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Author: ANDIA VLLAMASI, ERJON ÇOBANI, SONILA MURATAJ
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Rethinking urban morphologies through AI simulation

ANDIA VLLAMASI,
POLIS University
ERJON ÇOBANI,
POLIS University
SONILA MURATAJ1
POLIS University

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Abstract
Urban planning is entering a new phase as environmental instability, population dynamics and geographical complexity are confronting traditional governance frameworks. Cities are adopting technologies to transform spatial performance and morphological patterns into actionable knowledge for decision-makers. This research examines the integration of urban morphology analysis with real-time assessments of accessibility, density and proximity, highlighting how AI-supported spatial simulation via the Spacio.ai platform may promote adaptive government. This work illustrates that morphological simulation can elucidate hidden spatial characteristics, expose governance deficiencies and foster more transparent and proactive decision-making, utilizing Tirana and Barcelona as significant case studies.
The research utilizes a mixed-method approach that combines block-scale measurements, policy analysis, AI simulation operations, and morphological typology. Barcelona has a structured planning framework with set rules for mobility and regulated block layouts. In comparison, Tirana is a fast-growing post-socialist city with erratic expansion. This comparison shows how different governance cultures may be studied using the same analytical framework, which makes it possible to make planning suggestions that are specific to each situation.
The results show that urban planners can use AI-supported spatial simulation to look at morphological parameters including permeability, built-from density, and centrality in new ways. They should be viewed as governance-related variables that influence public communication, scenario development, and strategic priority, rather than as immutable descriptions. The results indicate that morphological simulation functions as a supplementary decision support instrument that improves transparency and integrates discipline expertise, rather than replacing planning experience.
The study posits that adaptive governance arises when simulation results are incorporated into iterative, deliberative planning procedures, allowing stakeholders to discuss prospective possibilities grounded in spatial performance rather than abstract policy terminology. The research adds to the ongoing conversations about how to make urban growth fit with governance techniques that are open to everyone, flexible, and based on facts.

Keywords: *morphological typologies, inclusive governance, AI-driven spatial simulation, decision-making urban metrics, land use efficiency*

INTRODUCTION

Urban form is more than the imprint of buildings on land; it represents the spatial grammar through which people, resources, ideas and services circulate. It influences both the physical fabric of cities and their ability to facilitate accessibility, mobility, social cohesion, and sustainability.

Urban governance faces contemporary challenges such as climate change, demographic shifts, and rapid economic transformation, highlighting the necessity of reinterpreting morphology as an active component in urban resilience rather than a static entity.

Masterplans, land-use legislation, and sectoral strategies represent traditional planning tools established in an era characterized by relatively predictable urban dynamics. Their inflexibility often hinders the adaptable, iterative, and collaborative approaches required by contemporary urban environments. Scholars such as Healey (2006) and Albrechts (2010) have long argued for a transition in governance towards frameworks that prioritize flexibility, cooperation, and evidence-based practices. Nonetheless, the specific evidence needed and its effective integration into decision-making remain ambiguous.

Morphology has been thoroughly examined as a descriptive field (Hillier, 2007; Marshall, 2012). Recent research has progressed from mere description to operationalization, establishing connections between morphological metrics and factors such as walkability, social interaction, thermal comfort, and accessibility (Porta et al., 2014; Mehaffy et.al., 2010). A persistent barrier exists: municipal decision-makers frequently lack possible tools to translate morphological insights into actionable policies.

The comparative analysis of various morphological typologies in European contexts elucidates how cities with differing histories, governance structures, and design traditions react to these pressures. In order to perform this analysis and to reinterpret the study of morphology, a new category of design tools is incorporated into the research methodology. Simulation technologies enhanced by AI have enabled a redefinition of morphology as an integral component of governance. AI-based models allow planners to examine the impact of variations in density, permeability and proximity on flows and interactions, rather than representing the city as a static physical configuration. This corresponds with broader proposals for "anticipatory governance" (Boyd et al., 2015), wherein decision-makers engage with multiple features via iterative feedback loops rather than relying on static forecasts.

Specifically, the research tests Spacio.ai, an AI-driven generative design and simulation platform, as an instrument for examining proximity and permeability, flows and governance, as well as inclusion and exclusion. The empirical testbeds include Tirana, Albania, characterized by rapid transition, and Barcelona, Spain, known for its long-standing compact and permeable urban form. The study emphasizes the tool as a method to evaluate morphological differences between two contrasting cities and assess the potential of an AI-supported visualization tool in improving governance and participation.

Tirana and Barcelona serve as case studies due to their representation of two different governance contexts. Barcelona's extensive history of public space design and the superblock (superilla) concept create a complex planning environment in which governance and morphology are closely interconnected (Rueda, 2019). Tirana exemplifies a dynamic post-socialist context characterized by uneven street networks, fragmented parcel patterns, and uncontrolled urbanization, which pose both opportunities and challenges for innovative governance (Lulo, 2017). The aim is to engage with three discussions by situating morphological simulation within the context of governance rhetoric:

(1) The role of AI simulation in enhancing transparency and deliberation;

(2) The operationalization of morphology as governance knowledge; and,

(3) The use of contrasting cities to illustrate context-dependent applications of new planning tools.

In this context, Spacio.ai presents itself as a viable methodological platform. Initially developed as design-support platform, it enables users to input building footprints, networks, and parcels in order to produce simulations of shadow patterns, accessibility metrics, pedestrian flow potentials, and proximity indicators. The tool's visual outputs are impressive; however, its significant contribution is in democratizing spatial simulation, thereby making analytical processes that previously necessitated advanced GIS expertise accessible to planners, architects, and policymakers.

METHODOLOGY

The methodological framework guiding this research incorporates qualitative, quantitative, and computational elements. The study situates AI simulation within a comprehensive governance-oriented analytical framework, rather than considering it an isolated technical task. The methodology is structured into four interconnected layers:

[1] selection and preparation of case study areas;

[2] morphological data structuring;

[3] AI-supported simulation using Spacio.ai; and

[4] interpretive governance analysis.

This strategy, which operates on multiple levels, guarantees that computational results are interpreted in a meaningful manner within policy frameworks.

Tirana vs Barcelona

Tirana and Barcelona were selected due to their differing morphological and governance characteristics. Tirana, a rapidly urbanizing post-socialist capital, presents a complex array of formal and informal developments, evolving regulatory frameworks, and dynamic street networks. The city's swift transformation in the past three decades has exceeded institutional capacities, leading to governance structures that tend to be reactive rather than anticipatory. This context provides an opportunity to evaluate the effectiveness of AI-supported morphological simulation in stabilizing knowledge flows and

enhancing decision-making consistency. Barcelona offers a contrasting perspective. The foundational Cerdà grid, along with the contemporary superblock policy framework, has fostered a planning culture that integrates morphological reasoning into governance. The city's enduring dedication to the expansion of public spaces illustrates how AI simulation can enhance established planning frameworks.

Data collection and spatial processing

Data inputs were sourced from publicly accessible spatial repositories and municipal datasets. Building footprints, street networks, and block geometries for Barcelona were obtained from the Ajunament de Barcelona's open data portal. Data for Tirana were collected from OpenStreetMap, the Municipality of Tirana webpage, and through field verification. All datasets were standardized to a uniform projection and processed to eliminate irregular geometries. The preprocessing steps comprised:

-Reducing computational load by simplifying building footprints,

-Ensuring topological continuity through the rationalization of street centerlines,

-Segmenting blocks according to parcel boundaries or visible morphological units,

-Exporting the refined geometries in GeoJSON format for ingestion by Spacio.ai.

The methodological approach has combined two complementary components: a comparative morphological analysis of Tirana and Barcelona, alongside simulation and visualization utilizing Spacio.ai.

First, the research compiled open-source spatial datasets, urban plans, and recent studies to determine the predominant morphological types in each city. As a result, are evidenced four distinct types of residential blocks:

(a) Informal or fragmented neighborhoods,

(b) Socialist-era apartment blocks,

(c) Recent high-rise developments,

(d) Mixed courtyard or perimeter blocks.

The samples from Tirana are presented in Figure 2, while those from Barcelona, which focus on the Cerdà grid, superblock

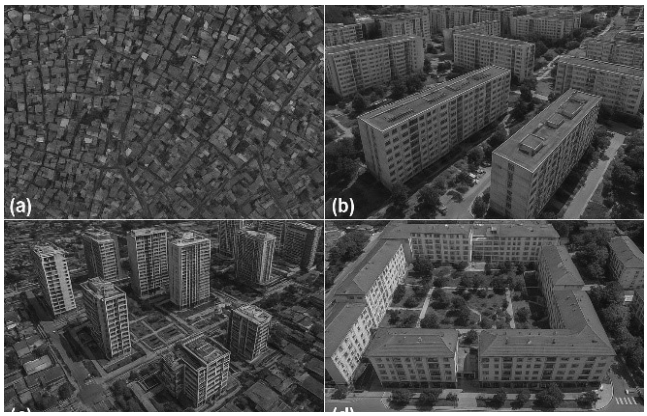


Figure 1. . The four predominant urban morphological types evidenced in both cities. (Image © Authors)

program, and specific waterfront redevelopments, are depicted in Figure 3, including both plan and orthographic views. These images function as methodological artifacts. They serve as both evidence and tools for discourse. Visual production in Spacio.ai was both ancillary and integral.

The next step that the methodology followed, after evidencing, is that all four morphological types were modeled and manipulated within Spacio.ai, through its innovative tools.

The exercise focused on generating new morphological blocks using AI tools, analogous to the documented cases of Tirana and Barcelona, while facilitating dynamic decision-making. The platform was utilized in two complementary modes. In generative mode, parameter sweeps yielded various massing configurations, including differing footprints, courtyard sizes and pedestrian flows. During the analysis phase, the platform produced key performance indicators (KPIs) including floor area ration (FAR), site use, open space ratio, and basic daylight metrics. High-resolution images and CSV reports were generated for qualitative analysis and comparison.

Simulation Workflow in Spacio.ai

Spacio.ai was selected for its blend of parametric massing and KPI export functions. Four different urban block layouts were generated under comparable regulatory and programmatic constrains, with block size 100x100m (1ha). Spacio.ai, as a web-based generative design platform, integrates parametric modeling with AI-assisted optimization. It is considered as a black-box generative design engine.The site boundary was firstly delineated, the automatically generated urban environment and terrain were imported, and zoning regulations (including maximum heights, setbacks, maximum coverage, and target floor-area ratio) were established for each case-study block. The software generated several building massing options by iteratively adjusting footprints, locations and heights to comply with restrictions while optimizing density and environmental performance indicators.

The initial stage involves defining inputs and parametrization. The user imports or delineates the site boundary in Spacio (parcel or urban block), prompting the automatic loading of integrated datasets that encompass the surrounding context, including adjacent buildings, terrain, and the street network, altogether with sidewalks and green areas. After establishing the spatial foundation, the user specifies a set of regulatory and design constraints, including maximum building heights per zone, required setbacks for building facades from property lines, permissible site coverage, Floor Area Ratio (FAR) targets, programmatic mix (residential, commercial, and services), and additional requirements such as parking and bicycles. The subsequent phase involved the definition of morphological parameters. The block "type" may be categorized as either irregular, characterized by non-orthogonal edges and street network, varying footprints, and fractures parcel structures, or regular, defined by orthogonal grids, aligned façades, and uniform footprints. The requirements are refined through a set of control factors, which include footprint size, building height distribution (minimum, maximum, and variance), coverage ratio,

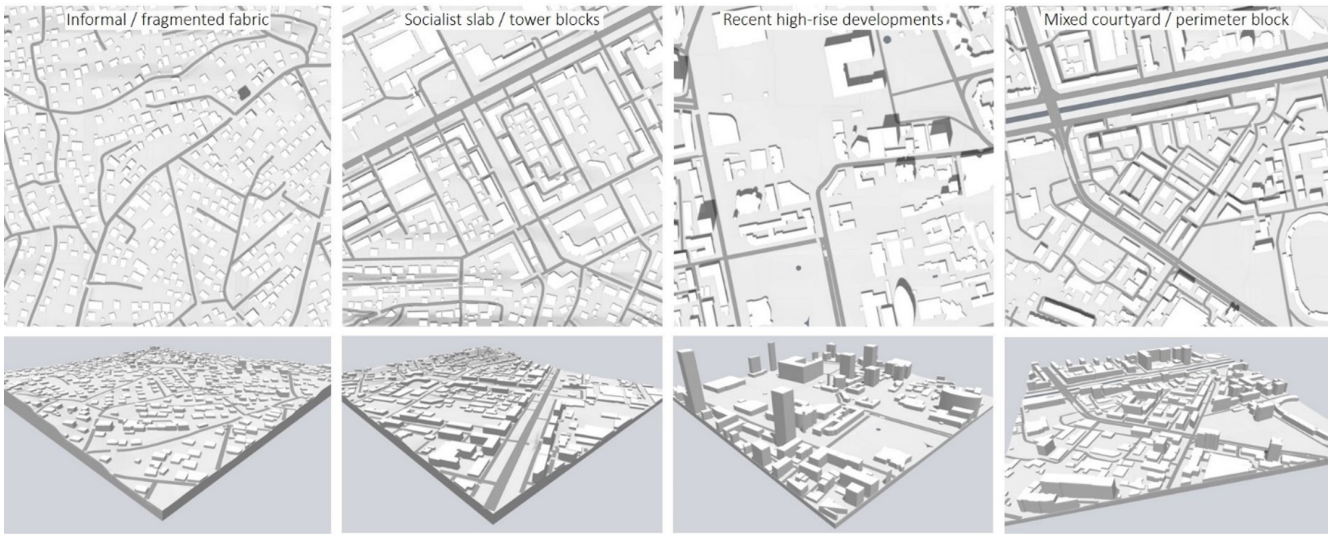


Figure 2. Urban morphological types in Tirana. (Image © Authors)

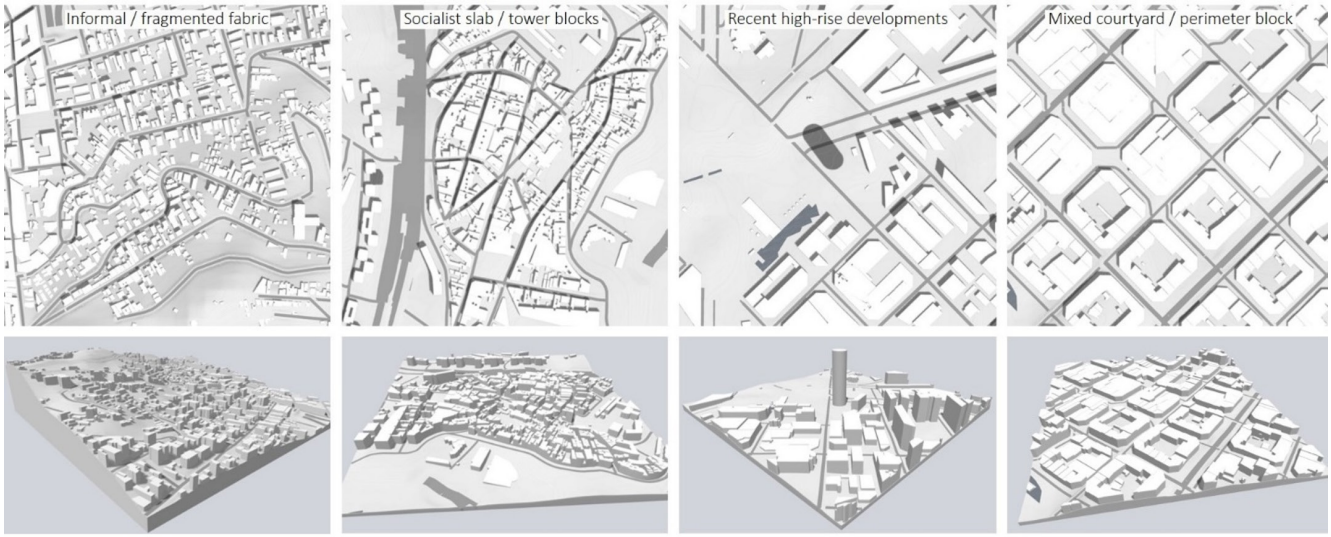


Figure 3. Urban morphological types in Barcelona. (Image © Authors)

open-space ratio, and building spacing or street width.

The simulation workflow comprised three stages:

1.Baseline reconstruction involved the reconstruction of existing morphology for selected neighborhoods in each city. This established a preliminary comparative baseline, encompassing current FAR, building height distribution, open-space ratio, and pedestrian network typology. Barcelona features the most the Cerda grid and at least one superblock, while Tirana encompasses informal hill neighborhoods, socialist slab zones, and recent high-rise developments.

2.Parametric experimentation involved conducting parameter sweeps for each baseline area, varying block porosity by introducing or removing pedestrian links, adjusting courtyard size within courtyard block typologies, and modifying building height envelopes to assess incremental densification. The sweeps were limited by plausibility rules that aligned with local massing geometry and exported all performance indicators. The main KPIs exported are: site area (m2), building footprint (m2), GFA – Gross Floor Area (m2), site use (%), FAR – Floor Area Ratio (%) and roof surface (m2).

3.Scenario packaging: Each neighborhood was assigned three scenarios to enhance policy relevance. (a) Baseline – current morphology; (b) Optimized – interventions that enhance permeability and micro-accessibility (e.g. new pedestrian connectors, active ground floors); (c) Extreme – densification or privatization scenarios that examine system extremes (e.g., increased FAR through vertical development or gated developments that decrease permeability).

The simulations were deliberately designed with a straightforward visual representation while being conceptually rooted in planning theory to enhance their relevance for policymaking. Each simulation produced outputs that were rendered as high-resolution images and integrated for analysis. Simulations facilitate the visualization of urban growth scenarios, thereby assisting policymakers in making informed decisions regarding zoning and land use. They assist in evaluating the effects of proposed infrastructure projects on traffic patterns and environmental sustainability. These simulations offer a clear visual representation, enabling stakeholders to understand and assess the potential outcomes of different policy options effectively.

Interpretive Governance Framework

The study connects simulation outputs to governance decision-making through a hybrid interpretive framework that incorporates theories of adaptive governance (Boyd et al., 2015), collaborative planning (Healey, 2006), and spatial decision-support systems (Geertman & Stillwell, 2009). The primary analytic question directing the interpretation was:

How do morphological simulations reveal governance-relevant spatial conditions that are not readily apparent through traditional planning instruments?

The framework emphasizes three interpretive dimensions:

a.Governance Blind Spots

"Governance" refers to the processes, structures, and mechanisms through which organizations or societies are directed and controlled. It encompasses the decision-making frameworks and the relationships among various stakeholders involved in the management of resources and policies. "Blind Spots" refer to spatial performance conditions that are inadequately defined in existing policy or remain unnoticed by current institutional practices.

b.Governance Leverage Points

Governance leverage points include localized morphological interventions such as connector insertion, courtyard activation, and FAR regulation modulation, which produce significant policy impacts at a low cost.

c.Deliberative Narratives

Deliberative narratives consist of storylines and visual frames generated from simulations, which can enhance stakeholder engagement and political negotiation.

Ethical considerations and replication

The research complies with the principles of transparency and reproducibility. All parameter settings, scenario rules, export logs, and KPIs tables have been archived. In instances where municipal data was not accessible, contributions from OpenStreetMap were utilized, with appropriate acknowledgement. The work emphasizes equity by examining distribution outcomes, specifically how changes impact various neighborhoods and socio-economic groups, in order to circumvent techno-solutionism.

RESULTS

This section integrates the simulation results and governance analyses from the two cities. The outcomes are structured along three axes: permeability and network dynamics, proximity and accessibility, and density and built-form trade-offs. The findings indicate that AI-assisted morphological simulation produces insights that vary markedly between Tirana and Barcelona, attributable to their differing governance contexts. The identical analytical workflow was utilized in both cities; however, interpretations differ due to variations in local planning cultures and spatial challenges.

Permeability and network dynamics

Tirana: Baseline simulations for selected neighborhoods in Tirana indicated the presence of fragmented pedestrian networks. The permeability index, calculated as pedestrian link length divided by block perimeter, exhibited significant variation. Informal neighborhoods demonstrated irregular yet locally dense linkages, characterized by individuals creating pathways through blocks. In contrast, gated recent developments displayed low permeability indices ranging from 0.12 – 0.18, indicative of enclosure. The parameter sweeps indicated that the addition of a limited number of connectors (5-8 per square kilometer) significantly decreased local travel times to essential services by as much as 18% in certain neighborhoods, representing an effective leverage point for municipal intervention.

Barcelona: Baseline runs validated the high permeability of the Cerdà grid; the permeability index ranged from 0.45 - 0.62, with flow potentials distributed more uniformly. Within superblock perimeters, the optimization scenario that expanded pedestrianized interior space resulted in concentrated high-comfort pedestrian cores, while slightly diminishing through-block connectivity for longer trips. Isochrones indicated a nuanced redistribution or flow rather than a general loss of accessibility.

Proximity and accessibility

Tirana: Accessibility surfaces demonstrated significant intra-city variation. Central neighborhoods, despite their density, experienced service clustering, with schools and clinics located nearby but overwhelmed. In contrast, many peripheral areas lacked accessibility. Optimized scenarios that strategically enhanced micro-services, such as mobile clinics and satellite markets, within 5-10-minute isochrones significantly improved accessibility for marginalized areas without substantial capital investment. The extreme densification scenario, characterized by the addition of vertical units without enhancing ground-level permeability, has exacerbated micro-accessibility by introducing physical barriers and congested street segments.

Barcelona: Its robust transportation network results in elevated levels of accessibility. Simulations revealed emerging edge zones in Sant Martí and peripheral nodes where rapid redevelopment posed a risk of surpassing the availability of nearby services. Scenario testing indicated that densification, when coupled with targeted micro-infrastructure investments such as pedestrian links and local green nodes, maintained accessibility levels. Adjustments to the superblock in optimized scenarios resulted in enhanced local amenity accessibility, while preserving connectivity at the city scale.

Density and built-form patterns

Tirana: Density modeling resulted in diverse FAR landscapes. Recent developments have led to increased verticality in isolated locations, resulting in shadows and microclimatic effects when towers are positioned without regard for street enclosure. Optimization scenarios that exchanged a minor percentage of FAR for increased courtyard areas resulted in enhanced daylight penetration and improved active ground floor potential, indicating a strategy for densification while maintaining livability.

Barcelona: The FAR gradients exhibited greater smoothness. Simulations indicated areas where incremental increases in

height could lead to overshadowing and diminished street-level amenity. Implementing incremental height caps instead of binary high-rise allowances resulted in enhanced urban microclimates and maintained pedestrian comfort.

Governance leveraging and narratives

Simulations in both cities revealed specific leverage points. For Tirana: (a) enhancing pedestrian connectivity; (b) implementing micro-services in areas lacking accessibility; (c) coordinating Floor Area Ratio modifications with improvements in permeability. For Barcelona: (a) calibrating superblock perimeters to mitigate peripheral access losses; (b) modifying height and density regulations in redevelopment areas; (c) conveying the trade-offs of densification through clear isochrone visualizations.

The same outputs produced varying governance narratives. In Tirana, simulations served as discovery instruments, uncovering previously unrecorded spatial deficiencies and facilitating the development of straightforward, implementable interventions. In Barcelona, simulations served as tools for refinement, quantifying trade-offs and facilitating precise policy calibration.

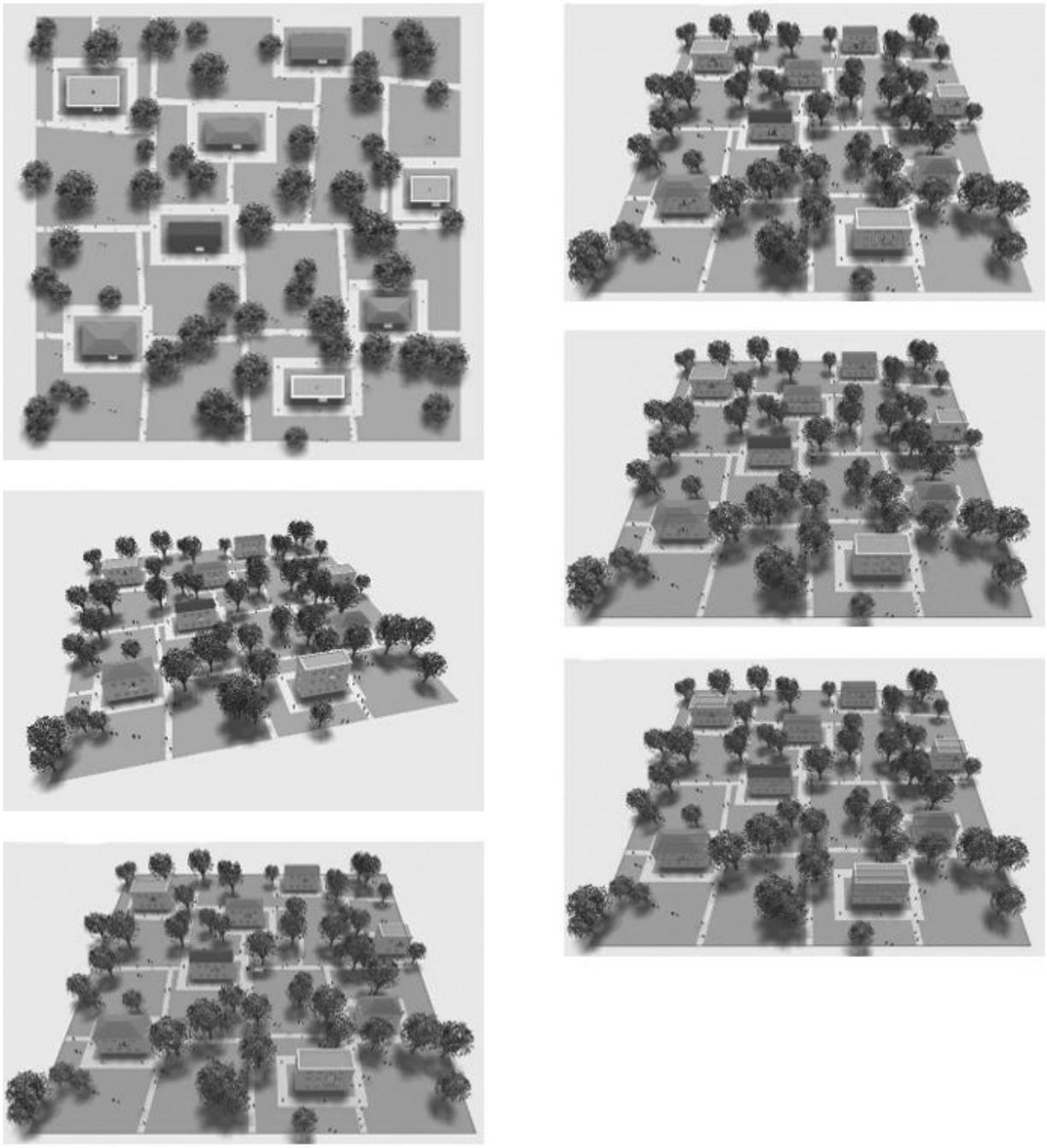


Figure 4. Informal fragmented neighborhood morphological type (plan view, ortho view, site area, building footprint, site use, FAR, roofs)

DISCUSSION

The findings of the study indicate that AI-supported morphological simulation can significantly enhance governance processes when incorporated into decision-making. Three main themes arise from the discussion: evidence translation, tool-context fit, and procedural integration.

Evidence translation: from morphology to policy

The simulation pipeline significantly contributes by translating morphological patterns into evidence that is relevant for policy-making. Morphology, when assessed via permeability indices, isochrone surfaces, and FAR dynamics, presents a clear set of indicators for planners and policy-makers related to service provision, mobility, and environmental performance. This translation narrows the divide between spatial scholarship and practical urban policy. Translation necessitates precise framing: policy actors must understand how morphological adjustments correspond to actual political and budgetary mechanisms. A municipal agency may employ connector insertion simulations to substantiate the reallocation of minor capital budgets towards the construction of pedestrian links, a position that is more convincingly presented with visualized reductions in travel time.

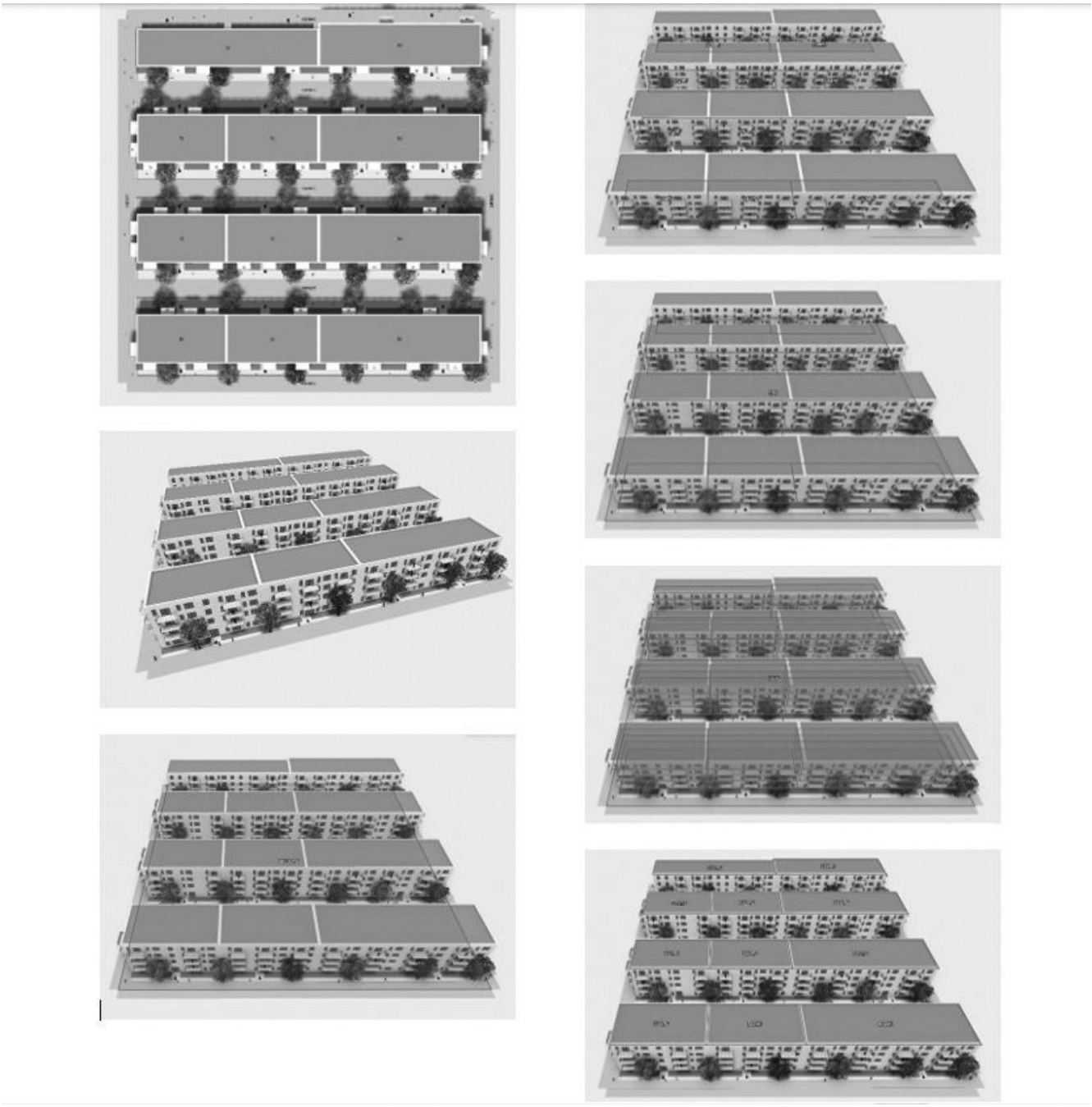


Figure 5. Socialist-era apartment blocks morphological type (plan view, ortho view, site area, building footprint, site use, FAR, roofs) (Images © Authors & Spacio.ai) (Images © Authors & Spacio.ai)

Tool-context fit: simulations do not deliver value uniformly

Simulations are not neutral; institutional preparedness determines how useful they are. Barcelona's planning culture incorporates mechanisms such as technical committees, urban laboratories, and public consultation traditions that effectively integrate simulation outputs into policy iterations. Tirana's institutional structure exhibits significant fragmentation. In these scenarios, simulation may serve as an evidence broker; however, its effectiveness is contingent upon simultaneous governance reforms, such as delineating municipal authority for sidewalk improvements and establishing micro-service grants. Simulations expand the range of potential actions, while institutional capacity dictates the transformation of these possibilities into policies.

Procedural integration and participatory governance

The most significant realization is probably that when simulation is integrated into an iterative and participatory process, it becomes relevant to governance. Isolated simulations pose a risk of technocratic imposition. In contrast, when simulation outputs are presented in deliberative workshops involving residents, local associations, developers, and officials, the models serve as boundary objects that promote negotiation. The design of these procedures is significant: workshops must be organized to examine values (what constitutes access?), trade-offs (density versus amenity), and distributional outcomes (who

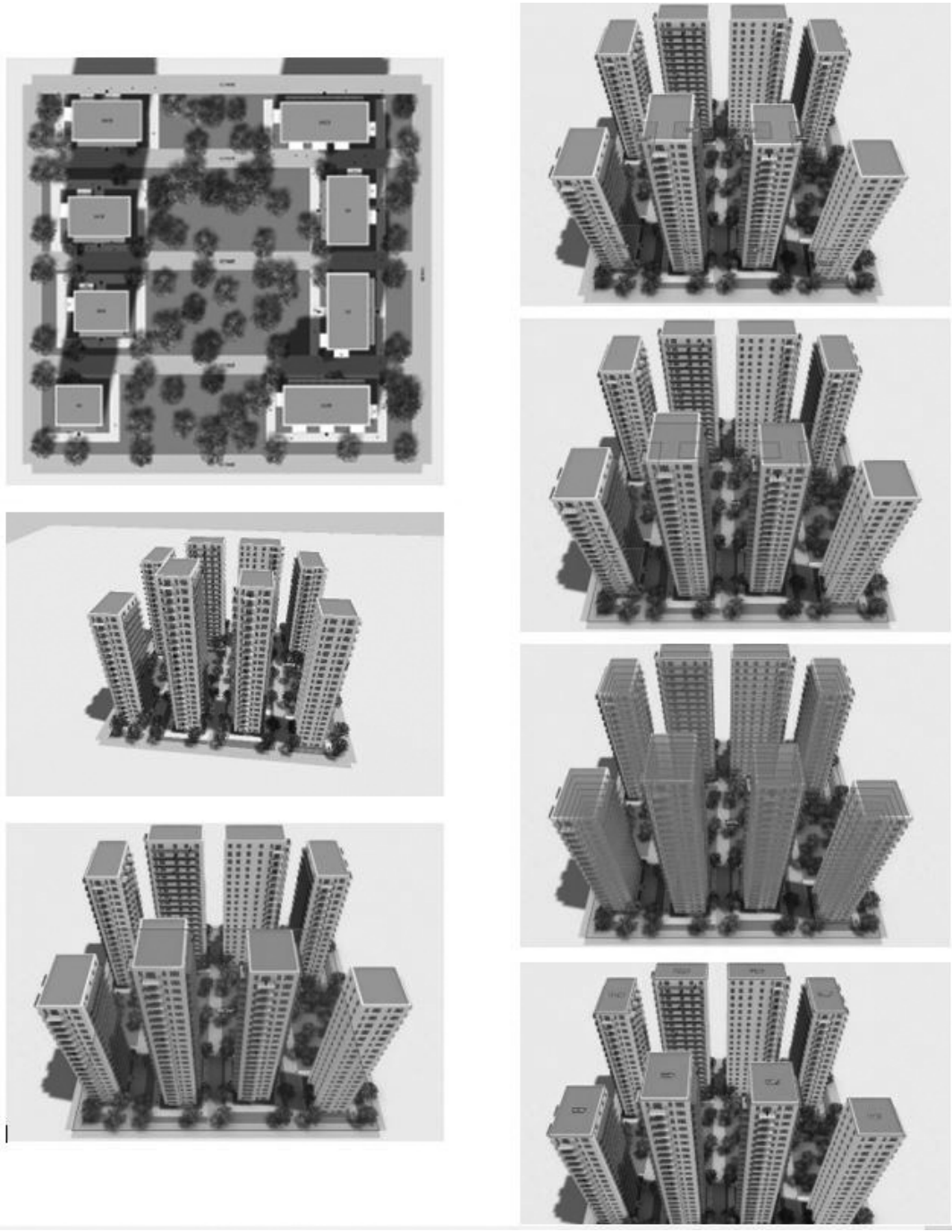


Figure 6. High-rise developments morphological type (plan view, ortho view, site area, building footprint, site use, FAR, roofs) (Images © Authors & Spacio.ai)

benefits?). Furthermore, clarity regarding model assumptions, data constraints, and scenario trade-offs is crucial for establishing trust.

Implications for equity and ethical use

Simulations should be implemented with consideration for ethical implications. Modeling assumptions regarding pedestrian speeds, service catchments, and developer behavior possess normative significance. The paper advocates for clear scenario transparency, sensitivity testing to identify robust outputs, and the incorporation of equity metrics, such as changes in relative accessibility for low-income neighborhoods. This approach mitigates the risk of simulation-induced polices that unintentionally perpetuate spatial inequality.

Limitations and future research

The study encounters limitations related to the accuracy of municipal data, the inherent abstraction in KPI simplifications, and the emphasis on block-scale analysis rather than comprehensive metropolitan dynamics. Future research should incorporate dynamic mobility data, such as mobile phone traces, examine long-term feedbacks in land markets, and empirically assess the impact of simulation-driven interventions on governance changes. Longitudinal studies that investigate the impact of simulation outputs on policy decisions across multiple municipal cycles are essential.

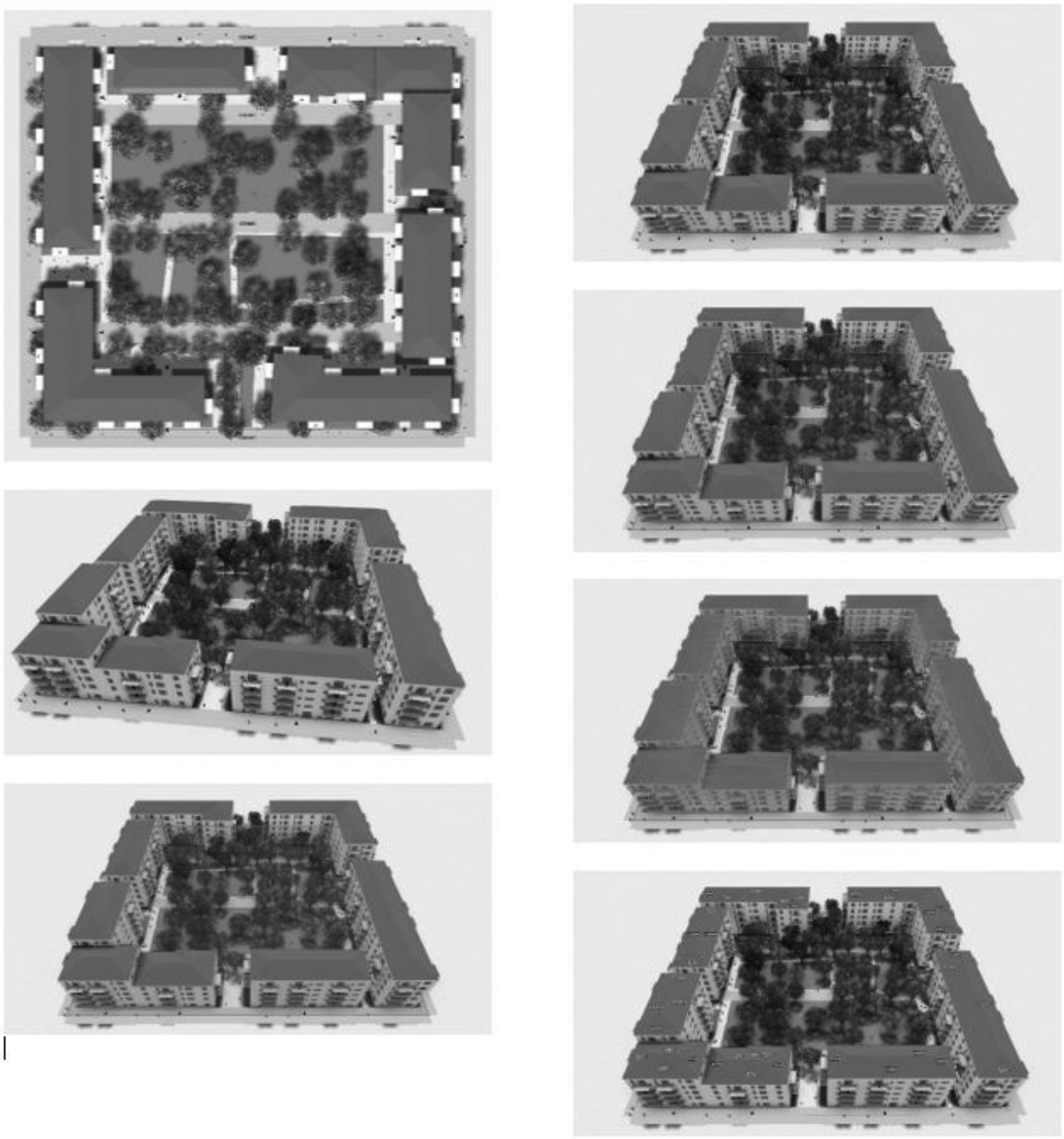


Figure 7. Mixed courtyard or perimeter blocks morphological type (plan view, ortho view, site area, building footprint, site use, FAR, roofs) (Images © Authors & Spacio.ai)

Contextual Dependence of Computational Tools

The case studies illustrate that the effectiveness of Ai simulation varies based on context. Barcelona can utilize simulations to enhance existing governance instruments, whereas Tirana needs simulations to establish fundamental governance capacities. Consequently, the same tool can yield varying outcomes based on the maturity of the governance context.

CONCLUSION

This paper has argued for the repositioning of morphological simulation as a governance tool, facilitating adaptive, deliberative, and evidence-based decision-making. The comparative analysis of Tirana and Barcelona illustrates that computational morphology can reveal governance blind spots, pinpoint significant leverage points, and generate clear narratives that aid in stakeholder negotiations.

The effectiveness of the tool depends on the institutional absorptive capacity and the design of procedures. Simulation enhances agency when utilized by actors dedicated to iterative learning and equitable outcomes. Integrating AI-supported morphology into municipal workflows necessitates (a) accessible tools and training, (b) defined procedural spaces for deliberation, and (c) measures to ensure transparency and equity. When these conditions are satisfied, morphological simulation can assist cities in re-evaluating their structures and managing them in a more adaptive and inclusive manner.

MAIN KPI	Informal fragmented neighborhood	Socialist slab / block	High-rise development zone	Mixed courtyard
Site Area (m²)	10000	10000	10000	10000
Building Footprint (m²)	583	4904	1565	3192
GFA - Gross Floor Area (m²)	1230	19616	30763	15993
Site Use (%)	6%	49%	16%	32%
FAR - Floor Area Ratio (%)	12%	196%	308%	160%
Roof Surface (m²)	583	4904	1565	3192

KPIs - Key Performance Indicators	Informal fragmented neighborhood	Socialist slab / block	High-rise development zone	Mixed courtyard
BUILDING				
GFA - Gross Floor Area (m²)	1230	19616	30763	15993
GIA - Gross Internal Area (m²)	997	17986	27531	14573
NIA - Net Internal Area (m²)	997	15947	23511	12839
Efficiency [NIA/GFA]	81%	81%	76%	80%
Volume (m³)	4272	63750	93854	51170
Footprint (m²)	583	4904	1565	3192
Roof Surface (m²)	583	4904	1565	3192
Buildings (no.)	8	11	8	7
SITE				
Site Area (m²)	10000	10000	10000	10000
Site Use (%)	6%	49%	16%	32%
FAR - Floor Area Ratio (%)	12%	196%	308%	160%
FSI - Floor Space Index	0.12	1.96	3.08	1.60
GSI - Ground Space Index	0.06	0.49	0.16	0.32
Landscape / Green Area (m²)	7060	79	5018	5025
MUA - Minimum outdoor recreation area per GIA (%)	80%	27%	6%	22%
MUA - Minimum outdoor recreation area per Space (m²)	47	14	2	11
UNITS				
Spaces (rooms, units, etc.)	17	356	835	301
Apartments	0	284	517	231
BUILDING ELEMENTS				
Windows (no.)	174	1112	2780	1114
Balcony / terraces (m²)	18	1272	2750	1491
Facade (m²)	2119	13599	27852	11612
Interior Wall (m²)	0	5790	7930	4089
Cores [stairs & elevators] (no.)	0	16	8	13
PARKING				
Car Demand (no.)	17	356	835	301
Bike Demand (no.)	43	890	2088	753

Table 1. Table of outputs: Main Key Performance Indicators and all other KPIs exported from the platform. (Table © Authors & Spacio.ai)

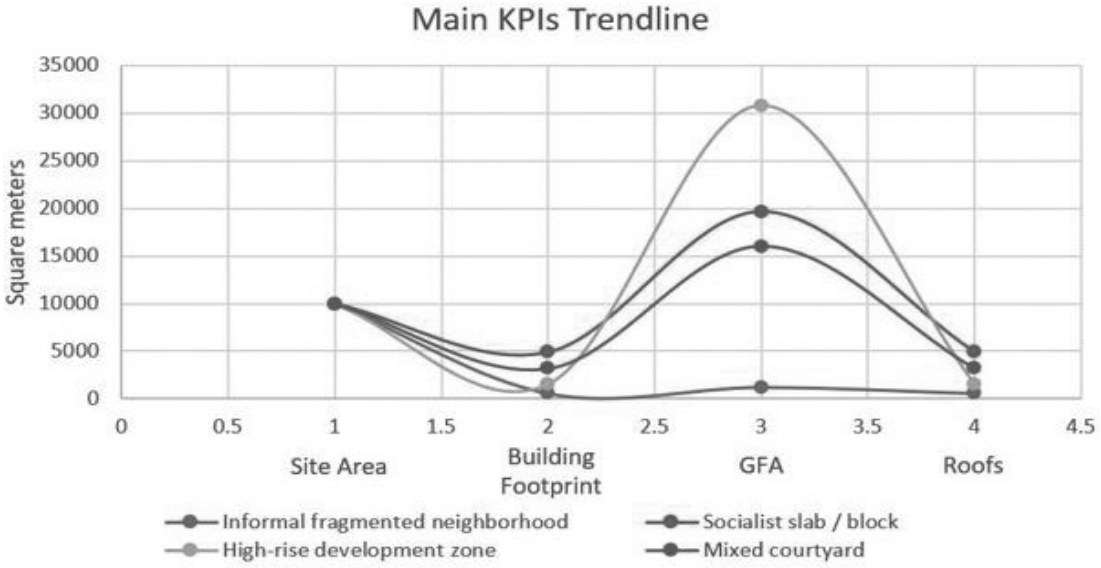
As urban areas encounter ongoing uncertainty, the incorporation of simulation tools into planning processes can enhance their ability to anticipate change, promote transparency, and facilitate decisions based on spatial performance. Adaptive governance arises not solely from the tool itself but from the effective integration of simulation within iterative, participatory decision-making frameworks.

ACKNOWLEDGMENTS

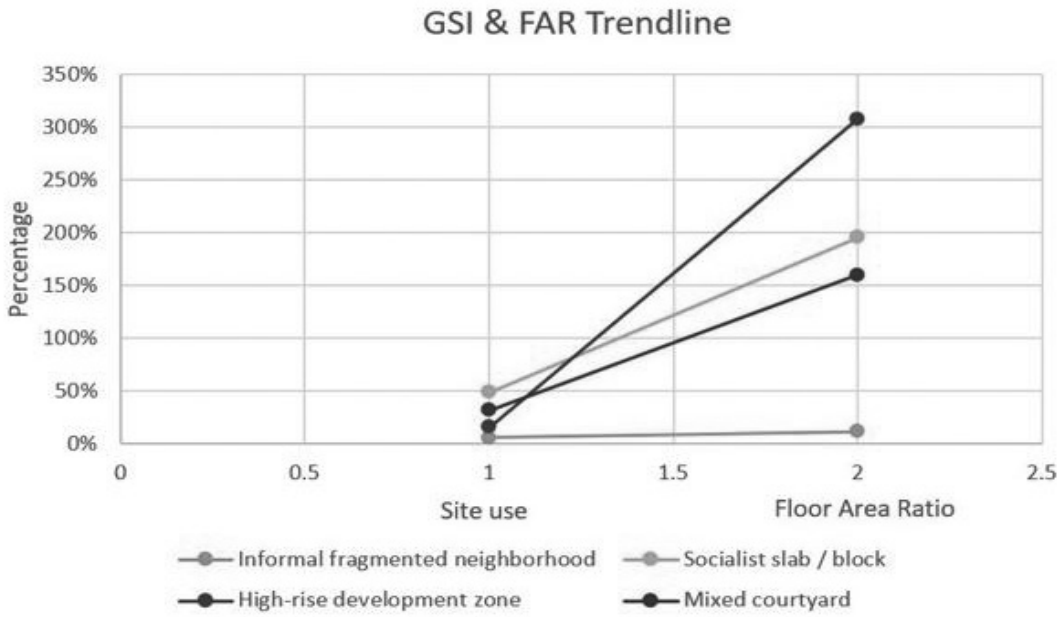
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Graph 1. The main KPIs trendline (Graph © Authors)



Graph 2. The trendline of Ground Space Index and Floor Area Ratio (Graph © Authors)

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