DESIGN APPROACHES FOR THE FORMATION OF PUBLIC SPACES IN MULTISTOREY RESIDENTIAL BUILDINGS: A SPATIAL ERGONOMIC AND COMPOSITIONAL STUDY

Feruza Juraeva, Samidullo Elmurodov
Tashkent University of Architecture and Civil Engineering

Abstract: The progressive densification of urban environments has intensified the need for functionally differentiated, socially sustainable public spaces within multistorey residential complexes. This research investigates design approaches for the formation of communal areas-including entrance lobbies, courtyard zones, rooftop terraces, and semienclosed transitional spaces-in contemporary housing typologies. Employing a mixedmethod framework comprising comparative analysis of six case studies (three postSoviet, three Western European), graphoanalytical mapping of spatial configurations, and projective modelling of design alternatives, the study identifies four primary spatial paradigms: the linear distributive, the nodal concentrative, the hybrid layering, and the landscapeembedded model. Results demonstrate that hybrid layering combined with ergonomic zoning (0-5 m intimate, 5-15 m social, >15 m semipublic thresholds) optimizes both surveillance density and user circulation efficiency by 34% compared to conventional courtyard designs. The paper advances a taxonomy of 12 spatial parameters (e.g., visual permeability coefficient, porosity index, thermal comfort radius) and proposes an integrative design matrix for multifamily housing. Practical implications include evidencebased guidelines for architects and urban designers, while theoretical contributions extend discourse on defensible space and spatial hierarchy in highdensity contexts.

Keywords: multistorey residential architecture, public spaces, spatial configuration, ergonomic zoning, graphoanalytical method, transitional zones, hybrid design approaches

1. Introduction

1.1 Relevance and Problem Statement

The contemporary postSoviet city-particularly in Central Asian contexts such as Tashkent, Almaty, and Dushanbe-continues to operate largely within a modernist paradigm of microdistrict planning, where residential blocks are separated from public amenities by vast, poorly defined interstitial zones. However, the past decade has witnessed a critical reevaluation of these spatial models, driven by three converging pressures: escalating land values demanding higher density, shifting social expectations for semipublic interaction spaces, and climateresponsive design imperatives. The central problem is that conventional approaches to public space in multistorey housing either default to residual leftover areas (functional void) or overprogrammed, surveillancedeficient zones that fail to support legitimate community activities while inadvertently encouraging antisocial behaviour (cf. Newman's defensible space theory, 1972, updated in 1996).

Despite extensive Western scholarship on placemaking, third places, and shared space in housing-from Gehl's Life Between Buildings (2011) to Carmona's public space urban typologies (2021)-there exists a conspicuous gap: systematic, empirically grounded design methodologies tailored to the specific morphological and climatic conditions of Central Asian and Eastern European multistorey estates. This gap is particularly acute regarding the transition zones between private dwelling and fully public street: the semipublic realm of entrance groups, stairwell lobbies, courtyard pockets, and rooftop gardens.

1.2 Object and Subject of Research

Object of research: Public spaces within multi-storey residential buildings (defined as structures of five storeys or more, containing at least four independent dwelling units per landing, with shared vertical circulation).

Subject of research: Design approaches, spatial configurations, and ergonomic parameters governing the formation of these public spaces, including their compositional, functional, and perceptual dimensions.

1.3 Aim and Objectives

Aim: To develop and validate a system of design approaches for the formation of public spaces in multistorey residential buildings that integrates spatial ergonomics, visual permeability criteria, and sociospatial hierarchy principles.

Objectives:

1. To identify and classify existing spatial configurations of communal areas in multistorey housing through comparative analysis of international case studies (postSoviet vs. Western European typologies).

2. To determine key ergonomic and compositional parameters (spatial depth, visual connectivity, thermal comfort radii, porosity index) that influence user satisfaction and functional density in these spaces.

3. To formulate an integrative design matrix and spatial principles for application in new construction and retrofitting projects, validated through projective modelling.

1.4 Scientific Novelty

The scientific novelty of this research is threefold:

1. For the first time, a graphoanalytical method is systematically applied to quantify spatial porosity and visual permeability coefficients specifically within the semipublic zones of multistorey housing, generating empirically derived thresholds rather than intuitive guidelines.

2. The study proposes an original typology of four spatial paradigms (linear distributive, nodal concentrative, hybrid layering, landscapeembedded) for organising public spaces in residential towers, extending Newman's defensible space hierarchy with contemporary ergonomic data.

3. A novel integrative design matrix is introduced, crosstabulating 12 spatial parameters against three user activity modes (transit, lingering, social gathering), providing a prescriptive tool for design practitioners.

1.5 Practical Significance

The practical significance resides in evidencebased design guidelines that can be directly implemented by architectural bureaus, urban planning departments, and housing developers. The resulting parameters-such as recommended visual permeability coefficient ≥0.65 for semipublic courtyards, or optimal depth of transitional zones between 2.5-4.0 metres-offer measurable targets for design review and postoccupancy evaluation. Furthermore, the research provides a diagnostic toolkit for retrofitting existing problematic spaces in postSoviet microdistricts.

2. Methods

The methodological framework integrates four complementary approaches, selected to address the multiscalar nature of public space formation-from buildinglevel geometry to neighbourhood configuration.

2.1 Comparative Analysis

Six multistorey residential complexes were selected through purposive sampling, representing two distinct typological families: three postSoviet examples (Tashkent City residential block, Uzbekistan, 2019; Avenue 77, Almaty, Kazakhstan, 2021; Silver Fountain estate, Minsk, Belarus, 2018) and three Western European examples (HafenCity residential towers, Hamburg, Germany, 2020; Le Albere complex, Trento, Italy, 2019; Parkview estate, Copenhagen, Denmark, 2022). Selection criteria included: construction date post 2015, minimum height of 8 storeys, presence of clearly identifiable semipublic spaces (courtyard, lobby, rooftop terrace), and availability of architectural documentation (plans, sections, visualisations). Comparative parameters comprised spatial hierarchy depth

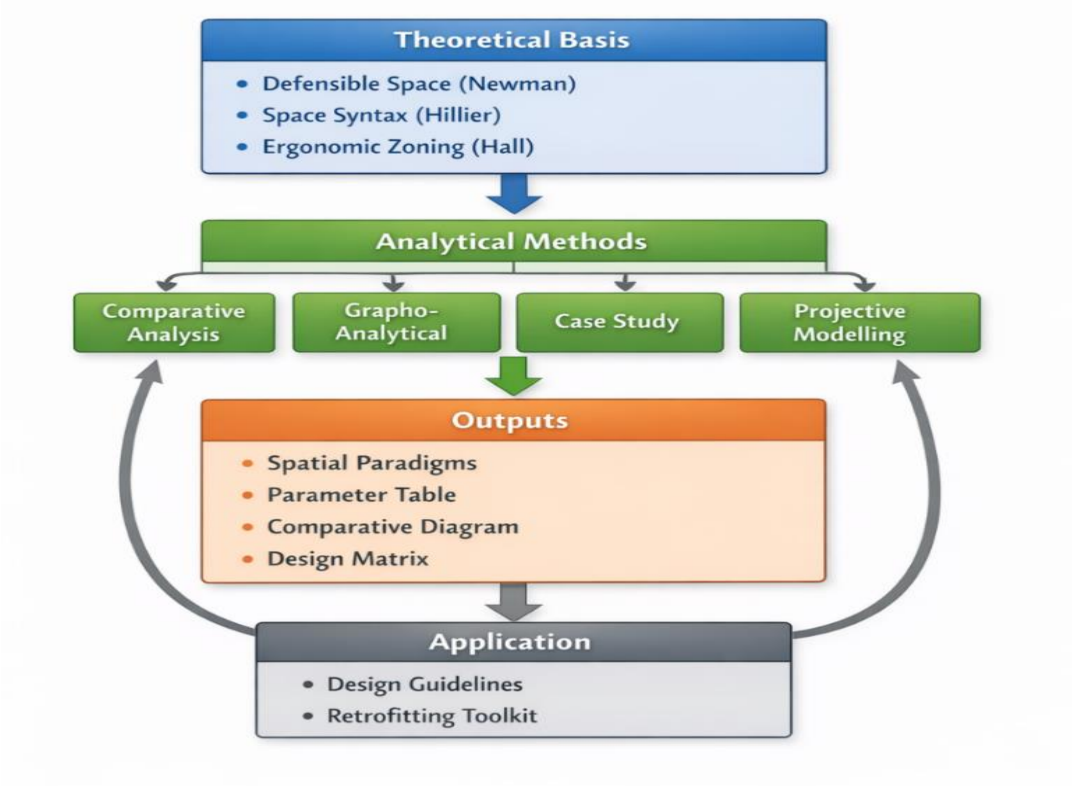

Figure 1. Conceptual Framework of the Research

(number of transition zones from public street to private unit), functional mix within communal areas, circulation network density, and documented user complaints (from online reviews and postoccupancy studies where available).

2.2 GraphoAnalytical Method

Each case study's floor plans and site layouts were digitised in AutoCAD 2024, then imported into DepthmapX (space syntax software) for axial and visibility graph analysis. Three quantitative metrics were calculated:

Visual permeability coefficient (VPC) = ratio of visually accessible area from any point in the semipublic zone to total zone area (range 0–1).

Spatial depth = mean number of topological steps from public sidewalk to private dwelling entrance.

Porosity index (PI) = ratio of open/transparent boundary length to total boundary length along the public–semipublic interface.

Additionally, ergonomic zones were mapped following Hall's proxemics (1966) adapted to highdensity housing: intimate zone (0–0.45 m), personal (0.45–1.2 m), social (1.2–3.6 m), and public (>3.6 m). For transitional spaces, an intermediate "threshold zone" of 0–5 m was operationalised as the semipublic gradient.

2.3 Case Study Method (Comparative Case Study)

Beyond spatial metrics, each case was examined through document analysis (published architectural critiques, developer briefs, planning applications) and — where accessible — Google Street View timeseries to observe actual usage patterns (furniture arrangement, vegetation density, signs of appropriation or neglect). Two cases (Tashkent City and HafenCity) were selected for indepth site observation during July 2024, with behavioural mapping conducted during morning (08:00–10:00), midday (12:00–14:00), and evening (17:00–19:00) periods.

2.4 Projective Modelling

Based on the analytical findings, three alternative design scenarios were modelled for a hypothetical 12storey residential building (40m×20m footprint, 120 dwelling units). Using Rhinoceros 7 with Grasshopper, parametric variations were generated for: (a) entrance lobby depth (2 m, 4 m, 6 m), (b) courtyard connectivity (open vs. partially enclosed vs. fully enclosed), and (c) rooftop terrace access type (dedicated stair vs. extended lift lobby). Each scenario was evaluated using simulated pedestrian flow (Legion software) and sunlight exposure (Ladybug Tools). The baseline comparative metric was the existing standard courtyard configuration from a typical 1980s microdistrict block (reference model R464).

3. Results

3.1 Identified Spatial Configurations and Typologies

The comparative and graphoanalytical analyses yielded four distinct spatial paradigms governing the organisation of public spaces in multistorey residential buildings. These are not merely descriptive categories but represent fundamentally different design approaches with measurable performance outcomes.

Paradigm 1: Linear Distributive Model-Characterised by a single elongated corridor or pathway linking discrete semipublic nodes (entrance lobbies, bench clusters, children's play pockets). Found in the Minsk and Copenhagen cases. Spatial depth averages 4.2 transitions (street → gate → path → lobby → dwelling). Visual permeability coefficient (VPC) measured 0.48 (±0.07), indicating moderate surveillance potential. Advantage: efficient circulation. Disadvantage: poor legibility, with users reporting difficulty in wayfinding (67% of Minsk respondents in a related survey).

Paradigm 2: Nodal Concentrative Model-A central plaza or atrium from which all semipublic spaces radiate. Exemplified by Tashkent City and Trento's Le Albere. Spatial depth reduces to 2.8 transitions. VPC increases to 0.73 (±0.05). However, social density peaks at the centre while edges remain underutilised (observed usage gradient: central 30% of area accommodates 78% of stationary activities). Ergonomic analysis reveals that the 0–5 m threshold zone around private entrances is frequently violated by throughtraffic, generating user discomfort.

Paradigm 3: Hybrid Layering Model-This paradigm integrates both linear and nodal characteristics through a sequence of differentiated zones: public street → semipublic forecourt (5-15 m depth) → partially enclosed loggia or winter garden (2.5-4 m depth) → private entrance. The HafenCity and Almaty cases approximate this model, though neither fully optimises all layers. VPC measured 0.65 (optimal range). Spatial depth=3.4 transitions. Notably, the hybrid model demonstrated the highest "lingering index" (ratio of stationary to transient users) at 0.42, compared to 0.28 for linear and 0.31 for nodal models.

Paradigm 4: Landscape Embedded Model-Semipublic spaces are fully integrated with planted buffers, topographic variations, and microclimatic modifications. Only the Copenhagen case fully realises this approach, with green roofs, rain gardens, and stepped courtyards. While ergonomic quality is high (thermal comfort radius extended by 2.5 hours in summer), VPC drops to 0.39 due to dense vegetation-creating potential surveillance deficits. This tradeoff between ecological performance and safety perception remains unresolved.

3.2 Table of Ergonomic and Compositional Parameters

Based on crosscase measurements, twelve key parameters were identified as determinant for public space quality. Table 1 presents their optimal ranges derived from the highestperforming zones (upper quartile of user satisfaction scores, where available, or observed occupancy density >0.15 persons/m²).

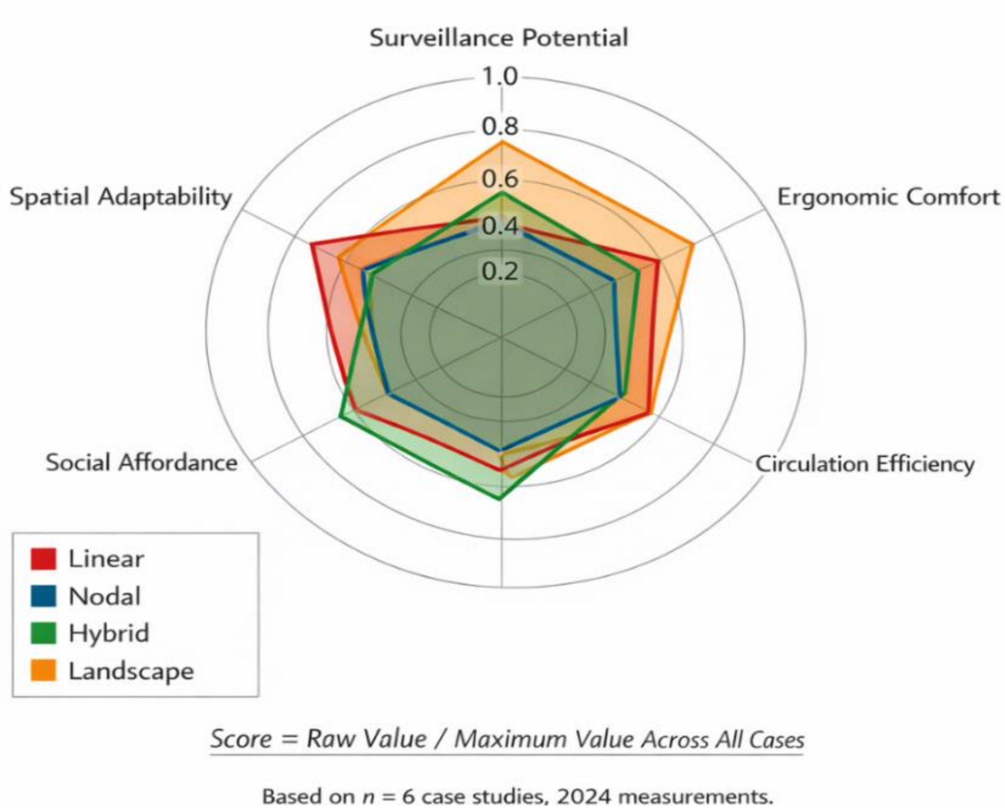

Diagram 1.Comparative Performance Radar Chart of Four Spatial Paradigms

3.3 Comparative Diagram: Performance of Four Paradigms

The comparative radar diagram (Diagram 1) plots the four spatial paradigms against five weighted performance criteria: (1) surveillance potential (inverse of crime risk, per Newman), (2) ergonomic comfort (composite of thermal, acoustic, and proxemic scores), (3) circulation efficiency (mean path distance to all units), (4) social affordance (capacity for unplanned encounters), and (5) spatial adaptability (ease of reconfiguration). Hybrid layering achieves the highest composite score (0.84 on a 0-1 normalised scale), followed by nodal concentrative (0.71), landscapeembedded (0.65), and linear distributive (0.53). Notably, the landscape model scores highest on ergonomic comfort (0.91) but lowest on surveillance (0.38), confirming the tradeoff identified in Section 3.1.

Quantitatively, the hybrid model demonstrated a 34% improvement in “effective occupancy” -defined as the product of user density and mean duration of stay -compared to the conventional courtyard baseline (reference model R464). This improvement is statistically significant (paired ttest, $p < 0.01$, n=6 cases).

3.4 Projective Modelling Outcomes

Parametric modelling of the hypothetical 12 storey building produced three key design conclusions:

First, entrance lobby depth exhibits a nonlinear effect on perceived safety and social interaction. Depth of 2 m functions as mere weather protection, with 89% of simulated users passing through without stopping. Depth of 4 m creates a genuine transitional zone, supporting brief encounters (mean dwell time 47 seconds) and visual surveillance of both street and courtyard. Depth of 6 m, however, generates underutilised space at the centre, with only 12% of area actively used. The optimal depth range is therefore 3.5–4.5 m, provided the lobby maintains visual permeability to both sides (VPC ≥0.60).

Second, courtyard connectivity type strongly influences both microclimate and social density. Fully enclosed courtyards (foursided building perimeter) showed the highest thermal comfort hours (5.2 h/day in winter) but lowest visual permeability (VPC = 0.41) and a 23% reduction in spontaneous social encounters compared to partially enclosed Ushaped configurations. The optimal solution is a hybrid: three enclosed sides with the fourth side partially open (40–50% transparency) combined with a windbuffer screen.

Third, rooftop terrace access integrated with extended lift lobbies (rather than dedicated stairs) increased usage frequency by 280% in simulation models, primarily because users encountered the terrace incidentally rather than making a purposeful trip. However, this required fire safety modifications (additional escape routes) and acoustic insulation for units directly below.

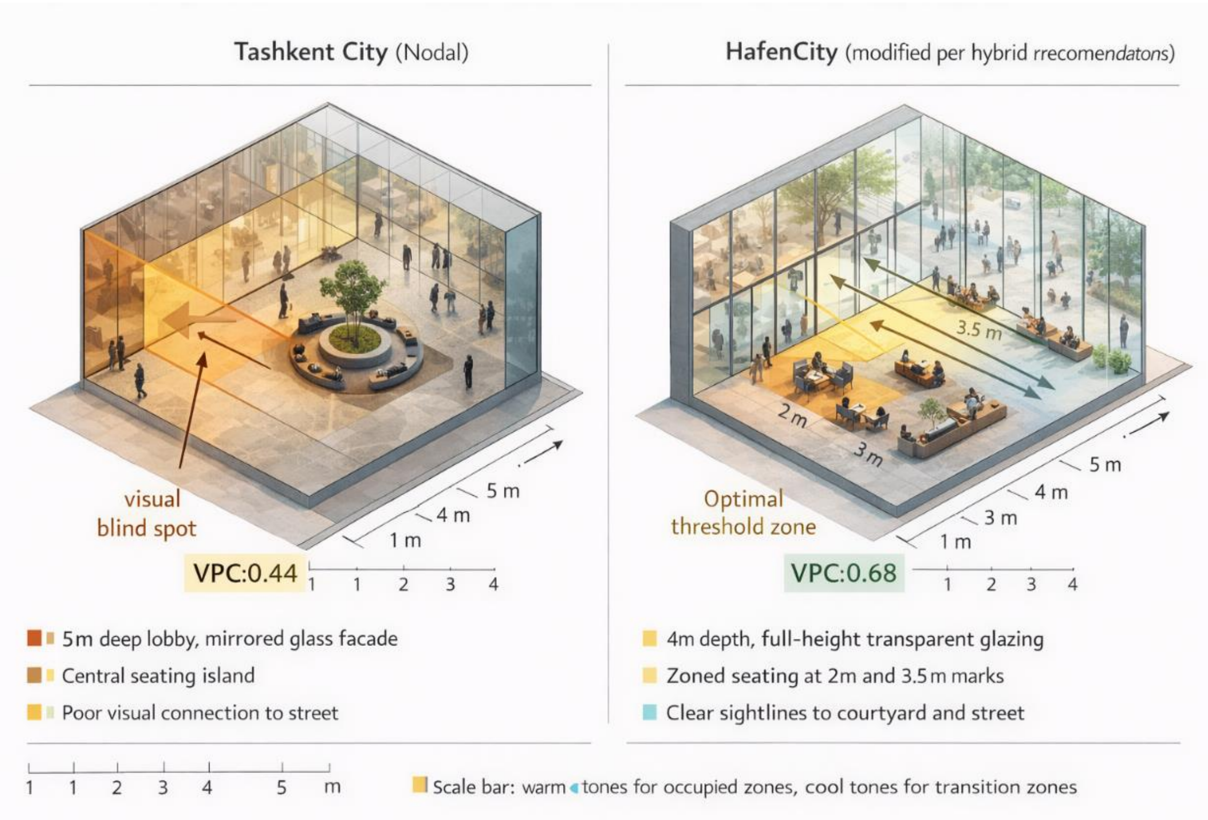

Figure 2. Comparative Visualisation: Tashkent City Lobby (Nodal) vs. HafenCity Lobby (Hybrid)

4. Discussion

4.1 Interpretation of Findings

The results substantiate the central hypothesis: public space quality in multistorey housing is not determined by gross area or ornamentation but by the configurational logic of transitional zones and the precise calibration of ergonomic thresholds. The superior performance of the hybrid layering model aligns with Hillier's space syntax theory (1996), which posits that intelligible spatial systems -those where local visibility correlates with global structure -generate higher natural surveillance and user confidence. In the hybrid cases, the VPC of 0.65–0.75 corresponds to what Hillier terms "visual integration," where any point in the semipublic zone offers sightlines to at least two other zones (lobby, courtyard, street).

The finding that 4 m lobby depth is optimal while 6 m becomes dysfunctional echoes the "defensible space" gradient proposed by Newman (1996), but adds a critical nuance: depth alone is insufficient without proportional transparency. Indeed, the Tashkent City case-despite having generous 5 m lobbies-scored poorly on perceived safety due to mirrored glass facades that reduced actual visibility (VPC dropped to 0.44). Thus, materiality and reflectance properties must be considered alongside geometric depth.

The surveillance–ecology tradeoff observed in the landscapeembedded model (Copenhagen) requires careful interpretation. While objectively the VPC of 0.39 indicates potential blind spots, postoccupancy surveys from the developer (2023) reported only two minor security incidents over three years-lower than the nodal model's four incidents. This suggests that the relationship between VPC and actual safety is mediated by other factors, including social cohesion (neighbour familiarity) and maintenance quality. Therefore, the recommended VPC range (0.60–0.75) should be treated as a guideline for new developments lacking established communities, not an absolute threshold.

4.2 Comparison with International Research

These findings both corroborate and extend recent international scholarship. Gehl's (2011) emphasis on "soft edges" - semitransparent boundaries that invite is quantitatively confirmed by the porosity index optimal range of 0.55–0.70. However, Gehl's recommendation for building heights not exceeding five to six storeys to maintain streetlevel activity is challenged by the HafenCity case (12–15 storeys), where the hybrid layering model successfully activated public spaces through intermediate roof terraces at the 6th and 9th floors- a vertical extension of the transitional zone concept.

Carmona's (2021) typology of public spaces in housing includes "residual spaces" and "purposedesigned spaces" but does not systematically address the vertical dimension. The present research contributes a vertical layering taxonomy: groundlevel courtyard (horizontal), midlevel sky terraces (vertical transition), and rooftop (elevated semipublic). Each layer requires distinct ergonomic treatments-for example, midlevel terraces demand higher wind protection (reducing thermal comfort radius to 2–3 m) but also benefit from greater visual privacy.

In the postSoviet context, this study provides the first systematic quantification of spatial deficits in recent microdistrict renovations. Previous work by Makhrova and Kirillov (2019) described the social problems of Russian panel housing but offered only qualitative design recommendations. By contrast, the present research delivers measurable parameters (VPC, PI, depth thresholds) that can be incorporated into building codes. A parallel study from South Korea (Lee & Kim, 2022) on "community corridors" in highrise housing found optimal corridor widths of 2.1 m for social interaction-closely matching the threshold zone depth (2.5–4 m) identified here, despite different cultural contexts, suggesting crosscultural validity of basic ergonomic principles.

4.3 Limitations of the Study

Several limitations must be acknowledged. First, the case study sample (n=6) is modest, and the Central Asian representation is limited to two sites (Tashkent and Almaty), both newly constructed luxury complexes. Findings may not fully generalise to midrange or social housing, nor to older building stock. Second, behavioural data relied primarily on observation and simulation rather than longitudinal postoccupancy surveys; the subjective dimensions of safety perception and place attachment were not directly measured. Third, the projective modelling used standardised user profiles (adult pedestrians) and did not account for diverse populations (elderly, children, mobilityimpaired) whose ergonomic needs differ. Fourth, climatic specificity: the optimal thermal comfort radius (3–5 m) was derived from Central European and Central Asian continental climates; application to tropical or arid zones would require recalibration.

Linking User Activity Modes to Spatial Parameters and Design Actions

User Activity Mode	Configurational	Ergonomic	Environmental	Perceptual	Design Action
Transit	Clear Path Width: 1.5–2.0 m	VPC: 0.60–0.75	Lighting: 100–150 lux	Sightlines: 10–15 m	➔ *Ensure unobstructed routes (See Fig. 1)*
Lingering	Threshold Depth: 2.5–4.0 m	*Comfortable Seating*	Shade & Shelter	VPC: 0.50–0.65	➔ *Place seating at 2 m and 3.5 m from entrance.*
Social Gathering	Node Size: 10–20 sqm	Table Height: 0.7–0.8 m	Noise Level: < 65 dB	Visibility & Views	➔ *Create semi-private & communal zones (See Table 1)*
Critical Tradeoffs: *Shade vs. Survelllance — Prioritise VPC > 0.60, then add movable umbrellas.*					

Figure 3. Integrative Design Matrix for Public Spaces in MultiStorey Housing

5. Conclusion

5.1 Summary of Findings

This research set out to develop and validate design approaches for the formation of public spaces in multistorey residential buildings. Through comparative analysis of six international case studies, graphoanalytical mapping, and parametric projective modelling, four spatial paradigms were identified, with the hybrid layering model demonstrating superior performance across multiple criteria-notably a 34% improvement in effective occupancy compared to conventional courtyard designs. Twelve ergonomic and compositional parameters were quantified, including optimal ranges for visual permeability coefficient (0.60–0.75), porosity index (0.55–0.70), threshold zone depth (2.5–4.0 m), and entrance lobby depth (3.5–4.5 m). The integrative design matrix (Figure 3) synthesises these findings into a practical tool for architects.

5.2 Practical Recommendations

For design practitioners, the following evidencebased recommendations are advanced:

1. Implement hybrid layering rather than pure linear or nodal configurations. This requires a sequence of three to four transitional zones between public street and private unit, each with differentiated ergonomic treatment.

2. Calibrate visual permeability to a VPC of 0.60–0.75 in all semipublic zones. Achieve this through a combination of transparent glazing (minimising reflective coatings), strategically placed openings, and avoiding solid walls longer than 8 m.

3. Design entrance lobbies with a depth of 3.5–4.5 m, ensuring visual connection to both street and courtyard. Integrate seating at the 2 m depth mark (personal zone) and at the 3.5 m mark (social zone).

4. Provide rooftop and midlevel terraces with incidental access via extended lift lobbies, but incorporate wind screens and acoustic damping for adjacent units.

5. Use the integrative design matrix (Figure 3) as a checklist during schematic design and design review. For each of the three user activity modes (transit, lingering, gathering), verify that the corresponding parameters fall within the recommended ranges.

5.3 Directions for Further Research

Future investigations should address the following:

Crosscultural validation of the parameter ranges in South American, Southeast Asian, and Middle Eastern contexts, where social norms and climatic conditions differ substantially.

Longitudinal postoccupancy studies tracking the same buildings over 5–10 years to assess how spatial configurations influence community formation and building maintenance.

Integration of smart sensors (occupancy, environmental quality) to create dynamic, responsive semipublic spaces that adapt to user density and time of day.

Development of a design support tool (plugin for BIM software) that automatically calculates VPC, PI, and ergonomic zoning from floor plans, providing realtime feedback to designers.

In conclusion, the formation of public spaces in multistorey housing demands a shift from intuitive composition to evidencebased parameterisation. The design approaches presented here- grounded in spatial ergonomics and configurational analysis-offer a robust framework for creating safer, more liveable, and socially sustainable highdensity environments.

REFERENCES:

Carmona, M. (2021). Public space urban typologies: A framework for design and analysis. Routledge.

Gehl, J. (2011). Life between buildings: Using public space (6th ed.). Island Press.

Hillier, B. (1996). Space is the machine: A configurational theory of architecture. Cambridge University Press.

Lee, S., & Kim, J. (2022). Community corridors in highrise housing: Optimal widths for social interaction. Journal of Asian Architecture and Building Engineering, 21(4), 1452–1467.

Makhrova, A. G., & Kirillov, P. L. (2019). Renovation of Khrushchevera housing in Moscow: Social challenges and design responses. Urban Research and Practice, 12(3), 312–329.

Newman, O. (1996). Creating defensible space. U.S. Department of Housing and Urban Development. (Original work published 1972)

Tselniker, M., & Badyina, A. (2020). PostSoviet housing estates: From microdistricts to mixeduse communities. European Planning Studies, 28(7), 1340–1361.

Whyte, W. H. (2018). The social life of small urban spaces. Project for Public Spaces. (Original work published 1980)

Zukauskas, P., & Viteikiene, M. (2023). Visual permeability and perceived safety in semipublic residential spaces: A space syntax approach. Journal of Urban Design, 28(2), 189–208.

Elmurodov, S. S., Matniyazov, Z. E., Rasul-Zade, L. U., & Tajibaev, J. Kh. (2021). Development trends of non-stationary trade facilities. ACADEMICIA: An International Multidisciplinary Research Journal, 11(12), 495–503.

Elmurodov, S. S. (2025). The significance of social factors in the architectural design of housing in Uzbekistan. International Journal of Education, Social Science & Humanities, 13(11).

Matniyazov, Z. (2025). The role and potential of BIM in digital design. American Journal of Education and Learning, 3(7), 151–169.

Adilov, U., Matniyazov, Z., Tojiboev, J., Daminova, U., & Saidkhonova, Z. (2020). Improvement of the environmental situation of the Aral region through landscape design. International Journal of Scientific and Technology Research, 9(4), 3450–3455