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Urban Morphology Links Green Space and Compact City Policy in a Shrinking Japanese Metropolis

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Article

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Abstract

The "compact city" model, a central tenet of sustainable urbanism, creates critical policy tensions in post-industrial nations, where land use intensification often conflicts with urban shrinkage and the need to preserve urban green space (UGS). This study addresses a significant research gap by moving beyond city-level metrics to conduct a fine-grained morphological analysis of urban form and UGS provision at the urban block level. Using Nagoya, Japan, as an archetypal case study of a city facing simultaneous compaction and shrinkage, we develop a comprehensive urban block typology through a GIS-based hierarchical classification. The analysis reveals a stark spatial polarization: block types embodying the compact city ideal (high-density commercial and residential) are the most green-deficient, characterized by small, fragmented, and morphologically inefficient non-built-up areas. Conversely, peripheral and specialized blocks (e.g., woodlands, farmland) function as the city's primary green reservoirs. These findings provide high-resolution evidence for the compact city-green space paradox, identifying the morphology of non-built-up space as a key mechanism of green exclusion. We contribute a transferable methodological framework that can be repurposed as a Planning Support System (PSS). Policy Implications: This typology enables a targeted "right-sizing" and greening strategy, allowing planners and policymakers to use morphological analysis to identify specific blocks for green infrastructure acquisition and land use interventions. This provides a practical tool for land use governance, helping to reconcile densification policies with the need for equitable and resilient urban environments.

1. Introduction

The 21st-century urban planning agenda has been largely dominated by the pursuit of the compact city (OECD, 2012). Promoted by influential international organizations, this land use paradigm advocates for high-density, mixed-use, and transit-oriented development as a principal strategy for achieving urban sustainability (Dantzig and Saaty, 1973; Couret, 2022; Abdullahi and Pradhan, 2018). The theoretical underpinnings are compelling: by intensifying urban form, cities can theoretically reduce automobile dependency, curb energy consumption, protect agricultural and natural hinterlands from sprawl, and foster economic vitality (OECD, 2012). This vision has been widely adopted in policy discourses and master plans globally, shaping the physical trajectory of metropolitan areas from Europe to Asia.

However, this prevailing narrative of densification is increasingly colliding with a powerful countertrend: urban shrinkage. Defined as a multidimensional process of sustained population loss, often coupled with economic restructuring, urban shrinkage is a defining feature of many post-industrial cities, particularly in Japan, Germany, and the American Rust Belt (Haase et al., 2017; Dewar and Thomas, 2013). The UN-Habitat *World Cities Report 2022* highlights that nearly half of all cities in developed regions are experiencing population decline, generating vast governance challenges related to under-utilized infrastructure, urban blight, and fiscal constraints (UN-Habitat, 2022).

This demographic shift presents a fundamental challenge to the growth-oriented logic embedded in many compact city policies. It raises a critical question for land use policy: how can, and should, cities

plan for a "compact" future when they are simultaneously destined to "shrink"? (Yoon, 2020).

This paradox is most acutely manifested in the conflict between urban densification and the provision of Urban Green Space (UGS). UGS—encompassing parks, gardens, woodlands, and other vegetated areas—is no longer considered a mere amenity but a critical component of urban infrastructure (Jim and Chen, 2003). It provides essential ecosystem services, enhances climate resilience, and is strongly linked to improved public health and social well-being (Wolch, Byrne and Newell, 2014; Cai et al., 2023; Besir and Cuce, 2018). Yet, the intensification of land use inherent in compact city strategies often leads to the direct loss and fragmentation of UGS, creating a direct trade-off between density and livability (Artmann, Inostroza, and Fan, 2019).

Recent research confirms this dilemma. A 2021 study of Amsterdam and Brussels, for example, empirically demonstrated that densification policies led to a significant decrease in the quantity, average size, and connectivity of urban green spaces, suggesting that development plans often dominate and override stated UGS policies (Balikci et al., 2021). This tension between "gray" and "green" intensification is a central problem in contemporary land use planning (Mouratidis, 2021).

Despite its widespread adoption in policy circles, the compact city thesis has been subject to sustained academic critique, leading some scholars to identify a "Compact City Fallacy" (Neuman, 2005; Gordon and Richardson, 1997). This critique argues that the empirical evidence supporting the model's purported benefits is often equivocal or context-dependent (Neuman, 2005). A primary criticism focuses on the unintended consequences of densification, including decreased housing affordability and complex travel behaviors (Westernick et al., 2012). This includes the "barbecue effect," where residents of dense cores, deprived of private green space, undertake more frequent long-distance recreational travel, potentially offsetting transport savings (Breheny, 1995).

Most pertinent to this study is the well-documented negative correlation between urban compactness and the quantity and quality of UGS (Jim and Chen, 2003; Rrat, 2012). The debate, therefore, has shifted from whether density is "good" or "bad" to how land use policy can *reconcile* its benefits with the essential functions of urban green infrastructure. This requires moving beyond simple density metrics to focus on urban form, morphology, and design (Eizenberg et al., 2019; Mouratidis, 2021).

Parallel to the compact city debate, a distinct body of literature has emerged to address urban shrinkage. For decades, the dominant planning response was denial or a pursuit of growth-oriented regeneration (Dewar and Thomas, 2013). A paradigm shift is now underway, moving towards an acceptance of shrinkage as a durable condition requiring new land use policies (Pallagst and Wiechmann, 2005). This new paradigm is variously termed "smart decline," "planning for shrinkage," or, most commonly, "right-sizing" (Hollander and Németh, 2011; Sousa and Pinho, 2015).

The core principle of rightsizing is the strategic adaptation of the city's physical fabric to the needs of a smaller population (Pallagst and Wiechmann, 2005). A central element is the reconceptualization of urban vacancies. Instead of viewing vacant lots as liabilities, right-sizing strategies treat them as assets

—opportunities for strategic greening interventions (Schilling and Logan, 2008). In this context, UGS is not an amenity to be traded off against development but a fundamental tool for managing decline and building a more resilient and livable urban future.

To operate and analyze these complex relationships, this study draws on urban morphology—the systematic study of the physical form of cities (Larkham, 2002). This approach is particularly salient in the Japanese context, where the urban form is a complex mosaic shaped by historical legacies (Jinnai, 1995). A morphological approach allows for a nuanced characterization of this fabric at the scale of the urban block, the fundamental unit of urban design. Recent studies confirm that the spatial *morphology* of UGS (e.g., shape, connectivity, fragmentation) is as critical as its total *quantity* in determining its ecological and social benefits (Haq, 2011; Tan et al., 2022; Gong et al., 2022).

The integration of these complex spatial analyses into planning practice is facilitated by Planning Support Systems (PSS). PSS are computer-based geo-information instruments that combine data, models, and visualization tools to support planners in evaluating alternative scenarios (Klosterman, 1997; Batty, 2009). A morphological typology, such as the one developed in this study, can serve as the analytical engine of a PSS, providing a conceptual framework for guiding greening interventions at the block level (Ghent, 2022).

This study investigates this complex interplay through an in-depth case study of Nagoya, Japan. As Japan's fourth-largest city, Nagoya provides an archetypal setting. The city is actively implementing its Master Plan, which champions high-density redevelopment to bolster its global competitiveness (Nagoya City, 2011, 2019). Concurrently, official forecasts project that the city is at the precipice of sustained population decline (Nagoya City, 2019, 2023). Nagoya is thus positioned at the critical policy nexus of compaction and shrinkage, making it an exemplary laboratory for examining the future of urban land use.

While the relationship between urban form and green space has been widely studied, much of the research relies on aggregated data at the city or district level (Lan et al., 2021). Such analyses often mask significant heterogeneity at the micro-scale. A notable gap exists in the literature for systematic, morphological studies at the urban block level that can quantitatively link land use patterns, physical form, and green space provision.

This study aims to fill this gap. The central objective is to analyze the intricate relationship between urban block typology and green space provision in Nagoya, using this analysis to illuminate the land use policy challenges and opportunities of planning for a city that is simultaneously compacting and shrinking. This objective is guided by the following research questions:

1. What are the dominant urban block typologies in a post-industrial Japanese city, and what are their characteristic morphological and green space profiles?
2. How does the spatial distribution of these typologies reveal patterns of green space provision and potential land use conflicts across the urban fabric?

3. What are the implications of these block-level patterns for land use policies and governance strategies that seek to reconcile densification with strategic greening in the context of demographic decline?

By addressing these questions, this paper seeks to provide not only a detailed empirical account of Nagoya's urban structure but also a transferable methodological framework and critical insights for planners and policymakers grappling with similar land use challenges worldwide.

2. Methodology and Data

2.1. Study Area: Nagoya, Japan

The study focuses on the entire administrative area of Nagoya City, Japan. Nagoya is the capital of Aichi Prefecture and the center of Japan's third-largest metropolitan area. Historically, the city's development originated from its 17th-century castle structure, which has left an imprint on its central layout (Jinnai, 1995). Following extensive damage in World War II, Nagoya underwent a massive reconstruction that established its modern grid of wide arterial roads. It evolved into a major industrial hub, particularly for the automotive and aerospace industries.

The contemporary planning context of Nagoya is defined by a dual policy agenda. On one hand, the Nagoya City Master Plan 2028 explicitly promotes a "compact and networked" urban structure, encouraging high-density, mixed-use redevelopment in key urban centers and along public transit corridors (Nagoya City, 2023). This is exemplified by massive ongoing projects such as the redevelopment of the Nagoya Station area (Nagoya City, 2011, 2019). On the other hand, the Master Plan acknowledges the city's challenging demographic future. After decades of modest growth, Nagoya's population is projected to peak and enter a period of sustained decline (Nagoya City, 2019, 2023). This places Nagoya at the forefront of cities that must navigate the inherent tensions between land use intensification, strategic management of decline, and the enhancement of urban green infrastructure.

2.2. Data Sources and Baseline Justification

The analysis is based on two primary vector data sets provided by the City of Nagoya:

1. **Nagoya Urban Planning Basic Research (2006)**: This comprehensive GIS dataset contains polygons for city blocks, building footprints (with attributes for use and number of floors), and detailed land use parcels.
2. **Present Data of Green of Nagoya (2020)**: This dataset contains polygons delineating all areas of green coverage, including parks, woodlands, farmland, and vegetated private lots.

A critical methodological consideration is the temporal difference in these datasets. This study frames this 2006–2020 timeframe as a unique analytical strength. The 2006 data capture the city's built form at or near its peak population, immediately preceding both the acceleration of major central-area redevelopment projects and the onset of demographic decline. The 2020 data provide a contemporary

snapshot of green coverage. This analysis therefore establishes a vital *historical baseline* of the "legacy" urban form—the morphological and green space conditions that contemporary and future land use policies must contend with as the city transitions into its new phase of simultaneous densification and shrinkage. All data were integrated and processed within an ArcGIS environment.

2.3. Analytical Framework

The methodology follows a systematic, multi-stage process designed to classify every urban block in Nagoya and analyze its characteristics. The entire process, from data preparation to final analysis, is depicted in the analytical workflow diagram (Fig. 1). This workflow ensures a transparent and reproducible approach to developing the urban block typology.

2.4. Derivation of Indices and Block Classification

A set of quantitative indices was calculated for each urban block to capture its land use composition, physical morphology, and green space characteristics. These indices, defined in Table 1, form the statistical basis for the classification.

Table 1
Land Use Indices Used in the Analysis

Indicator	Definition	Formula	Data Source
Block Green Coverage Ratio (BGCR)	The proportion of the total block area is covered by vegetation.	BGCR = (Σ Total green coverage area in the block) / Block area	Green Coverage Data (Nagoya City, 2020)
Block non-built-up Area Ratio	The proportion of the block area not covered by building footprints.	BNAR = (Block area - Σ Total building footprint area) / Block area	Building Footprint Data (Nagoya City, 2006)
Block Land Use Composition (BLUC)	The proportion of the block area occupied by specific land use (e.g., commercial, residential).	$BLUC_i$ = (Σ Total area of land use i) / Block area	Land Use Data (Nagoya City, 2006)
Floor Area Ratio (FAR)	The ratio of the total floor space of all buildings to the block area.	FAR = (Σ (Building footprint area × Floors)) / Block area	Building Footprint Data (Nagoya City, 2006)
Non-built-up Openness Index	A measure of the openness of the non-built-up space within a block.	(Proprietary index from Nagoya City)	Derived from Nagoya City (2006) datasets
Compact Ratio	A measure of the shape efficiency of the non-built-up space within a block.	(Proprietary index from Nagoya City)	Derived from Nagoya City (2006) datasets

Using these indices, a three-stage hierarchical classification method was employed to assign each block to one of 26 mutually exclusive Block Land Use Composition (BLUC) types. This process was chosen for

its theoretical and practical rigor, allowing for a logical 'sieve' that first isolates blocks defined by non-development (Stage 1), then by public function (Stage 2), before analyzing the heterogeneous private urban fabric (Stage 3). This ensures typological clarity and policy relevance.

- **Stage 1 (Green Dominant Classification)**: Blocks with a cumulative area of "positive-for-green" land uses (farmland, woodland, parks, vacant land, and temples) exceeding 50% of the total block area were identified and classified first.
- **Stage 2 (Public and Institutional Classification)**: From the remaining pool, blocks dominated by specific public or institutional uses (e.g., parking lots, public buildings, schools) with a coverage of > 75% were extracted.
- **Stage 3 (Private Urban Fabric Classification)**: The final set of blocks, representing the core private urban fabric, was classified based on the relative proportions of residential, commercial, and industrial land uses, using a ternary system. These types were further subdivided by density, using thresholds for FAR and the proportion of multiple-dwelling housing.

2.5. Spatial Analysis of Land Use Governance

To understand how the derived block types are distributed, their spatial concentration was analyzed within two distinct geographical frameworks from Nagoya's official planning documents:

1. **Geographical/Urbanization Zones**: The city was divided into five zones: Downtown (A), Urbanized Flatland (B), Newly Developed Flatland (C), Urbanized Hillside (D), and Newly Developed Hillside (E).
2. **Road Proximity Zones**: All blocks were categorized as either being adjacent to a wide lane road (width > 15 meters) or not.

The degree of spatial concentration for each BLUC type within each zone was quantified using a Specialization Coefficient (SC). This coefficient compares the proportion of a specific block type within a given zone to its proportion in the city. A value greater than 1.0 indicates that the block type is disproportionately concentrated, or "specialized," in that zone. The coefficient is calculated as follows:

First, the block area composition rate (Uij) for each BLUC type i in a zone j is calculated: $U_{ij} = S_{ij} / \Sigma$ (from i = 1 to 26) S_{ij}, where S_{ij} is the total area of block type i in zone j. Next, the total block area composition rate (Vj) for zone j is calculated: $V_j = (\Sigma$ (from i = 1 to 26) $S_{ij}) /$ Total City Area. The Specialization Coefficient (SCij) is then the ratio of these two values: $SC_{ij} = U_{ij} / V_j$, This analysis allows for a robust, quantitative assessment of the spatial logic of the city's morphology, linking specific block types to distinct parts of the urban landscape.

3. Results

3.1. A Typology of Nagoya's Urban Blocks

The three-stage classification process yielded a comprehensive typology of 26 distinct Block Land Use Composition (BLUC) types, which collectively account for the entire urban fabric of Nagoya. This typology provides a fine-grained decomposition of the city, moving beyond monolithic land use categories. Table 2 summarizes the key characteristics of these 26 types, grouped into broader functional categories, highlighting the vast differences in physical form and green space provision.

Table 2
The Block Land Use Composition (BLUC) Typology of Nagoya

Category	BLUC Symbol	BLUC Type Name	Total Area (ha)	Mean BGCR (%)	Mean FAR (%)
High-Density Core	01HDC	High Density Commercial	147	3.1	> 300
	02HDC/R	High Density Commercial/Residential	1,049	4.5	> 100
	05HDR	High Density Residential	2,309	8.9	> 100
Low-Density Built-up	03LDC	Low Density Commercial	695	6.2	< 100
	04LDC/R	Low Density Commercial/Residential	1,045	7.5	< 100
	06MDH	Multiple Dwelling House	519	15.3	Variable
	07LDR	Low Density Residential	6,606	12.1	< 100
Industrial & Mixed	08C/I	Commercial/Industrial	403	5.8	Variable
	09In	Industrial	2,149	6.5	Variable
	10R/I	Residential/Industrial	1,204	9.7	Variable
	11C/R/I	Commercial/Residential/Industrial	1,536	7.1	Variable
Public & Institutional	12P	Parking Lot	91	2.5	N/A
	13Sh	School	725	18.2	Variable
	14PB	Public Building	131	11.4	Variable
	15OPB	Other Public Building	92	14.6	Variable
Green Dominant	16Te	Temple	143	25.1	Variable
	17Te/Bu	Temple/Building Mixed	190	19.8	Variable
	18VA	Vacant Land	408	33.5	N/A
	19VA/Bu	Vacant Land/Building Mixed	474	24.3	Variable
	20PA	Park	1,123	65.8	N/A
	21PA/Bu	Park/Building Mixed	290	41.2	Variable
	22FA	Farmland	564	78.3	N/A

Category	BLUC Symbol	BLUC Type Name	Total Area (ha)	Mean BGCR (%)	Mean FAR (%)
	23FA/Bu	Farmland/Building Mixed	321	55.7	Variable
	24W	Woodland	314	82.4	N/A
	25W/Bu	Woodland/Building Mixed	630	60.1	Variable
Other	26ONB	Other Non-Building Mixed	1,088	13.5	N/A

3.2. The Morphological Signature of Land Use

The analysis reveals a strong, systematic relationship between a block's land use composition and the morphology of its non-built-up space. Figure 2 visualizes this relationship by plotting the average non-built-up Openness Index against the average Compact Ratio for each of the 26 BLUC types.

A distinct polarization is evident. Block types associated with intense urban development (e.g., High Density Commercial (01HDC), Industrial (09In), Commercial/Residential/Industrial Mix (11C/R/I)) are clustered in the bottom-left quadrant. These blocks exhibit low value for both openness and compactness, indicating that their non-built-up areas (e.g., courtyards, alleys, setbacks) are small, fragmented, and have complex, inefficient shapes.

In stark contrast, block types dominated by "positive-for-green" land uses (e.g., Farmland (22FA), Woodland (24W), Park (20PA)) occupy the top-right quadrant. These types have high values for both indices, signifying that their non-built-up spaces are large, contiguous, and morphologically simple. This quantitative result provides clear evidence that the underlying land use function of a block imparts a distinct morphological signature on its open spaces, directly influencing their suitability for functional greening.

3.3. Spatial Patterns of Specialization and Green Inequality

The specialization coefficient analysis reveals a highly structured spatial distribution of the BLUC types, creating distinct zones of morphological character and green space provision. The key findings are summarized in Table 3 and visualized in Figs. 3 and 4.

Table 3
Specialization Coefficients and Block Green Coverage Ratios for Key BLUC Types

BLUC Type	Zone of Highest Specialization	Specialization Coefficient	Mean BGCR in Zone (%)
01HDC (High Density Commercial)	Downtown (A)	16.9	2.0
02HDC/R (High Density Comm/Res)	Downtown (A)	5.5	5.0
05HDR (High Density Residential)	Downtown (A)	1.4	10.0
09In (Industrial)	Urbanized Flatland (B)	1.9	6.0
12P (Parking Lot)	Urbanized Flatland (B)	1.9	3.0
22FA (Farmland)	Newly Developed Flatland (C)	4.9	75.0
24W (Woodland)	Newly Developed Hillside (E)	2.7	85.0
03LDC (Low Density Commercial)	Along Wide Lane Roads	1.8	2.0

The spatial analysis covers several distinct patterns that define the city's socio-ecological structure (visualized in Table 4, Figs. 5 and 6):

Table 4 Specialization coefficient and the block green coverage ratio

BLUC Symbol	Group 1-5										geographical features / urbanization					wide lane road			
	Group1		Group2		Group3		Group4		Group5		flat land			hillside		wide lane road		other	
	SC	BGC	SC	BGC	SC	BGC	SC	BGC	SC	BGC	DT(A)	UB(B)	ND(C)	UB(D)	ND(E)	RSC	GC	RSC	GC
01HDC	–	–	0.0	0.2	1.2	0.0	0.2	0.0	4.4	0.0	16.9	0.2	0.0	0.7	0.0	2.2	0.0	0.1	0.0
02HDC/R	–	–	0.2	0.2	1.9	0.0	0.6	0.0	2.4	0.0	5.5	1.2	0.3	0.6	0.4	1.6	0.0	0.5	0.0
03LDC	0.6	0.6	0.6	0.3	1.1	0.0	2.2	0.1	0.5	0.0	2.1	1.2	0.7	0.3	0.9	1.8	0.2	0.3	0.1
04LDC/R	0.1	0.5	1.0	0.3	1.5	0.1	1.5	0.1	0.6	0.1	0.5	1.1	1.3	0.6	0.9	1.3	0.1	0.8	0.1
05HDR	0.0	0.5	0.7	0.2	1.5	0.1	0.5	0.1	2.6	0.1	1.5	1.4	0.5	1.6	0.6	0.8	0.1	1.2	0.1
06MDH	0.1	0.5	1.4	0.3	0.8	0.1	2.4	0.1	0.0	0.0	0.3	1.0	1.0	1.3	1.1	0.7	0.2	1.3	0.2
07LDR	0.3	0.5	2.0	0.3	1.1	0.1	0.5	0.1	1.0	0.1	0.2	0.8	1.0	1.6	1.3	0.4	0.2	1.5	0.2
08C/I	0.0	0.5	0.6	0.3	1.6	0.0	1.9	0.0	0.6	0.0	2.1	1.5	1.2	0.0	0.3	1.6	0.1	0.5	0.1
09In	0.1	0.6	0.5	0.3	1.3	0.0	1.5	0.1	1.5	0.0	0.1	1.9	1.0	0.1	0.2	1.7	0.1	0.4	0.1
10R/I	0.1	0.5	1.1	0.3	1.6	0.1	0.8	0.1	1.3	0.1	0.6	1.4	1.5	0.3	0.4	0.7	0.1	1.2	0.1
11C/R/I	0.0	0.5	0.6	0.3	1.8	0.0	0.9	0.1	1.4	0.0	2.5	1.4	1.1	0.1	0.4	1.3	0.1	0.8	0.1
12P	0.0	0.7	–	–	–	–	4.9	0.0	–	–	0.3	1.9	0.7	0.0	0.4	1.6	0.0	0.5	0.1
13Sh	0.2	0.6	0.8	0.3	0.3	0.1	3.5	0.1	0.0	0.0	1.1	1.1	0.7	2.9	0.6	0.8	0.2	1.1	0.1
14PB	0.0	0.5	1.0	0.3	0.8	0.0	2.3	0.1	0.7	0.1	3.0	1.0	0.3	2.3	0.8	1.6	0.1	0.5	0.1
15OPB	2.1	0.7	0.0	0.4	0.3	0.1	2.6	0.1	0.0	0.0	0.4	0.9	0.4	1.5	1.5	1.0	0.2	1.0	0.5
16Te	1.3	0.7	1.0	0.3	0.5	0.1	2.1	0.1	0.0	0.1	1.7	1.1	0.2	2.2	1.0	1.5	0.3	0.6	0.3
17Te/Bu	1.0	0.6	2.2	0.3	0.2	0.1	1.3	0.2	0.3	0.1	2.1	1.1	0.4	2.4	0.8	1.2	0.2	0.8	0.4
18VA	2.2	0.7	0.4	0.4	0.1	0.1	2.4	0.1	0.1	0.0	0.2	0.4	1.0	0.1	2.0	1.1	0.3	0.9	0.5
19VA/Bu	2.0	0.6	0.9	0.4	0.1	0.0	2.0	0.1	0.0	0.0	0.3	0.6	0.7	0.2	2.0	1.2	0.4	0.8	0.3
20PA	4.2	0.6	0.0	0.4	–	–	1.0	0.3	–	–	0.7	0.7	0.8	1.1	1.6	1.2	0.7	0.9	0.6
21PA/Bu	3.0	0.6	1.6	0.4	–	–	0.6	0.2	–	–	0.2	1.0	0.6	0.3	1.5	1.6	0.5	0.5	0.5
22FA	5.2	0.9	0.0	0.4	–	–	0.1	0.1	–	–	0.0	0.0	4.9	0.0	0.3	0.5	0.9	1.4	0.9
23FA/Bu	5.0	0.6	0.2	0.4	–	–	0.1	0.1	–	–	0.0	0.2	4.2	0.0	0.4	0.5	0.6	1.4	0.6
24W	5.2	0.9	0.0	0.4	–	–	0.1	0.2	–	–	0.0	0.0	0.0	2.5	2.7	1.3	0.9	0.8	0.9
25W/Bu	5.3	0.7	0.0	0.4	–	–	0.0	0.2	–	–	0.0	0.0	0.0	0.1	3.1	1.5	0.8	0.6	0.8
26ONB	3.5	0.6	1.1	0.4	0.1	0.1	0.5	0.2	–	–	0.4	0.3	0.9	1.1	2.0	1.3	0.5	0.8	0.5

SC ; specialization coefficient of the block area BGC ; the average of the block green coverage ratio
DT ; downtown area UB ; urbanized area ND ; newly developed area
RSC ; specialization coefficient of the block area of the road side GC ; green coverage ratio

- **The Compact, "Gray" Core**: High-density commercial (01HDC, 02HDC/R) and residential (05HDR) blocks are overwhelmingly specialized in the Downtown (A) zone. This zone exhibits the city's lowest green coverage, confirming a strong spatial correlation between the most intense urban forms and a profound deficit of green space.
- **The Industrial Belt**: Industrial (09In) and mixed industrial blocks show a strong specialization in the Urbanized Flatlands (B), historically the locus of the city's manufacturing economy.
- **The Suburban and Peri-Urban Fringe**: Low-density residential blocks (07LDR) are the dominant type in the newly developed areas. These zones, particularly the flatlands, also show a high specialization of farmland (22FA) and vacant land (18VA), resulting in high green coverage.
- **The Green Reservoirs**: The city's primary green assets are spatially segregated. Woodland blocks (24W) are heavily concentrated in the eastern hillside zones (E), forming a large greenbelt. Parks (20PA) and temples (16Te) are more prevalent in the urbanized hillside and newly developed areas than in the central core.
- **Linear "Gray" Corridors**: A distinct pattern emerges along major arterial roads. Low-density commercial (03LDC) and parking lot (12P) blocks show a strong specialization in these transport corridors, creating linear zones of extremely low green coverage that fragment the urban green fabric.

Collectively, these results paint a picture of a city with significant green space inequality, where the highest levels of access to green amenities are found at the periphery, while the densest, most populated

central areas are the most deprived.

4. Discussion

4.1. The Compact City Paradox: A Micro-Scale Policy Critique

The findings provide robust, block-level empirical evidence that substantiates key critiques of the compact city model (Neuman, 2005; Westernick et al., 2012). The results demonstrate a clear and inverse relationship between urban compactness and green space provision in Nagoya. The very block types that closely align with the compact city ideal—high-density, mixed-use commercial and residential cores (01HDC, 02HDC/R, 05HDR)—are precisely those with the lowest green coverage and the poorest quality of non-built-up space.

This analysis moves beyond a simple correlation by identifying *urban morphology* as the critical intervening mechanism. The low openness and compactness scores of the dense central blocks (see Fig. 2) reveal *why* they are green-deficient. The economic logic of densification, particularly on the fine-grained plot structure typical of Japanese cities, incentivizes maximizing floor area. This process treats non-built-up space as a residual, resulting in fragmented, poorly configured, and inaccessible leftover areas like lightwells, service alleys, and shaded slivers between buildings. These spaces are morphologically unsuitable for supporting functional UGS, such as small parks or even meaningful tree canopy.

This creates a condition of "morphological lock-in," where the physical form established by high-density development inherently precludes the integration of effective green infrastructure. The implication for land use policy is profound: policies that focus solely on increasing density metrics (e.g., Floor Area Ratio), without concurrently regulating the quality, contiguity, and usability of the resulting open space, will exacerbate green space deficits and undermine livability. This finding, derived from a non-Western context, echoes research from European cities like Amsterdam and Brussels, where densification policies were found to degrade UGS quantity and connectivity (Balikci et al., 2021). Achieving a "green compact city" requires a form-based approach that actively designs for high-quality open space as an integral component of densification, not as an afterthought (Mouratidis, 2021).

4.2. A Typology-Based PSS for 'Smart Decline' and Land Use Governance

The impending onset of urban shrinkage in Nagoya demands a strategic shift from purely growth-oriented planning to one that also manages decline. Population loss will not be spatially uniform; it is likely to disproportionately affect specific areas, leading to increased vacancy in block types like older industrial zones (09In) or low-density residential areas (07LDR). This challenge, however, presents a unique opportunity for land use policy.

The BLUC typology developed in this paper can be repurposed from a descriptive, diagnostic tool into a prescriptive Planning Support System (PSS) to guide a targeted "right-sizing" strategy (Dewar and Thomas, 2013; Hollander and Németh, 2011). This framework moves beyond reactive vacancy management and allows for proactive, strategic land use governance. The process involves a spatial overlay of vulnerability and needs:

1. **Diagnostic Tool**: The typology map (Fig. 6) acts as a green equity audit, immediately identifying block types suffering from severe green space deficits (e.g., 01HDC, 05HDR).
2. **Prescriptive Tool**: The typology also identifies blocks with characteristics suggesting a higher risk of future vacancy and lower land values (e.g., 09In Industrial, 10R/I Residential/Industrial).

By identifying areas where these two conditions are in proximity, planners can develop a highly targeted land acquisition and redevelopment strategy. For example, a cluster of declining industrial blocks (09In) adjacent to a green-deficient high-density residential neighborhood (05HDR) becomes a prime candidate for transformation into a new district park or green corridor. This approach, rooted in the "smart decline" literature (Schilling and Logan, 2008), allows the city to leverage the process of shrinkage in one area to address a long-standing quality-of-life deficit in another.

This methodology provides a practical, block-level implementation framework for national-level policies, such as Japan's "location normalization plan," which aims to create more compact urban structures in the face of depopulation (Yoon, 2020). The typology acts as a dynamic tool for strategic urban acupuncture, enabling planners to make targeted, efficient, and equitable decisions about where to invest in green infrastructure as the city adapts to a smaller population.

4.3. Limitations and Methodological Transferability

This study's primary strength lies in its fine-grained, block-level analysis. By disaggregating the city into 26 distinct morphological types, the methodology reveals nuanced land use patterns obscured by aggregated approaches (Lan et al., 2021).

The main limitation is the use of 2006 building/land use data. However, as argued, this is intentionally framed as a methodological strength, providing a critical *baseline* of Nagoya's urban form at its demographic peak. This baseline is essential for future longitudinal studies to accurately measure the morphological impacts of both densification and shrinkage. Future research should replicate this study with contemporary datasets to track these changes over time. Furthermore, integrating fine-grained socioeconomic data would allow for a deeper analysis of the environmental justice dimensions of green space access across the block typologies.

The methodological framework itself is highly transferable. The multi-stage classification process—integrating land use composition, building density, and open space morphology—is not specific to Nagoya. The availability of increasingly detailed, building-level geospatial data in cities worldwide makes this type of analysis more feasible than ever. Applying this framework to other cities in Europe, North

America, and Asia would enable robust comparative urban morphological research, helping to identify common patterns and context-specific variations in the land use-sustainability relationship.

5. Conclusion and Policy Implications

This research has dissected the urban fabric of Nagoya, Japan, to reveal the intricate and often contradictory relationship between urban form, density, and the provision of green space. In doing so, it offers three primary contributions to land use policy and planning. First, on an empirical level, it presents a novel 26-category urban block typology, quantitatively demonstrating the stark spatial polarization of green space in a major post-industrial city. Second, on a theoretical level, it provides high-resolution evidence for the "compact city paradox," identifying the morphology of non-built-up space as a key mechanism through which densification policies can lead to green space exclusion. Third, on a practical and policy level, it demonstrates how a morphological typology can transcend its descriptive function to become a proactive Planning Support System for implementing targeted "right-sizing" and greening strategies in cities facing demographic decline.

The findings yield several actionable recommendations for land use policy and governance in Nagoya and other cities facing similar trajectories:

1. **Adopt Form-Based Codes to Complement Density-Based Zoning**: Municipalities should move beyond simplistic land use and density controls (e.g., Floor Area Ratio) and develop form-based codes that regulate the *qualitative attributes* of non-built-up space. This could include establishing minimum standards for openness, contiguity, and solar access of open spaces created within new high-density developments, ensuring they are functional for greening and recreation, not just residual artifacts.
2. **Implement Typology-Based Green Equity Audits**: Planners can use the BLUC typology as a framework to conduct "green equity audits." By mapping the distribution of block types against demographic data, they can identify which communities are most affected by green space deficits (e.g., residents of 05HDR blocks) and prioritize land acquisition and green investments accordingly, thereby advancing environmental justice.
3. **Develop Proactive Land Acquisition Policies for 'Right-Sizing'**: In shrinking cities, municipalities should adopt proactive land banking and acquisition policies focused on block types identified as vulnerable to decline (e.g., aging industrial or low-density residential areas). This would allow cities to assemble land strategically over time, creating a network of future green infrastructure that can serve the needs of adjacent, green-deficient neighborhoods, effectively using shrinkage as a tool for urban regeneration.

This study opens several avenues for future research. A crucial next step is to conduct a longitudinal analysis, replicating this study with updated data to measure the morphological transformations that have occurred as Nagoya has undergone its recent wave of redevelopment. Further research should also integrate fine-grained socioeconomic data to explore the environmental justice dimensions of green

space access and assess the ecological connectivity of the UGS network. By refining our understanding of the city at this fine-grained scale, we can better equip planners to formulate land use policies that create cities that are not only compact but also green, equitable, and resilient.

Declarations

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

Ethical Approval

This article does not contain any studies with human participants or animals performed by the author.

Informed Consent

Not applicable, as this study does not involve human participants.

Consent to Publish

The author consents to the publication of this manuscript in the *Journal of Humanities and Social Sciences*, should it be accepted.

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Author Contribution

T.O. is the sole author of this work and was responsible for all aspects of the study, including conceptualization, methodology, analysis, visualization, and writing.

Data Availability Statement

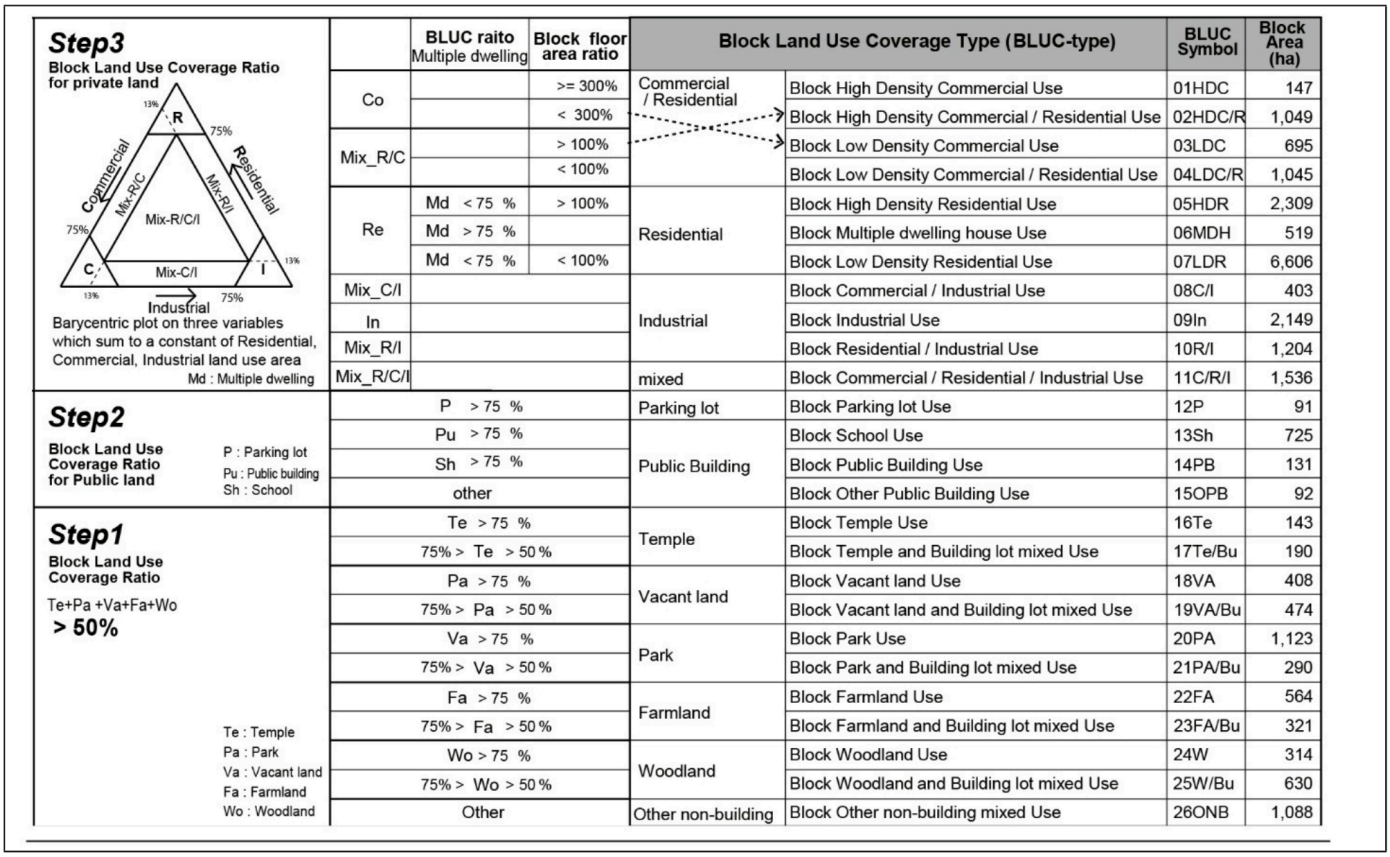
All data generated or analyzed during this study are available from the corresponding author upon reasonable request. The spatial datasets used for morphological classification were derived from publicly available sources.

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Figures



	BLUC raito Multiple dwelling	Block floor area ratio	Block Land Use Coverage Type (BLUC-type)		BLUC Symbol	Block Area (ha)
Co		>= 300%	Commercial / Residential	Block High Density Commercial Use	01HDC	147
		< 300%		Block High Density Commercial / Residential Use	02HDC/R	1,049
Mix_R/C		> 100%		Block Low Density Commercial Use	03LDC	695
		< 100%		Block Low Density Commercial / Residential Use	04LDC/R	1,045
Re	Md < 75 %	> 100%	Residential	Block High Density Residential Use	05HDR	2,309
	Md > 75 %			Block Multiple dwelling house Use	06MDH	519
	Md < 75 %	< 100%		Block Low Density Residential Use	07LDR	6,606
Mix_C/I			Industrial	Block Commercial / Industrial Use	08C/I	403
In				Block Industrial Use	09In	2,149
Mix_R/I				Block Residential / Industrial Use	10R/I	1,204
Mix_R/C/I			mixed	Block Commercial / Residential / Industrial Use	11C/R/I	1,536
P > 75 %			Parking lot	Block Parking lot Use	12P	91
Pu > 75 %			Public Building	Block School Use	13Sh	725
Sh > 75 %				Block Public Building Use	14PB	131
other				Block Other Public Building Use	15OPB	92
Te > 75 %			Temple	Block Temple Use	16Te	143
75% > Te > 50 %				Block Temple and Building lot mixed Use	17Te/Bu	190
Pa > 75 %			Vacant land	Block Vacant land Use	18VA	408
75% > Pa > 50 %				Block Vacant land and Building lot mixed Use	19VA/Bu	474
Va > 75 %			Park	Block Park Use	20PA	1,123
75% > Va > 50 %				Block Park and Building lot mixed Use	21PA/Bu	290
Fa > 75 %			Farmland	Block Farmland Use	22FA	564
75% > Fa > 50 %				Block Farmland and Building lot mixed Use	23FA/Bu	321
Wo > 75 %			Woodland	Block Woodland Use	24W	314
75% > Wo > 50 %				Block Woodland and Building lot mixed Use	25W/Bu	630
Other			Other non-building	Block Other non-building mixed Use	26ONB	1,088

Figure 1

Analytical Workflow for Urban Block Typology and Spatial Analysis

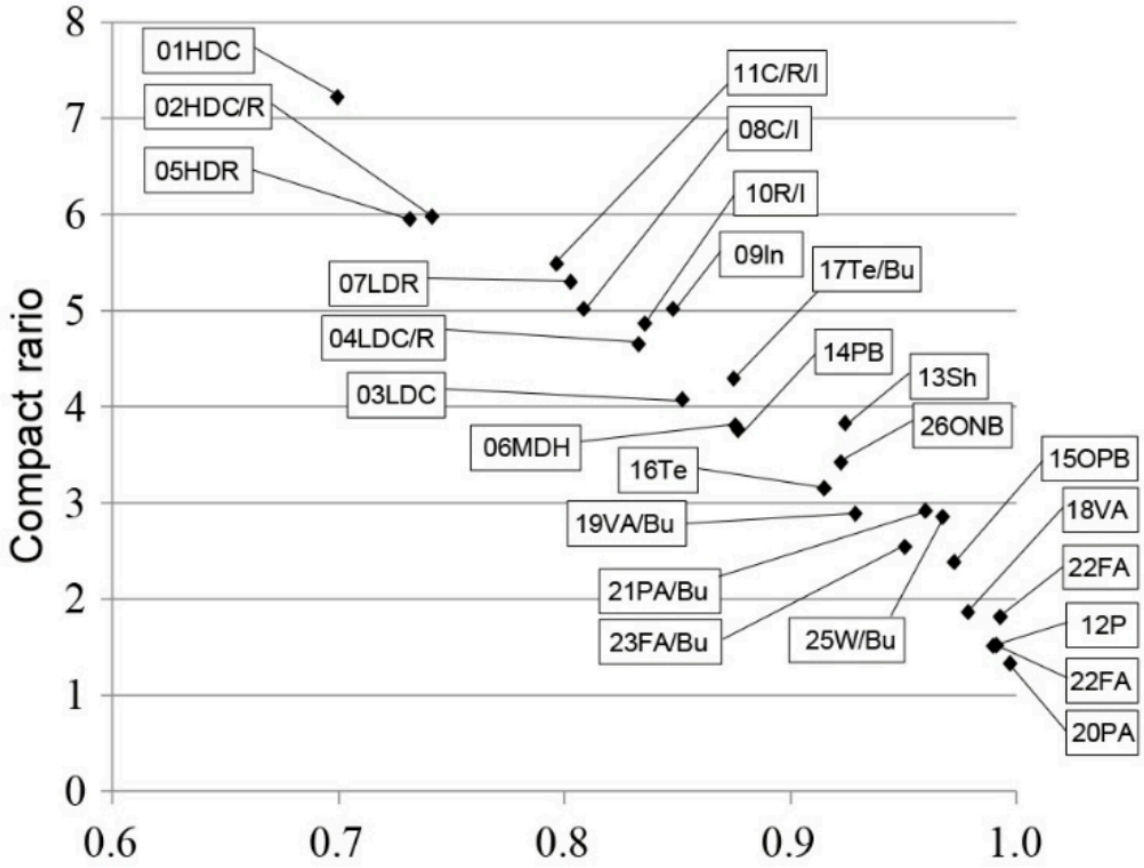


Figure 2

Relationship between Compact Ratio and Non-built-up Openness Index

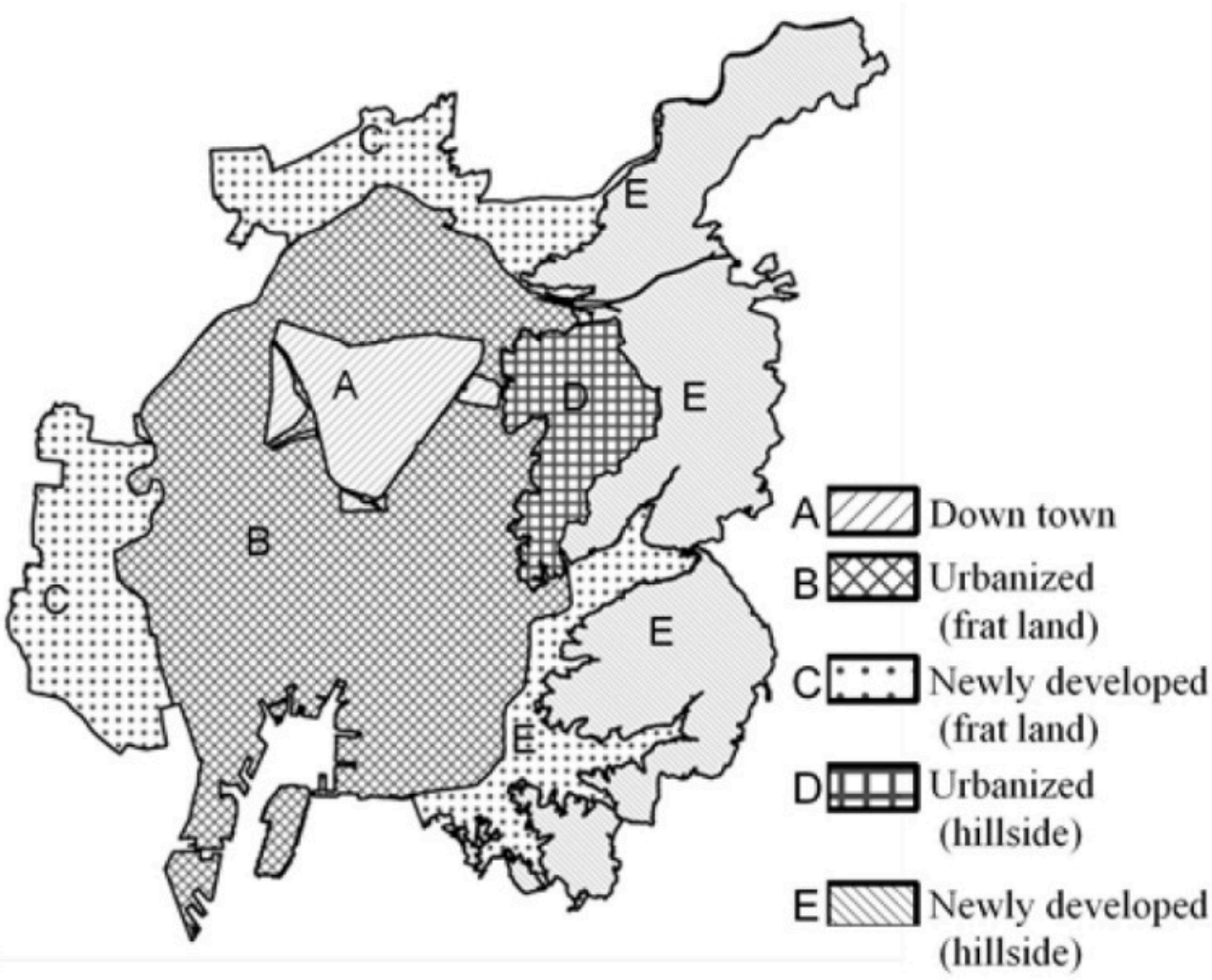


Figure 3

Spatial Distribution and Specialization of Key Urban Block Typologies

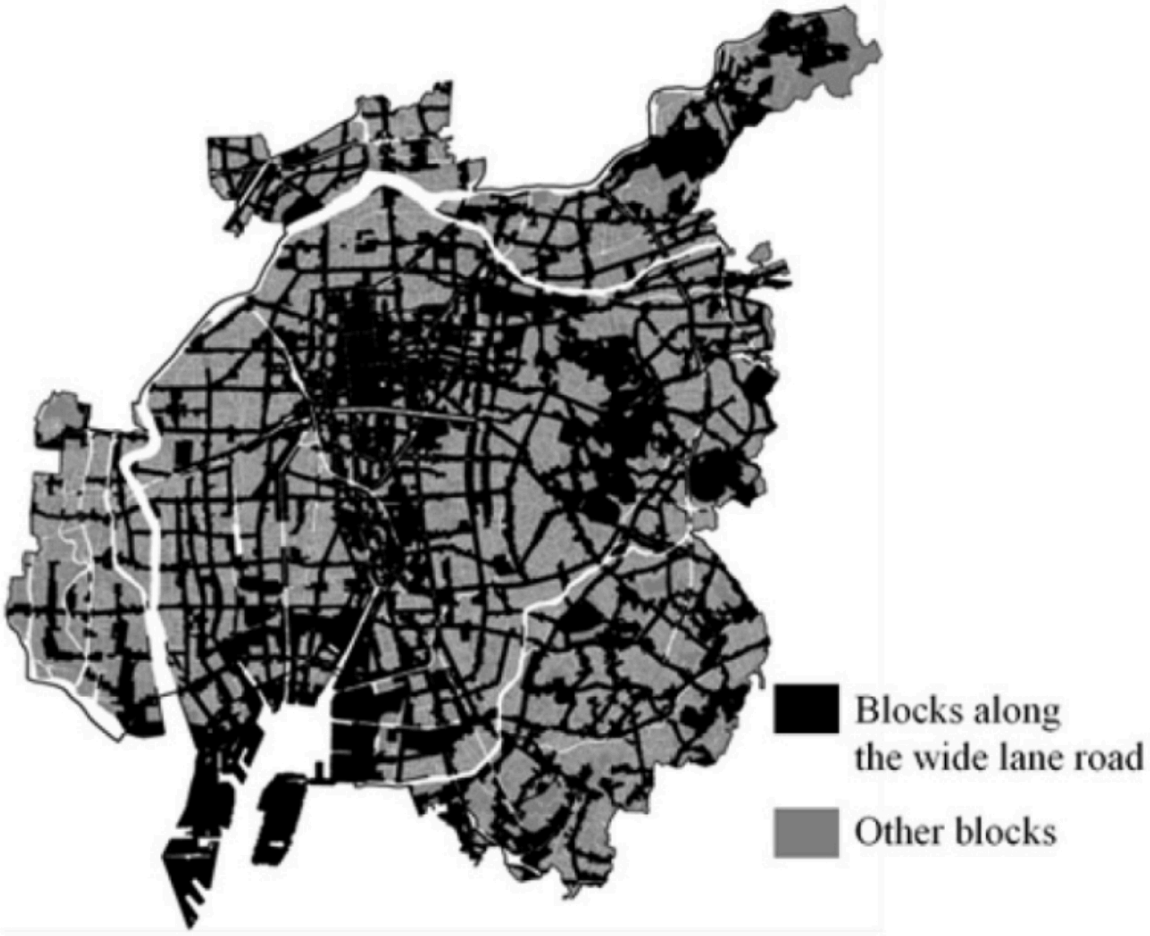


Figure 4

Spatial Distribution by wide lane road

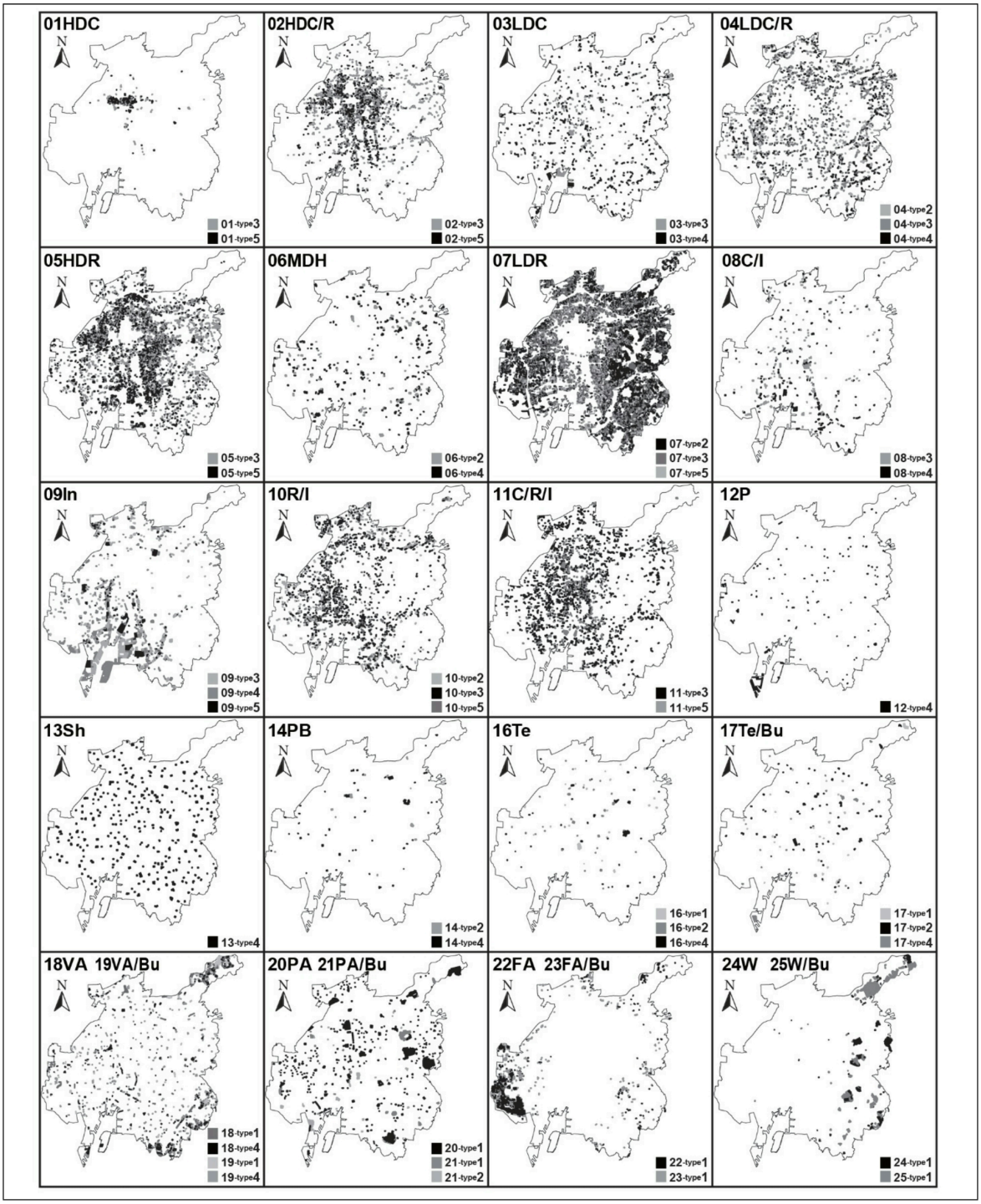

01HDC
01-type3
01-type5
02HDC/R
02-type3
02-type5
03LDC
03-type3
03-type4
04LDC/R
04-type2
04-type3
04-type4
05HDR
05-type3
05-type5
06MDH
06-type2
06-type4
07LDR
07-type2
07-type3
07-type5
08C/I
08-type3
08-type4
09In
09-type3
09-type4
09-type5
10R/I
10-type2
10-type3
10-type5
11C/R/I
11-type3
11-type5
12P
12-type4
13Sh
13-type4
14PB
14-type2
14-type4
16Te
16-type1
16-type2
16-type4
17Te/Bu
17-type1
17-type2
17-type4
18VA 19VA/Bu
18-type1
18-type4
19-type1
19-type4
20PA 21PA/Bu
20-type1
21-type1
21-type2
22FA 23FA/Bu
22-type1
23-type1
24W 25W/Bu
24-type1
25-type1

Figure 5

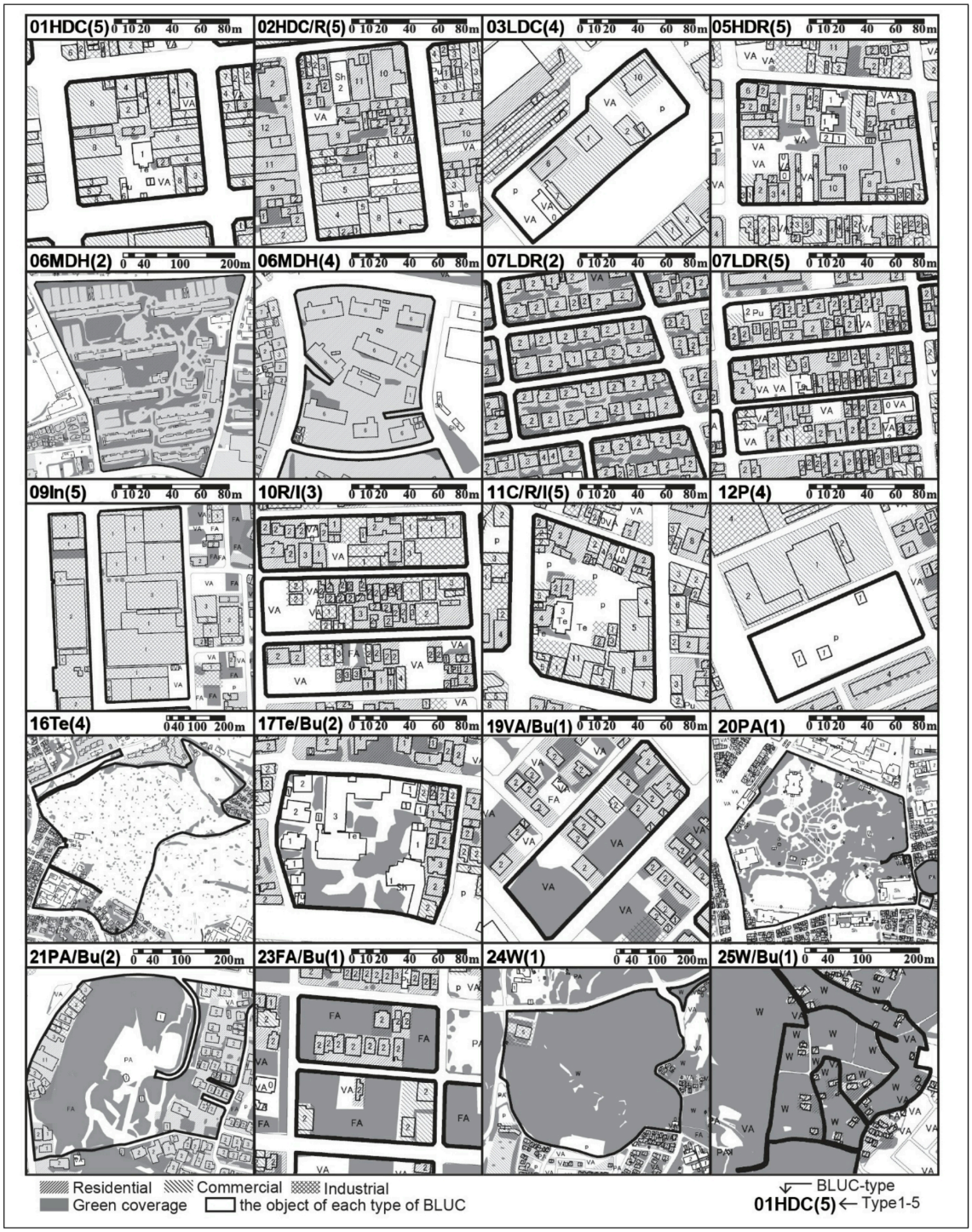


Figure 6

The Block Land Use Coverage Types