Tripura Space Application Centre (TSAC), and published City Development Plan reports (JNNURM, 2006). GIS-based spatial analysis was conducted using ArcGIS 9.3 and Global Mapper 8.1, with high-resolution Google Earth imagery employed as a base cartographic reference. Cadastral polygons were georeferenced and attributed with ward-level land use classifications derived from the field survey.

Three inferential statistical procedures were applied to the survey data. First, chi-square tests of independence were used to evaluate whether housing quality category was significantly associated with municipal ward zone (inner, intermediate, peripheral), testing the null hypothesis of spatial homogeneity in housing type distribution. Second, Spearman's rank correlation coefficient (ρ) was computed between estimated land value (Rs. per sq. ft.) and Euclidean distance from the CBD to quantify the direction and

magnitude of the land value–distance relationship. Third, a composite Infrastructure Adequacy Index (IAI) was constructed by summing binary adequacy scores (adequate = 1; inadequate = 0) across nine service dimensions for each ward zone and normalising the index to a 0–100 scale. Descriptive statistics including means, standard deviations, and frequency distributions were computed using SPSS v22.

Housing quality was classified into four ordered typological categories reflecting both structural condition and socio-economic character: (i) high-quality RCC structures predominantly occupied by upper-income households; (ii) intermediate semi-permanent structures associated with middle-income occupancy; (iii) mixed or low-quality structures accommodating lower-income families; and (iv) dilapidated or temporary structures in states of severe disrepair. This classification draws upon the field observation protocol and is consistent with frameworks employed in comparable Indian urban geography research (Pacione, 2009; Mandal, 2000).

4. Historical Evolution of Residential Land Use in Agartala

The residential fabric of Agartala has been shaped by a succession of distinct historical episodes spanning nearly three centuries. The contemporary urban nucleus traces its origin to 1748, when Maharaja Krishna Manikya relocated the princely capital of Tripura from Rangamati (present Udaipur) to a settlement designated Haveli on the western bank of the Haora River—a site corresponding to what is now referred to as Old Agartala (Sengupta, 1998). A complementary settlement, designated New Haveli, was subsequently established on the river's eastern bank in 1838; this nucleus evolved into the modern city. In 1849, Maharaja Krishna Kishore Manikya formally transferred the state capital to New Haveli, motivated by recurrent tribal insurgency and the strategic imperative of maintaining reliable communication with British Bengal (Chattopadhyay, 1989).

The Agartala Municipality was constituted in 1871, at which time the urban population comprised only approximately 875 persons. A watershed event in the physical evolution of the city occurred in 1917, when Maharaja Birendra Kishore Manikya commissioned the southward diversion of the Haora River channel through construction of an embankment (locally termed Bundh), decisively reducing the flood risk that had previously constrained residential expansion in the eastern and central sectors of the town (Ganachoudhuri, 1945). Topographical data from the Survey of India (1932) indicate that, during the early twentieth century, residential settlement was confined primarily to the localities of Malarmath, Krishnanagar, West Ramnagar, Shibnagar, and Banamalipur, with the surrounding terrain characterised by vegetation cover and seasonal wetlands.

Two demographic discontinuities fundamentally altered the scale and character of residential land use in Agartala. The Partition of Bengal in 1947 and the Bangladesh Liberation War of 1971 together generated large-scale refugee migration into the city and its peripheral hinterland, precipitating the rapid development of new residential colonies in areas such as Noagaon Colony, Chandrapur, Aralia, East Pratapgarh, and Badarghat (Chattopadhyay, 1989; Clean and Green Agartala, 2007). This demographic

influx accelerated horizontal urban expansion beyond the existing municipal boundary and established the differentiated residential morphology that subsequent planning efforts have been required to accommodate.

Table 1 summarises the trajectory of residential land use expansion between 1991 and 2021, illustrating both the absolute growth in hectarage and the shifting proportional contribution of residential use to total urban land area.

Table 1
Temporal Trajectory of Residential Land Use Expansion in Agartala City (1991–2021)

Year	Residential Area (ha)	Total Urban Area (ha)	Residential Share (%)	Decadal Change (ha)	Decadal Growth Rate (%)
1991	588.05	1,580.0	37.22	—	—
2001	2,277.55	9,202.0	24.75	+ 1,689.5	+ 287.32
2011	2,915.00	9,202.0	31.68	+ 637.5	+ 27.99
2021	3729.50	9202.0	40.53	+ 814.5	+ 27.94

The temporal trajectory of residential land use in Agartala (1991–2021) reflects a sustained absolute expansion from 588.05 ha to 3,729.50 ha, representing a cumulative growth of 534.2% over three decades. Decadal analysis reveals the highest absolute increment during 1991–2001 (+ 1,689.50 ha; 287.32%), with subsequent decades recording comparatively moderated yet sustained expansion of + 637.45 ha (27.99%) and + 814.50 ha (27.94%) during 2001–2011 and 2011–2021 respectively. The marked decrease in the proportional share of residential land between 1991 and 2001 (from 37.22% to 24.75%) is attributable primarily to the substantial expansion of the Agartala Municipal Corporation boundary in the intervening period, which incorporated large tracts of non-residential and peri-urban land, thereby altering the denominator of the proportional calculation rather than signifying any actual contraction of residential area (CDP, 2006). The absolute increase from 1991 to 2011 of approximately 2,327 hectares confirms the sustained momentum of residential expansion. The subsequent proportional recovery to 31.68% (2011) and 40.53% (2021) reflects progressive infilling and peri-urban densification driven by sustained in-migration, infrastructural investments under AMRUT and the Smart Cities Mission, and regional political stabilization.

5. Classification and Spatial Distribution of Residential Land Use

Residential land use in Agartala City was classified into four typological categories through integration of field observation, household interview data, and visual assessment of structural conditions (Fig. 2). These categories designated as high-class, intermediate, poor-mixed, and dilapidated reflect both the physical condition of the built fabric and the socio-economic profile of resident populations. Table 2 presents the spatial distribution of each category by area and constituent localities.

5.1 High-Class RCC Residential Areas

Accounting for approximately 18.89% of the total residential area surveyed (506.61 ha), high-quality reinforced concrete (RCC) residential structures are predominantly concentrated within and immediately adjacent to the urban core. The localities of Ramnagar, Krishnanagar, Malarmath, and Santipara constitute the primary nodes of upper-income residential concentration, reflecting the spatial logic of economic actors with higher bid-rent capacity occupying the most accessible urban locations. These areas host senior government functionaries, established commercial families, professionals, and other upper-income groups. Structural characteristics include multi-storeyed (typically two- to three-storey) RCC construction, modern architectural detailing, landscaped compound areas, and superior access to civic infrastructure. The concentration of this residential category near the CBD is consistent with Alonso's (1964) bid-rent framework, wherein higher-income households outcompete lower-income groups for centrally accessible residential sites.

Table 2

Spatial Distribution of Residential Housing Categories in Agartala City (Based on Field Survey, 2019-20)

Housing Category	Primary Localities	Area (ha)	Share (%)
High-Class RCC	Ramnagar, Krishnanagar, Malarmath, West Ramnagar, Santipara, parts of West Joynagar and West Shibnagar	506.61	18.89
Intermediate Semi-Pucca	Abhoynagar, Radhanagar, Dhaleswar, Shibnagar, Banamalipur, Bordowali, Kunjaban, A.D. Nagar (both parts), partial Krishnanagar	1,017.80	37.95
Poor/Mixed Quality	Barjala, Lichubagan, Nandannagar, Khayerpur, Pratapgarh, East/West Pratapgarh, Raj Laxmi Nagar, South Badarghat, Bhattapukur, Rajnagar, Sidhi Ashram, Aralia, Chanmari, parts of Kunjaban and A.D. Nagar	774.69	28.89
Dilapidated/Temporary	Aralia, Jogendranagar, North and East Jogendranagar, Chanmari, Nandannagar, Ranjitnagar, parts of Rajnagar	403.62	15.05
Total		2,702.72	100.00

5.2 Intermediate Semi-Permanent Residential Areas

The intermediate housing category constitutes the dominant residential typology in Agartala by spatial extent, encompassing 37.95% of total residential area (1,017.80 ha). These localities house a broad stratum of middle-income families including government employees, small-scale traders, and skilled service sector workers. Settlements in Abhoynagar, Radhanagar, Dhaleswar, Banamalipur, and Bordowali represent the expanding middle-class residential periphery that has developed progressively outward from the inner core over the past four decades. Structural characteristics are mixed, with a predominance of semi-permanent single-storey or two-storey construction utilising permanent materials

for the principal structural elements alongside lower-quality finishings. Access to municipal services is moderately adequate, though variability across wards within this category is considerable.

5.3 Poor and Mixed-Quality Residential Areas

Occupying 774.69 ha (28.89% of the total residential area), poor and mixed-quality residential zones characterise the outer urban ring and peri-urban transition areas. These localities have developed primarily in response to population pressure from lower-income migration streams and the limited affordability of housing in more centrally located areas. Residential structures are predominantly single-storey constructions using a combination of permanent and temporary materials. Access to piped water, surfaced roads, covered drainage, and waste collection is markedly inferior to inner-city areas. Localities including Barjala, Pratapgarh, Rajnagar, and Siddhi Ashram exemplify the emerging peripheral residential landscape characterised by incomplete infrastructure provision (Fig. 2).

5.4 Dilapidated and Temporary Residential Settlements

Dilapidated residential areas account for approximately 15.05% of total residential area (403.62 ha) and are primarily located in the most peripheral zones of the expanded municipal boundary. Construction materials in these areas are predominantly non-permanent, including bamboo frame, mud plaster, corrugated tin sheeting, and salvaged materials. Many structures exhibit the evidence of structural deterioration including damaged roofing, weakened load-bearing walls, and inadequate weatherproofing. These areas display the highest concentrations of urban poverty within Agartala and are characterised by near-total absence of formal infrastructure provision. Slum settlements along the Haora River embankment and Kata Khal canal corridor—including areas within Chanmari, Ranjitnagar, and Radhanagar wards represent the most extreme manifestation of residential deprivation in the city (Fig. 2).

6. Statistical Analysis of Residential Differentiation

6.1 Housing Quality Analysis

To evaluate whether the distribution of housing quality categories differs significantly across the three concentric urban zones (inner, intermediate, peripheral), a chi-square test of independence was performed. Wards were classified into three zones based on Euclidean distance from the CBD: inner zone (≤ 2 km), intermediate zone (2–5 km), and peripheral zone (> 5 km). Table 3 presents the observed frequency distribution of housing category by zone.

Table 3
Cross-tabulation of Housing Quality Category by Urban Zone (n = 990)

Housing Category	Inner Zone	Intermediate Zone	Peripheral Zone	Total
High-Class RCC	198 (56.9%)	112 (32.2%)	38 (10.9%)	348
Intermediate Semi-Pucca	87 (22.2%)	186 (47.4%)	119 (30.4%)	392
Poor/Mixed Quality	29 (14.6%)	71 (35.7%)	99 (49.7%)	199
Dilapidated	6 (11.8%)	14 (27.5%)	31 (60.8%)	51
Total	320 (32.3%)	383 (38.7%)	287 (29.0%)	990

The chi-square statistic was computed as $\chi^2(6) = 187.34$, $p < 0.001$ (Cramér's $V = 0.308$), providing strong statistical evidence to reject the null hypothesis of spatial homogeneity in housing quality distribution. The association is substantively meaningful: 56.9% of high-class RCC dwellings are located in the inner zone, while 60.8% of dilapidated units are concentrated in the peripheral zone. Intermediate semi-permanent housing peaks in the intermediate zone (47.4%), consistent with its transitional character between the high-quality urban core and the degraded urban fringe. These results confirm that housing quality in Agartala exhibits significant spatial clustering and declines systematically with increasing distance from the CBD.

6.2 Land Value Gradient Analysis

Field-survey-estimated land values (Rs. per sq. ft.) were compiled for 14 representative localities distributed across the full range of urban zones. Spearman's rank correlation was computed between distance from the CBD (km) and land value (Rs./sq. ft.) to assess the direction and strength of this relationship. Table 4 presents the locality-level data.

Spearman's rank correlation between distance from CBD and land value yielded $\rho = -0.81$ ($p < 0.001$), confirming a strong negative monotonic relationship: land values decline consistently as distance from the commercial core increases. This empirical pattern aligns closely with the theoretical predictions of Von Thünen's (1826) land rent model and Alonso's (1964) bid-rent framework, wherein proximity to the principal centre of economic activity commands a sustained land value premium. Notable local deviations from the smooth gradient are observed along the National Highway-44 corridor, where transport accessibility generates positive externalities that elevate land values above zone-level averages in A.D. Nagar and parts of Bordowali.

6.3 Infrastructure Adequacy Index

An Infrastructure Adequacy Index (IAI) was computed for each urban zone by aggregating binary adequacy assessments across nine service dimensions: piped water supply, water regularity, road surface quality, road

Table 4
Land Value Gradient by Distance from CBD in Agartala City (Field Survey Data)

Locality	Distance from CBD (km)	Land Value (Rs./sq. ft.)	Housing Category
Post Office Chowmuhan (CBD)	0.0	> 1,000	Commercial core
Ramnagar / Krishnanagar	0.6	850–1,000	High-Class RCC
West Joynagar / Malarmath	1.0	800–950	High-Class RCC
Santipara / Shibnagar (parts)	1.4	750–900	High-Class RCC
A.D. Nagar (NH-44 corridor)	2.0	700–850	Intermediate
Abhoynagar / Dhaleswar	2.5	600–750	Intermediate
Badarghat / Siddhi Ashram	3.0	550–700	Intermediate
Radhanagar / Kunjaban	3.5	500–650	Intermediate
Bordowali (parts)	4.0	450–600	Intermediate
Pratapgarh / Rajnagar	4.8	450–580	Poor/Mixed
Barjala / Bhattapukur	5.5	400–550	Poor/Mixed
Chanmari / Aralia	6.2	350–500	Poor/Mixed
Jogendranagar	7.0	300–450	Dilapidated
Raj Laxmi Nagar	8.0	250–400	Dilapidated

accessibility, proximity to market facilities, access to secondary education, access to healthcare, drainage coverage, and solid waste collection regularity. Scores were normalised to a 0–100 scale, with higher values indicating superior infrastructure provision. Table 5 presents the IAI by urban zone.

The IAI reveals a pronounced and consistent attenuation of infrastructure provision from the inner zone (IAI = 72.4) to the peripheral zone (IAI = 36.1), representing a reduction of nearly 50% across the urban gradient. The most severe disparities are observed in daily solid waste collection (22% vs. 4%), direct metalled road access (42% vs. 8%), and piped water access (78% vs. 38%). Education and market proximity show the smallest inter-zone differentials, reflecting the more equitable spatial distribution of these facility types. Overall, the city-wide composite IAI of 55.3 suggests a moderate level of infrastructure provision that masks substantial internal inequality across residential zones.

Table 5
Infrastructure Adequacy Index (IAI) by Urban Zone in Agartala City

Infrastructure Dimension	Inner Zone	Intermediate Zone	Peripheral Zone	City Average
Piped Water Access (%)	78	64	38	62
Water Regularity (days/wk)	6.2	4.8	3.1	4.7
Metalled Road Access (%)	42	28	8	26
Road Accessibility Score	74	58	34	56
Market Proximity (≤ 2 km, %)	95	82	61	80
School Proximity (≤ 2 km, %)	98	91	76	89
Hospital Proximity (≤ 3 km, %)	88	74	52	72
Drainage Coverage (%)	82	71	48	67
Daily Waste Collection (%)	22	12	4	14
Composite IAI Score (0–100)	72.4	57.8	36.1	55.3
Mean	65.27	54.09	36.01	52.58
Std. Deviation	25.63	24.87	23.91	23.74
Coefficient of Variation (%)	39.27	45.98	66.40	45.15

7. Internal Spatial Structure and Urban Land Use Modelling

The internal residential spatial structure of Agartala City has been evaluated in relation to three classical models of urban land use: Burgess's (1925) Concentric Zone Theory, Hoyt's (1939) Sector Model, and Harris and Ullman's (1945) Multiple Nuclei Model. Each model offers a distinct conceptual framework for understanding how socio-economic differentiation manifests spatially across the urban landscape.

Burgess's Concentric Zone Theory posits a series of annular rings radiating outward from a central business district, with housing quality declining and land values decreasing systematically from centre to periphery. While the aggregate land value gradient in Agartala broadly conforms to this prediction ($\rho = -0.81$), the actual spatial pattern of residential quality departs significantly from a simple concentric arrangement. Hoyt's Sector Model emphasises axial expansion along transport corridors, generating wedge-shaped residential zones of homogeneous income character. Consistent with this model, the National Highway-44 corridor exhibits elevated land values and relatively superior housing quality compared to equivalent-distance areas not served by major arteries. However, neither the concentric nor the sector model adequately captures the multiplicity of growth centres evident in Agartala's residential landscape.

The Harris-Ullman Multiple Nuclei Model (1945), which posits that urban land use develops around multiple discrete nuclei rather than a single dominant centre, provides the most applicable theoretical framework for Agartala's residential structure (Fig. 3). The CBD at Post Office Chowmuhani constitutes the primary nucleus, but secondary nodes of commercial and institutional activity—including the Capital Complex area, Battala Market, and Maharajganj Bazar—have each generated surrounding residential zones with locally elevated land values and superior infrastructure provision. The emergence of these secondary nodes reflects the cumulative spatial influence of large-scale government employment at the Capital Complex, the commercial gravity of major retail markets, and the transportation accessibility of National Highway junctions.

Furthermore, the topographic configuration of the Haora-Kata Khal floodplain system has imposed an additional layer of spatial constraint that no classical Western-derived model explicitly incorporates. Slum settlements have clustered on low-value Lunga lands along the river and canal banks, driven by the minimum-rent accessibility of these environmentally marginal sites (Bhattacharya, 2013). This pattern echoes findings from comparable South Asian cities where river-proximate land constitutes a refuge of last resort for urban migrants unable to access formal housing markets (Pacione, 2009).

8. Spatial Patterns of Urban Land Value

The spatial distribution of land values in Agartala City reflects a complex overlay of distance-from-centre effects, transport accessibility externalities, commercial node proximity, and topographic constraints. Peak values exceeding Rs. 1,000 per sq. ft. are observed in the principal commercial corridors of the city centre, encompassing Post Office Chowmuhani, RMS Chowmuhani, Colonial Chowmuhani, Ganaraj Chowmuhani, and the Motorstand area, where commercial demand intensity, footfall, and transport connectivity converge to sustain premium land prices (Fig. 4).

Immediately adjacent to the commercial core, high-class residential areas in Ramnagar and Krishnanagar sustain land values of Rs. 850–1,000 per sq. ft., attributable to the combined advantages of CBD proximity, well-maintained road infrastructure, relatively complete civic service provision, and historical prestige value. The A.D. Nagar area, despite its somewhat greater distance from the CBD (approximately 2 km), commands relatively elevated land values due to its National Highway-44 frontage—a demonstration of the transport accessibility premium identified in bid-rent theory.

At the urban periphery, localities such as Jogendranagar and Raj Laxmi Nagar record values in the range of Rs. 250–450 per sq. ft., reflecting the combined disadvantages of greater CBD distance, inferior road connectivity, incomplete infrastructure provision, and the historically low desirability of low-lying Lunga terrain. However, field observations suggest that these peripheral land values are rising at an accelerating rate as urban expansion converts previously agricultural and wetland areas into residential plots, consistent with van Bergeijk's (2012) observation of CBD influence attenuation accompanying polycentrism.

Von Thünen's (1826) foundational land rent theory, as elaborated for the urban context by Alonso (1964) and Thrall (1987), posits that land rent at any location is determined by the competitive interaction between potential users, with those capable of generating the greatest locational surplus outcompeting lower-surplus users. In Agartala City, this competition manifests in the dominance of commercial uses in the CBD (paying the highest rents), followed by high-income residential use in adjacent zones, and progressively lower-income residential and mixed uses at increasing distances from the centre. This hierarchical structure is consistent with the theoretical bid-rent framework, though the specific rent curve is modulated by local accessibility, topographic, and historical factors specific to Agartala's developmental trajectory.

9. Urban Infrastructure: Provision, Adequacy, and Spatial Inequity

9.1 Drinking Water Supply

Drinking water provision in Agartala draws upon three principal source types: municipal piped supply (60% of surveyed households), hand pumps (32%), and tube wells (8%). The Agartala Municipal Corporation delivers piped water twice daily—during morning hours (06:00–08:00) and afternoon hours (14:00–16:00)—though supply timing and duration vary considerably across wards. Field interviews consistently highlighted concerns regarding water quality, with numerous respondents reporting turbidity and bacterial contamination, particularly during monsoon periods when the shallow aquifer system is susceptible to surface infiltration.

The spatial dimension of water supply inequality is most pronounced in the northern and peripheral wards, where AMC piped supply reaches only 38% of surveyed households (Table 5) compared to 78% in the inner zone. Despite the city's geographic situation at the confluence of the Haora River and Kata Khal canal, groundwater-based supply systems continue to serve the majority of peripheral residents, reflecting the incomplete territorial extension of the municipal distribution network into recently incorporated peri-urban areas.

9.2 Road Connectivity

Road surface quality and accessibility exert a decisive influence on residential amenity and land value. The survey reveals that only 16% of sampled dwellings are directly accessible from main metalled roads, while 37% front on mixed-surface minor roads, 26% on unimproved lanes, and 21% on narrow by-lanes. The inner zone records 42% metalled road access compared to 8% in the peripheral zone, underscoring the stark disparity in transportation infrastructure provision across the urban gradient. These findings are consistent with patterns documented in comparable northeastern Indian cities, where unplanned peripheral expansion consistently outpaces the extension of formal road infrastructure.

9.3 Drainage Infrastructure

Approximately 68% of surveyed households possess access to some form of drainage facility; however, qualitative field assessment reveals that a substantial proportion of these systems are inadequately

maintained, structurally compromised, or chronically blocked by solid waste accumulation. Seasonal flooding affects virtually all residential zones to some degree, with the most severe impacts concentrated in low-lying Lunga areas of the peripheral zone. Inner-zone drainage coverage of 82% contrasts sharply with peripheral coverage of 48% (Table 5). The practice of disposing household refuse directly into drainage channels—reported by 82% of respondents as a significant contributor to waterlogging compounds the structural deficiencies of the drainage network and constitutes a significant public health risk.

9.4 Solid Waste Management

Solid waste management emerged as the most acutely deficient infrastructure dimension across all residential zones. At the city level, only 8% of respondents reported daily municipal waste collection, while 52% indicated that collection operates on no fixed schedule. The city-level mean collection frequency of 26.20% (SD = 17.25; CV = 65.84%) reflects profound spatial heterogeneity, with daily collection reported by merely 8% of respondents citywide and 52% indicating a complete absence of scheduled service indicative of systemic municipal failure rather than localized deficiency. Ward-level disaggregation reveals comparatively superior performance in inner-zone localities including Ramnagar (Ward 4), Krishnanagar (Ward 7), and Banamalipur (Ward 9), where 3 to 4 times per week collection was reported by approximately 60% of respondents, yet still falling short of the daily collection. Within the peripheral zone, only 4% of households received daily collection services. Peripheral wards notably Champaknagar (Ward 22), Kathaliya (Ward 27), and Aralia (Ward 30) recorded daily collection as low as 4%, with 40% of households receiving monthly or sub-monthly service. Distance-decay regression confirms a statistically significant negative relationship between zonal distance and daily collection frequency ($\beta = -9.00$; $R^2 = 0.991$; $p < 0.05$), with each incremental zonal unit associated with a 9 percentage-point decline in service coverage. The environmental consequences of inadequate waste management are multi-dimensional. 82% of respondents identified roadside waste dumping as a major driver of monsoon waterlogging, while 38% specifically identified plastic waste as the primary contributor to drainage blockage. The persistence of informal waste disposal practices despite municipal restrictions on plastic bag use with 62% of respondents expressing low awareness of or concern about this prohibition underscores the need for integrated behavioural and infrastructural interventions.

Table 6
Solid Waste Collection Frequency by Urban Zone in Agartala City

Waste Collection Parameter	Inner Zone (%)	Intermediate Zone (%)	Peripheral Zone (%)	City Total (%)
Collection: Daily	22	12	4	8
Collection: 3–4 times/week	60	45	28	44
Collection: Once/month or less	8	18	40	22
No scheduled collection	10	25	28	26
Morning collection only (%)	51	38	28	40
Mean (%)	30.20	27.60	20.80	26.20
Std. Deviation	21.38	13.58	16.32	17.25
Coefficient of Variation (%)	70.8	49.2	78.5	65.84

10. Discussion

The empirical evidence assembled in this study reveals a residential spatial structure in Agartala City characterised by pronounced socio-spatial differentiation that broadly conforms to the Multiple Nuclei Model while exhibiting deviations attributable to locally specific geographic and historical conditions. The strong negative land value gradient ($\rho = -0.81$) and the significant chi-square association between housing quality and urban zone ($\chi^2(6) = 187.34$, $p < 0.001$) together confirm that CBD distance remains the primary organising principle of residential quality distribution, consistent with classical bid-rent theory (Alonso, 1964; Thrall, 1987) and with recent empirical evidence from comparable Global South cities (Gamal et al., 2024; Marandu et al., 2024).

However, the observed pattern deviates from a simple concentric gradient in three important respects. First, the National Highway-44 corridor generates a transport accessibility premium that elevates residential quality and land values in A.D. Nagar and parts of Bordowali beyond levels predicted by distance alone a pattern more consistent with Hoyt's (1939) Sector Model. Second, the emergence of secondary commercial and institutional nodes (Capital Complex, Battala Market, Maharajganj Bazar) has created localised residential quality peaks at non-central locations, reflecting the multiple nuclei dynamics identified by Harris and Ullman (1945). Third, the floodplain topography of the Haora-Kata Khal system introduces a vertical dimension of spatial constraint absent from the classical model framework, channelling slum development onto marginal riverine and canal side land at elevations below the prevailing urban floor.

The Infrastructure Adequacy Index analysis reveals a city-wide IAI of 55.3, masking a near 50% differential between inner and peripheral zones (72.4 vs. 36.1). These infrastructural gradient parallels and reinforces the residential quality gradient, creating compounding disadvantages for peripheral residents who simultaneously inhabit lower-quality dwellings, occupy lower-value land, and access inferior services. This pattern of cumulative spatial disadvantage is consistent with broader observations from South Asian urban geography regarding the reinforcing feedback loops between housing informality, service deprivation, and economic marginalisation (Pacione, 2009; Knox & McCarthy, 2012).

The particular severity of solid waste management deficiencies (city IAI dimension: 14%; peripheral zone: 4% daily collection) merits emphasis. Inadequate waste management in a low-lying, flood-prone urban environment generates non-linear environmental harms: blocked drainage compounds seasonal flooding, creating waterlogged conditions that damage property, incubate vector-borne disease, and deter private investment in precisely those peripheral areas where public investment is most urgently needed. Addressing this dimension of infrastructure adequacy therefore carries a disproportionate leverage potential for overall improvements in urban environmental quality.

11. Conclusion and Policy Recommendations

This study has examined the socio-spatial dynamics of residential land use in Agartala City through an integrated framework combining GIS-based spatial mapping, primary household survey data ($n = 990$), and inferential statistical analysis. The findings establish several substantive contributions to the empirical literature on urban land use in mid-sized Indian cities.

First, the residential spatial structure of Agartala most closely approximates the Multiple Nuclei Model of urban land use, shaped by the compounded influences of its historical settlement trajectory, the topographic constraints of the Haora-Kata Khal floodplain, post-partition migration dynamics, and the emergence of functionally distinct secondary activity nodes within the urban area.

Second, land values exhibit a strong negative gradient with respect to CBD distance (Spearman's $\rho = -0.81$, $p < 0.001$), consistent with classical bid-rent theory, but with meaningful departures generated by transport corridor proximity and secondary commercial node effects.

Third, housing quality is significantly associated with urban zone location ($\chi^2(6) = 187.34$, $p < 0.001$, Cramér's $V = 0.308$), with high-quality RCC dwellings concentrated in the inner zone and dilapidated structures predominating in the peripheral zone. Fourth, infrastructure adequacy declines sharply from the inner zone (IAI = 72.4) to the peripheral zone (IAI = 36.1), with the most extreme disparities in solid waste collection, road surface quality, and piped water access.

Based on these findings, the study advances the following policy recommendations for consideration by the Agartala Municipal Corporation and the Government of Tripura:

1. Decentralisation of services: Secondary commercial and institutional sub-centres should be systematically developed in intermediate and peripheral zones to redistribute economic gravitational pull and reduce pressure on the inner-city core.
2. Targeted infrastructure investment in peripheral zones: Solid waste collection, drainage construction, and piped water extension should be prioritised in zones with IAI scores below 45, using performance-linked municipal financing mechanisms.
3. Vertical densification: Incentive structures should be designed to promote multi-storey residential construction in areas with existing infrastructure capacity, reducing horizontal encroachment on ecologically sensitive Lunga wetland areas.
4. Integrated wetland and floodplain management: Residential encroachment on Haora River and Kata Khal canal banks should be regulated through enforceable riparian buffer zones, with affected residents relocated to improved housing in designated peripheral residential areas.
5. Community-based waste management: Ward-level solid waste management committees, supported by municipal technical assistance and incentivised through performance grants, should be established to address the scheduling, routing, and community compliance dimensions of urban waste management.

Future research should extend this analysis to incorporate spatial econometric modelling of the simultaneous determinants of land value and housing quality, longitudinal tracking of residential change using multi-temporal remote sensing, and comparative analysis across northeastern Indian cities to assess the generalisability of the Agartala findings.

Declarations

Author Contribution

Abhijit Santra wrote the the main manuscript and prepared all the figures. Also review the manuscript.

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Figures

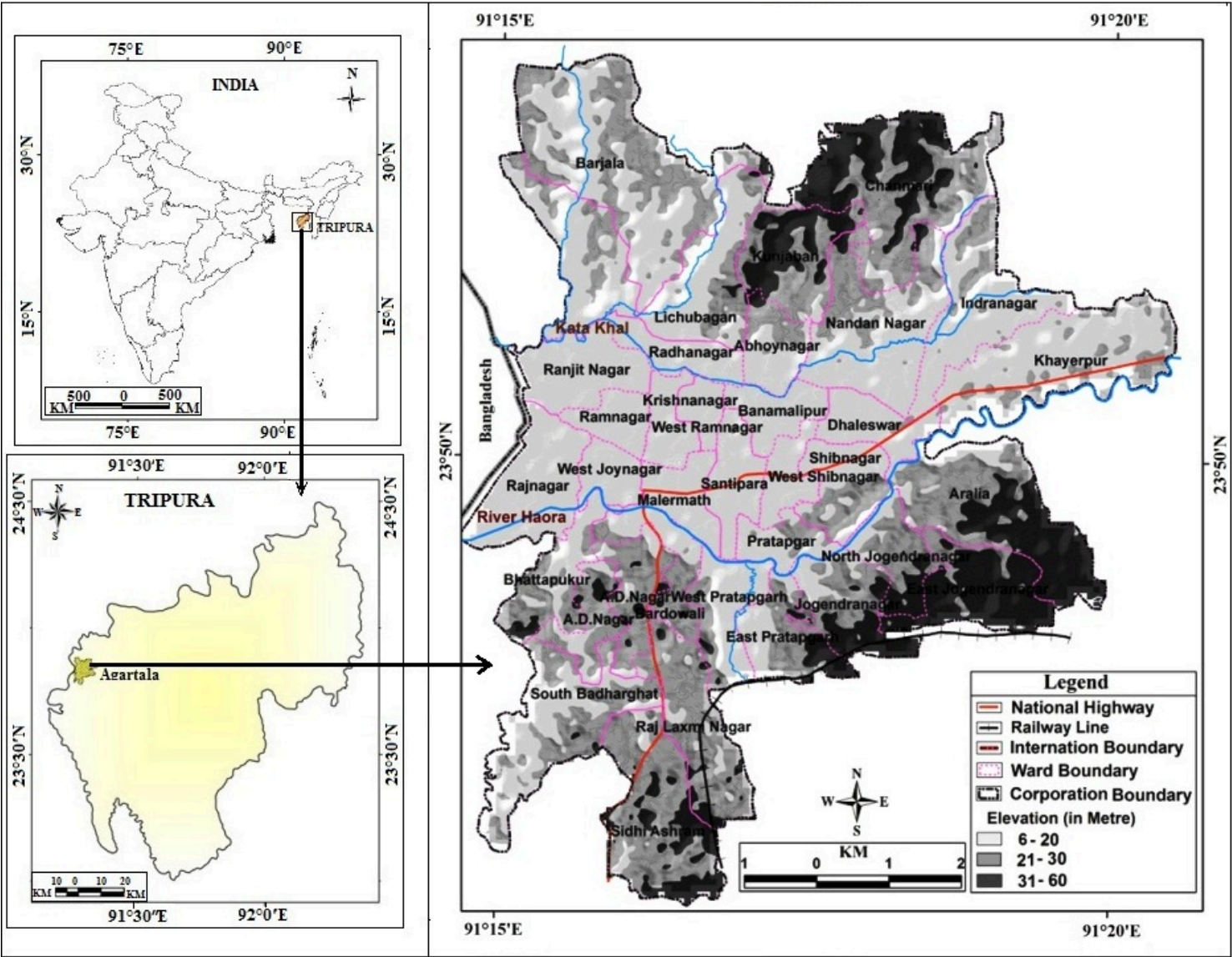


Figure 1

Location map of the study area

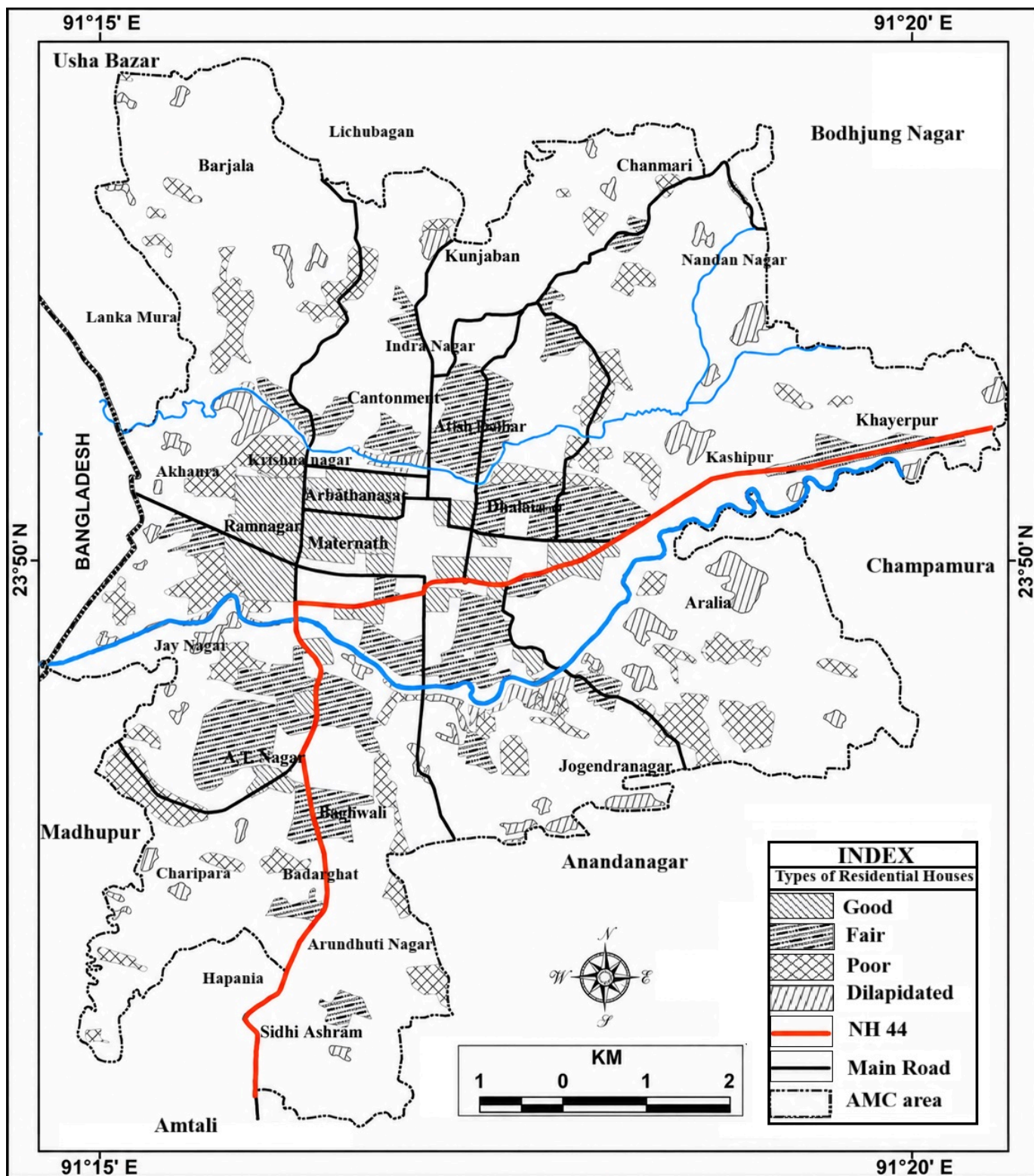


Figure 2

Spatial Distribution of Residential House in Agartala City

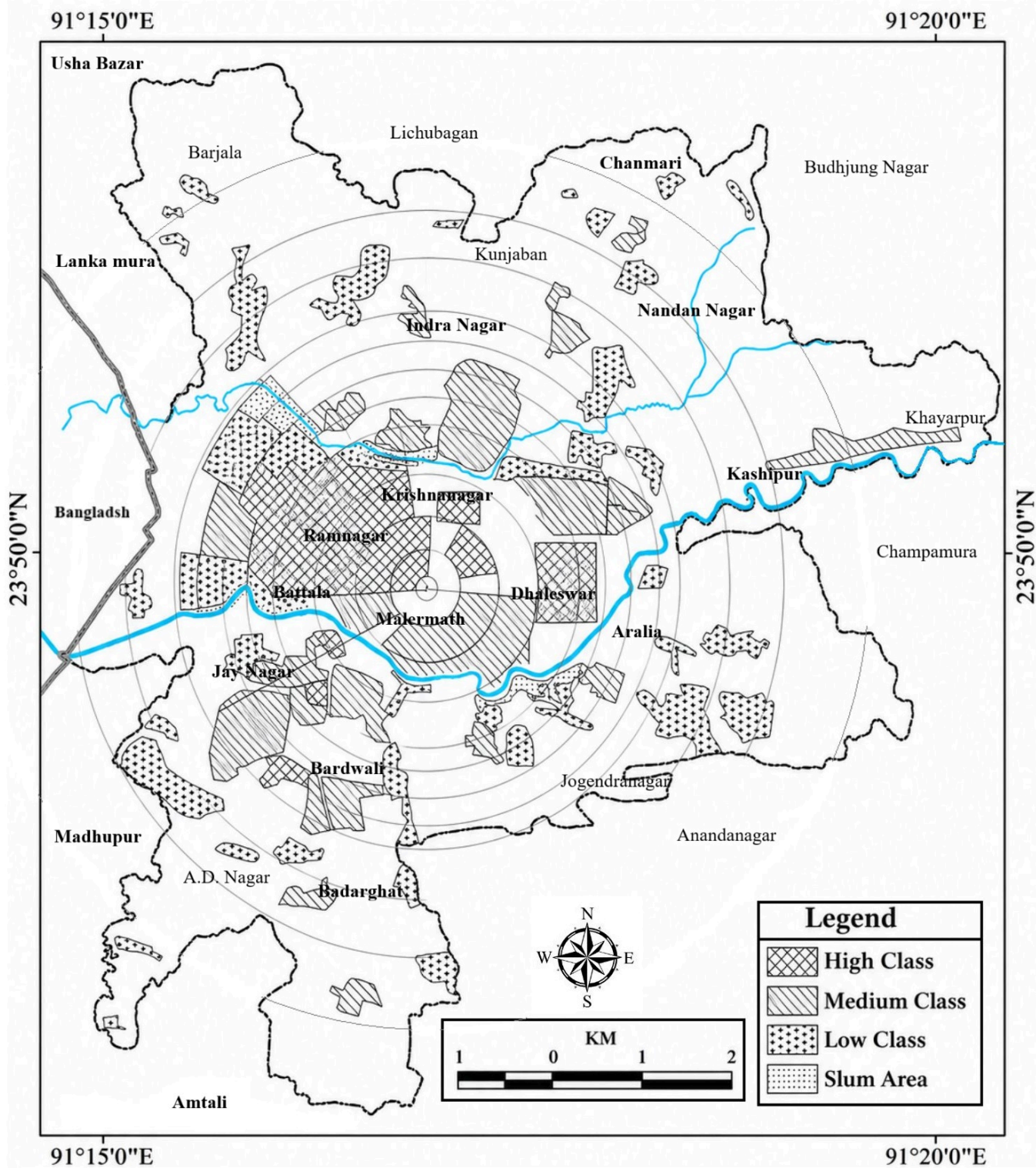


Figure 3

Internal Structure of Residential Land Use in Agartala City

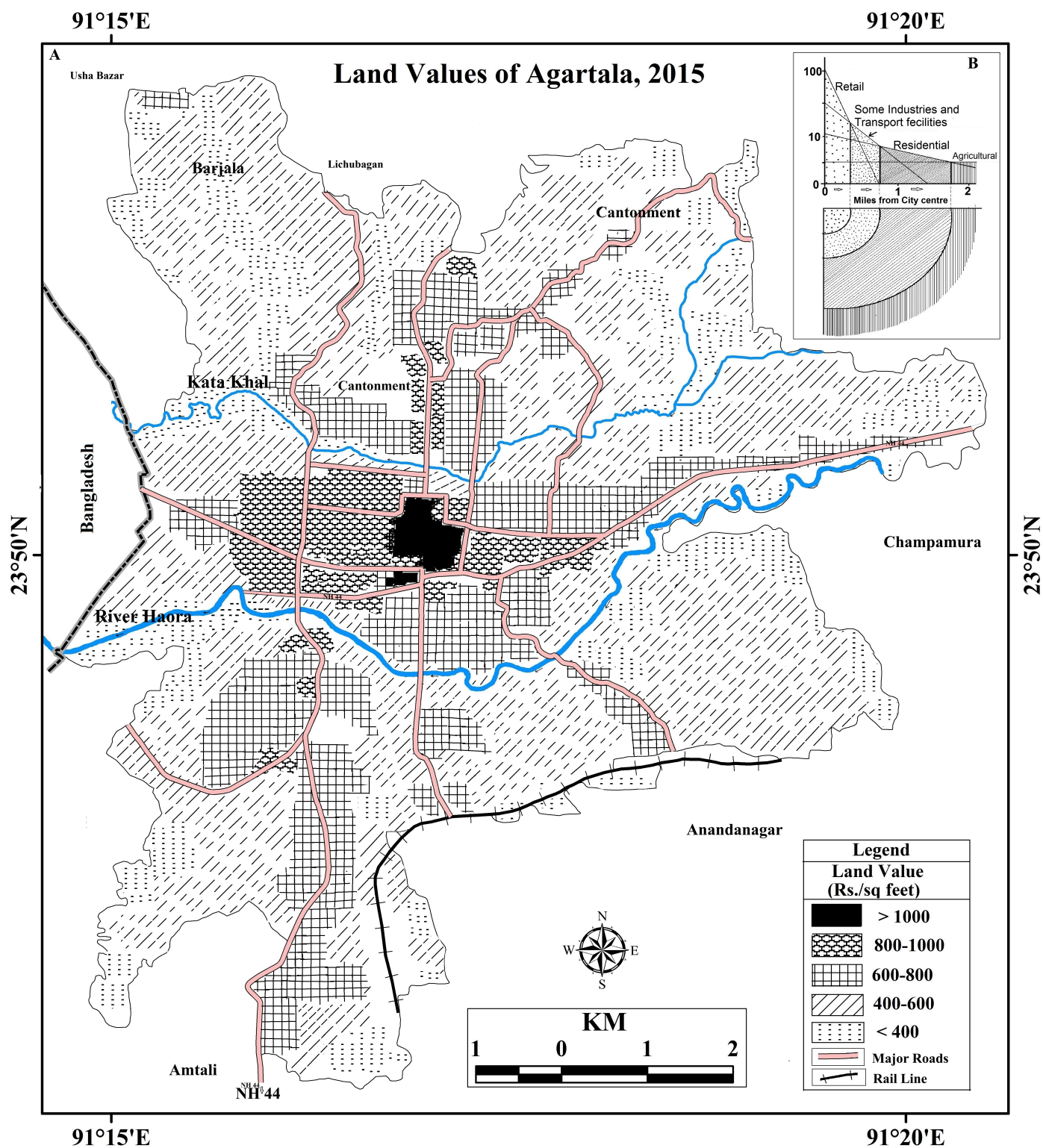


Figure 4

Spatial Pattern of Residential Land Values in Agartala City