Constrained Possibilities: Housing Typology, Regulation and Non-Deterministic Evolution of Urban Form in Tehran

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ORIGINAL RESEARCH ARTICLE

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Abstract

Background and Objectives: The transformation of Tehran's urban fabric throughout the twentieth century generated a wide spectrum of housing typologies shaped by shifting planning ideologies, regulatory frameworks, and socio-spatial conditions. Existing literature has often interpreted these changes through linear narratives of modernisation or Western influence, neglecting the mediating role of regulation and the significance of intermediate spatial scales. This study aims to examine the evolutionary trajectory of housing typology and urban morphology in Tehran between 1900 and 2000, focusing on the interaction between macro-scale planning mechanisms and micro-scale architectural form. The primary objective is to assess whether housing evolution followed a deterministic path or whether multiple typological outcomes emerged within constrained regulatory and spatial conditions.

Materials and Methods: The research adopts a multi-scalar and interdisciplinary methodology integrating urban history, morphological analysis, and empirical spatial investigation. Three representative residential areas of 500 × 500 m, corresponding to distinct phases of Tehran's urban development, are analysed

Keywords:
Urban Morphology, Housing Typology, Regulatory Frameworks, Archetypal Modelling, Plot–Block Relations, Tehran.

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Research Questions:

1. How did the interaction between macro-scale planning mechanisms and micro-scale architectural form shape the evolution of housing typologies in Tehran between 1900 and 2000?

2. To what extent did regulatory frameworks, including plot structure, block morphology, and site-development standards, constrain or enable multiple typological outcomes within the city's residential fabric?

3. Does the transformation of Tehran's housing—from courtyard houses to row houses and apartment buildings—follow a deterministic trajectory, or does it reflect a non-deterministic and probabilistic relationship between regulation and architectural form?

4. How do variations in architectural variables such as access systems, frontage conditions, day-lit depth, and spatial configuration correspond to shifts in planning regulations across different historical periods?

5. What role does the intermediate spatial scale (plots, blocks, and housing types) play in mediating between city-wide planning policies and the emergence of localised morphological patterns?

6. In what ways can the analytical framework developed in this study contribute to contemporary debates on housing policy, regulatory reform, and urban design practices in rapidly transforming contexts?

using Geographical Information Systems (GIS). This is combined with archetypal modelling based on Steadman's geometric principles to examine relationships between block structure, plot subdivision, density, site coverage, and housing layout. Architectural variables—including access systems, frontage conditions, day-lit depth, and spatial configuration—are systematically evaluated in relation to planning regulations, enabling comparative analysis across historical periods.

Results and Conclusion: The results indicate that housing typologies in Tehran were strongly influenced by plot structure, block morphology, and regulatory constraints; however, these influences operated in a non-deterministic manner. Multiple spatial configurations emerged within similar regulatory frameworks, demonstrating a probabilistic relationship between planning rules and architectural form. The transition from inward-oriented courtyard houses to outward-facing row houses and later apartment buildings is therefore interpreted as an adaptive process shaped by functional requirements and regulatory negotiation rather than a direct transplantation of Western models. By foregrounding the intermediate scale of plots, blocks, and housing types, this study challenges reductive interpretations of Tehran's urban transformation and highlights the coexistence of traditional spatial logics and modern planning systems. The research contributes a robust analytical framework for linking regulation to architectural form and offers insights relevant to contemporary housing policy and urban design.

1. Introduction, Research Context and Aims

This study examines the evolutionary development of housing in Tehran with two central questions: whether the observed trajectory of housing change followed a necessary or constrained path, and whether alternative built forms could have emerged within the city's prevailing block dimensions and regulatory conditions.

Housing transformation is analysed across urban and architectural scales, focusing on the relationship between changes in urban layout and housing typology. At the urban

scale, Tehran's residential fabric evolved from irregular, fine-grained blocks to larger, more regular grids. At the architectural scale, housing types shifted from inward-looking courtyard houses to terraced houses with south-facing courts, and ultimately to multi-storey apartment buildings. The core analytical concern is the relationship between these two processes: whether changes in urban layout and housing typology constitute a co-evolutionary process or represent parallel developments brought together by circumstance.

Building on the archetypal approach developed by Steadman[1] and extended in subsequent work by Shayesteh & Steadman[2], the study develops an integrated model that links parameters of urban structure - such as block and plot size, density, and ground coverage - with parameters of built form, including access, frontage, day-lit depth, and building configuration (courtyard, C-shaped, L-shaped, and linear forms).

2. Historical Formation of Tehran's Urban Structure

Tehran's morphological transformation occurred across several major historical phases: the Safavid Dynasty (1501–1736), the Qajar Dynasty (1786–1925), the Pahlavi era (1925–1979), and contemporary developments. Although the paper focuses primarily on changes in the 20th century, earlier stages illustrate the origins of the city's spatial structure.

During the Safavid period, the decline of the ancient city of Ray and Tehran's favourable climate contributed to its emerging prominence. Shah Tahmasb's construction of a defensive wall in 1515 - featuring four principal gates - marked the city's formal recognition as an urban settlement, despite limited political or military significance at the time. This enclosure symbolised Tehran's shift from a peripheral village into a place worthy of state attention. Tehran's transformation accelerated under the Qajar Dynasty, when Aqa Mohammad Khan designated it the capital in the late 18th century. Early cartographic records such as Berzin's 1851 map depict the city still contained within its Safavid-era walls and organised around key traditional elements: the Arg (citadel), the Bazaar, major mosques, and four residential quarters (Mahalleh). Social hierarchies were reflected in this spatial structure, where the court, merchants, artisans, and clergy occupied distinct yet interconnected roles within the urban fabric. Throughout this period, domestic architecture largely followed the courtyard-house typology typical of Iranian cities.

More detailed mapping in the late 19th century shows the onset of Tehran's first major phase of physical expansion. Under Naser al-Din (or Naseraddin) Shah Qajar, the old walls were demolished and replaced by new fortifications, forming an irregular octagonal plan reminiscent of Renaissance ideal cities and influenced by French urban design. This period marked the beginning of Tehran's dual morphology: the coexistence of an older, organically developed core and newer, planned extensions. The city expanded in all directions but especially northward, driven by two key forces identified in contemporary accounts - greater European presence and the royal preference for the cooler northern districts. Roads leading to northern gardens became spines of urban growth, and European-style detached houses and villas ap-

1.Philip Steadman, 'Binary Encoding of a Class of Rectangular Built Forms' (A. Alfred Taubman College of Architecture and Urban Planning, University of Michigan, 2001).

2.Homeira Shayesteh and Philip Steadman, 'The Impact of Regulations and Legislation on Residential Built Forms in Tehran', *Journal of Space Syntax* 4, no. 1 (2013): 92–107; Homeira Shayesteh and Philip Steadman, 'Coevolution of Urban Form and Built Form: A New Typo-Morphological Model for Tehran', *Environment and Planning B: Planning and Design* 42, no. 6 (2015): 1124–47, https://doi.org/10.1068/b140002p.

peared along the new, straighter streets. As a result, Tehran's area grew from roughly 4 km² to 19 km² and its population quadrupled, reaching about 200,000 by the end of the 19th century.

Scholars such as Alemi[3] interpret these developments as early indicators of Tehran's modernization, revealing both physical and institutional transformations. New house types, new public institutions, and shifting social patterns accompanied changes in the built form. Yet, despite these European influences, travellers observed that Tehran remained culturally rooted in local traditions - an urban environment 'born in the East' but increasingly shaped by Western models. Traditional courtyard houses persisted as the dominant residential type until well into the 20th century, with only elite houses documented in detail and later preserved by cultural heritage authorities.

Overall, Tehran's historical development reflects a complex interplay of geography, political power, cultural exchange, and modernisation. Its urban morphology emerged not through abrupt shifts but through layered transformations that differentiated the traditional core from its expanding, increasingly western-influenced surroundings.

3. Housing Typology and Urban Morphology in Tehran (1920–2000)

Between 1920 and 2000, Tehran underwent a rapid and profound transformation in both housing typology and urban morphology, driven by modernisation policies, demographic growth, regulatory change, and economic forces rather than by shifts in architectural style alone. Across three main phases, the evolution of housing provides a clear lens through which broader urban dynamics can be understood.

3.1 State-Led Modernisation and the Row House (1920–1942)

During the Pahlavi I Period, demolition of city walls and introduction of a grid enabled regular plot subdivision and the emergence of row houses. These outward-facing dwellings retained residual courtyard space and represented a transitional house type. This period also marked the beginning of Tehran's north-south socio-spatial division.

3.2 Speculative Growth and Regulation (1942–1979)

Rapid, under-regulated expansion characterised this period. Rural migration, land reform, oil revenues, and speculative development produced fragmented suburban growth. Planning regulations - especially plot coverage limits tied to solar orientation - formalised spatial logic but often produced unintended morphological consequences.

3.3 Post-Revolution Densification (1979–2000)

After 1979, housing shortages were addressed through vertical densification. Floor Space Index regulations incentivised apartment construction, leading to widespread demolition of earlier housing types. While increasing supply, this strategy intensified infrastructural strain and resulted in fragmented streetscapes. From courtyard houses to row houses and finally to multi-family apartments, each typological shift embodied broader social, political, and economic processes.

3. Mahvash Alemi, 'The 1891 Map of Tehran: Two Cities, Two Cores, Two Cultures', *AARP Environmental Design* 1 (1985) :74–84.

4. Interpretations of Tehran's Morphological Transformation

This section reviews key intellectual traditions addressing morphological change in Iranian cities, with particular reference to Tehran. It highlights the interdisciplinary nature of urban morphology and argues that no single explanatory framework can fully account for urban transformation, given the interaction of political, social, economic, and environmental forces. Within Iranian scholarship, two dominant perspectives are identified. The first explains urban change primarily through modernisation, attributing new spatial and formal patterns to the introduction of European-inspired technologies, institutions, planning practices, and cultural aspirations. The second challenges this view by arguing that apparent modern grids often extended pre-existing orthogonal structures rooted in agricultural land division and irrigation systems rather than Western influence. The section sets up a critical comparison of these perspectives, focusing especially on the contrasting interpretations of Alemi[4] and Bonine[5], while situating their arguments within a broader body of scholarship on Iranian urban morphology.

4.1 Modernisation and European Influence as Social Drivers of Morphological Change

Alemi[6] interprets Tehran's morphological transformation as part of Iran's broader social and cultural reorientation toward Europe, identifying four interrelated forces shaping the city's spatial change. First, intensified cultural and intellectual exchanges with Europe fostered new ideals of urban order, progress, and architectural representation. Second, technological advances - particularly the introduction of European cartographic and surveying techniques - enabled more regular street layouts and facilitated state-directed urban interventions. Third, the establishment of new institutions such as embassies, ministries, and garden residences introduced unfamiliar building types and actively steered urban growth through the construction of connecting roads. Finally, these processes culminated in the emergence of a 'European city' ideal, expressed in gridded streets, outward-oriented buildings, and new residential forms. Together, Alemi argued, these factors repositioned streets as instruments of cultural expression and marked a deliberate shift away from the irregular, inward-looking patterns of

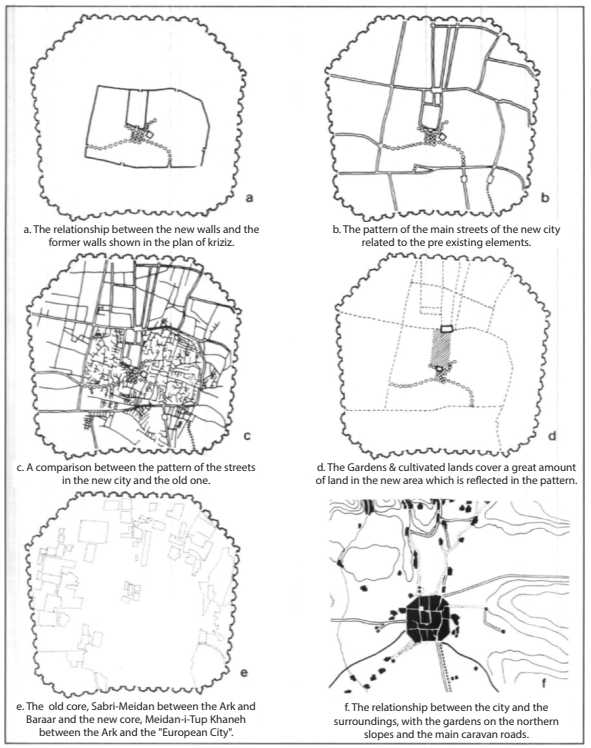


Figure 1. Tehran, morphological stages of change. (Alemi, 1985).

4. Ibid.

5. Michael E. Bonine, 'The Morphogenesis of Iranian Cities', *Annals of the Association of American Geographers* 69, no. 2 (1979): 208–24, https://doi.org/10.1111/j.1467-8306.1979.tb01252.x.

6. Ibid.

traditional Iranian urbanism toward a more rational, extroverted urban form.

4.2. Land Division and Irrigation-Based Morphology

Bonine[7] challenged the view that traditional Iranian cities were inherently irregular, arguing instead that their morphology was structured by the geometric logic of irrigation-based agriculture. He contends that rectangular agricultural plots, shaped by irrigation channels aligned with topography, formed the original spatial matrix of early settlements. Paths running along these channels later became streets, with houses orienting themselves to access routes rather than to the underlying orthogonal system, creating an appearance of irregularity. As cities expanded and absorbed surrounding villages, these rural field patterns were incorporated into the urban fabric. Bonine further argued that modern 20th-century grids largely extended or overlaid these pre-existing networks rather than replacing them. Applied to Tehran, this perspective suggests that new streets often followed established routes, and that northward expansion was primarily guided by the direction of water flow from the Alburz Mountains rather than by climate or institutional location.

4.3 Complementary Perspectives: Urban Evolution, Housing Change, and External Influence

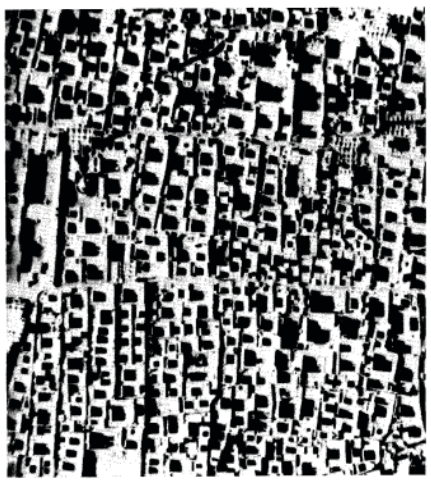
Several scholars offer complementary perspectives on Tehran's morphological transformation, though most stop short of detailed morphological analysis. Costello[8] provided a descriptive account of Tehran's growth, tracing the shift from garden houses to apartments and high-rise blocks, but largely calls for future morphological studies rather than undertaking one himself. Mirmoghtadaee[9] focused on the transformation of housing types and the mismatch between rapid adoption of apartment living and slower cultural adaptation, offering valuable social insight but limited spatial or geographic specificity. Sintusingha and Mirgholami[10] framed Tehran's development through the concept of self-colonisation, arguing that imported Western urban models - particularly wide, vehicular streets - conflicted with local practices and contributed to the deterioration of the historic core. Madanipour[11] emphasised environmental factors such as water systems and solar orientation in shaping Tehran's form, though his analysis remains at a macro scale. Mazumdar[12] interpreted Tehran's evolution politically, linking urban expansion to autocratic interventions across different dynastic periods; however, like the others, his work lacks detailed examination of urban morphology at the levels

7. Ibid.

8.Vincent F. Costello, 'The Morphology of Tehran: A Preliminary Study', *Built Environment* (1978-))1998) 201–16.

9. Mahta Mirmoghtadaee, 'Process of Housing Transformation in Iran', *Journal of Construction in Developing Countries* 14, no. 1 (2009).

Figure 2. Orientation of houses along linear regular (left) and irregular (right) streets of Yazd. (Bonine, 1979, p.214 & 215).



Linear streets and linear rows of open courtyard houses in Yazd.

Irregular streets and open courtyards oriented to the direction of the streets in Yazd.

of plots, blocks, and buildings.

4.4 Synthesis and Analytical Reflections

The literature shows that Tehran's morphological evolution cannot be explained by a single factor. Modernisation perspectives stress cultural aspiration, technology, and European influence; environmental approaches emphasise irrigation systems and land geometry; political analyses focus on centralised power and state intervention; and socio-cultural studies highlight tensions between changing lifestyles and inherited spatial forms. Despite these insights, research largely concentrates on the citywide scale and gives little attention to the intermediate scales of plot, block, and housing form. In particular, the incremental transformation of dwellings in response to regulation, lifestyle change, and speculative development remains underexplored[13]. This gap motivates the present study's focus on linking macro-scale urban change with housing morphology.

5. Typology as theory and historiography: Theoretical and Methodological Framework

This section outlines the theoretical and methodological foundations of the study by situating it within key debates on typology, urban morphology, and housing form. It argues that typology should be understood not as a classificatory end in itself, but as a purpose-driven analytical tool that is essential for explaining how built forms emerge, persist, and transform over time. Drawing on architectural theory, housing typology is framed here as a fundamentally morphological concern, aligned with interpretations of the city as a repository of historical continuity, cultural values, and collective meaning[14]. The discussion draws on a range of established typo-morphological traditions, which, despite methodological differences, share a commitment to historical analysis and to the study of ordinary residential buildings as key indicators of urban change. The Italian school of urban morphology, associated with Muratori and Caniggia[15], foregrounds typological process and the gradual evolution of basic housing types (tipo portante) through incremental transformation. Central to this tradition is the parcel or plot as the fundamental unit of the urban fabric, through which continuity and change can be traced across successive phases of development.

The English school, exemplified by Conzen[16], contributes a rigorous cartographic and analytical framework centred on the interrelationship between streets, plots, and buildings. Concepts such as plot cycles, fringe belts, and morphological regions enable the reconstruction of urban morphogenesis over long time periods, offering a systematic means of linking changes in land subdivision to broader patterns of urban growth.The French tradition, often associated with the Versailles school and articulated through the work of Moudon[17] and Talen[18], extends morphological analysis by incorporating social practices, regulatory frameworks, and everyday decision-making processes. This approach emphasises how cumulative, small-scale actions -shaped by planning controls, economic pressures, and cultural norms - gradually reshape neighbourhood form, thereby bridging the gap between formal urban structure and lived experience.

In addition to these theoretical traditions,

10. Sidh Sintusingha and Morteza Mirgholami, 'Parallel Modernization and Self-Colonization: Urban Evolution and Practices in Bangkok and Tehran', *Cities* 30 (2013):122–32, https://doi.org/10.1016/j.cities.2012.02.001.

11.Ali Madanipour, *Tehran: The Making of a Metropolis*, World Cities Series (Chichester: Wiley, 1998).

12. Sanjoy Mazumdar, 'Autocratic Control and Urban Design: The Case of Tehran, Iran', *Journal of Urban Design* 5, no. 3 (2000): 317–38.

13. Homeira Shayesteh, 'Typo-Morphological Approach to Housing Transformation in Tehran' (PhD diss., University College London, 2013); Shayesteh and Steadman, 'The Impact', 92–107; Shayesteh and Steadman, 'Coevolution', 1124–47; A. M. Milani, 'The Impact of Regulations on the Typo-Morphological Transformation of Residential Buildings in Tehran', *Urban Morphology* 25, no. 2 (2021): 173–87, https://doi.org/10.51347/UM25.0012.

the study reviews a number of practical housing classification systems developed by Sherwood[19], Kirschenmann & Muschalek[20] and Scoffham[21]. These studies demonstrate how housing forms can be systematically categorised according to orientation, access, aggregation, scale, and evolutionary change. Although largely descriptive, such classifications provide important precedents for form-led analysis of residential environments and help establish a common vocabulary for comparing housing types across different contexts.

5.1 Typology as Analytical Method: Configurational and Archetypal Approaches

Building on the typo-morphological traditions outlined, this study adopted two complementary analytical frameworks in order to move beyond descriptive accounts of urban form and toward an explicitly explanatory and testable methodology. While classical typo-morphological approaches provide robust tools for reconstructing historical transformation, they are less equipped to analyse the internal spatial logic of housing layouts or to evaluate alternative formal outcomes under shared dimensional and regulatory constraints. To address these limitations, the research combined configurational analysis derived from Space Syntax with Steadman's archetypal modelling approach.

Space Syntax is employed to examine the configurational structure of housing plans and to identify recurring spatial genotypes that reflect culturally embedded patterns of domestic use[22]. By analysing the relational organisation of rooms and circulation, this method enables systematic comparison across housing types and historical periods, revealing continuities and shifts in patterns of access, privacy, and social interaction. In the context of Tehran, configurational analysis helps clarify how successive housing types accommodated changing lifestyles while retaining underlying spatial logics rooted in Iranian domestic culture.

However, Space Syntax engages only indirectly with the dimensional, geometric, and plot-based constraints that condition housing production at the scale of the parcel and block. For this reason, it is supplemented by Steadman's archetypal approach, which systematically explores the geometric possibilities of built form within rectangular plots under defined constraints[23]. This method enables quantitative analysis of relationships between plot dimensions, building configuration, density, and layout, while explicitly accounting for generic spatial requirements such as street access, daylighting, adjacency, and building depth.

Recent extensions of this approach by Shayesteh and Steadman demonstrate how archetypal modelling can be applied to residential blocks to examine the probabilistic relationship between regulation, plot structure, and housing typology[24]. Their work shows that planning codes do not determine a single formal outcome but instead narrow the field of viable typological options, making certain configurations more likely than others. This insight is central to the present study, which adopts archetypal modelling not only as an analytical tool but also as a generative framework for testing alternative housing forms under identical morphological and regulatory conditions. While Space Syntax reveals how internal spatial organisation responds to cultural and social practices, archetypal model-

14. Aldo Rossi, *The Architecture of the City* (Cambridge, MA: MIT Press, 1982); Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (London: Thames & Hudson, 2000).

15. Gianfranco Caniggia and Gian Luigi Maffei, *Architectural Composition and Building Typology: Interpreting Basic Building* (Florence: Alinea Editrice, 2001).

16. Michael R. G. Conzen, 'Alnwick, Northumberland: A Study in Town-Plan Analysis', *Transactions and Papers (Institute of British Geographers)* 27 (1960): iii–122.

17.Anne Vernez Moudon, 'Urban Morphology as an Emerging Interdisciplinary Field', *Urban Morphology* 1, no. 1 (1997): 3–10, http://www.urbanmorphology.org.

18.Emily Talen, *City Rules: How Regulations Affect Urban Form* (Washington, DC: Island Press, 2012).

19. Roger Sherwood, *Modern Housing Prototypes* (Cambridge, MA: Harvard University Press, 1978).

20. J. C. Kirschenmann and Christian Muschalek, *Residential Districts* (London:

ling makes it possible to examine how housing form is conditioned by plot geometry, density targets, and regulatory constraints. Combined, configurational analysis and archetypal modelling enable analysis of both realised and alternative housing forms under shared constraints. This methodological synthesis frames the central research question of the article: how the evolution of housing types in Tehran relates to the development of residential urban layouts, and whether prevailing forms were the result of regulatory necessity, morphological constraint, or contingent design choices rather than inevitable outcomes of modernisation or Western influence. The following section operationalises this framework through GIS-based analysis of selected urban areas, translating theoretical models into empirically grounded morphological evidence.

5.2 Typology as empirical test and explanatory model: Housing Transformation, Regulation, and Morphological Constraint

Changes in Iranian society over the past century, particularly its rapid movement toward modernism, have been expressed across all domains of urban life. While transformation in housing was substantial, it proceeded at a slower pace than changes in political institutions and public architecture, where shifts in governance enabled earlier and more explicit adoption of modern forms. Housing, however, could not remain insulated from broader social change. Despite higher economic and material costs, domestic architecture underwent accelerated transformation as new lifestyles, technologies, and patterns of everyday life took hold.

This study argues that even in the absence

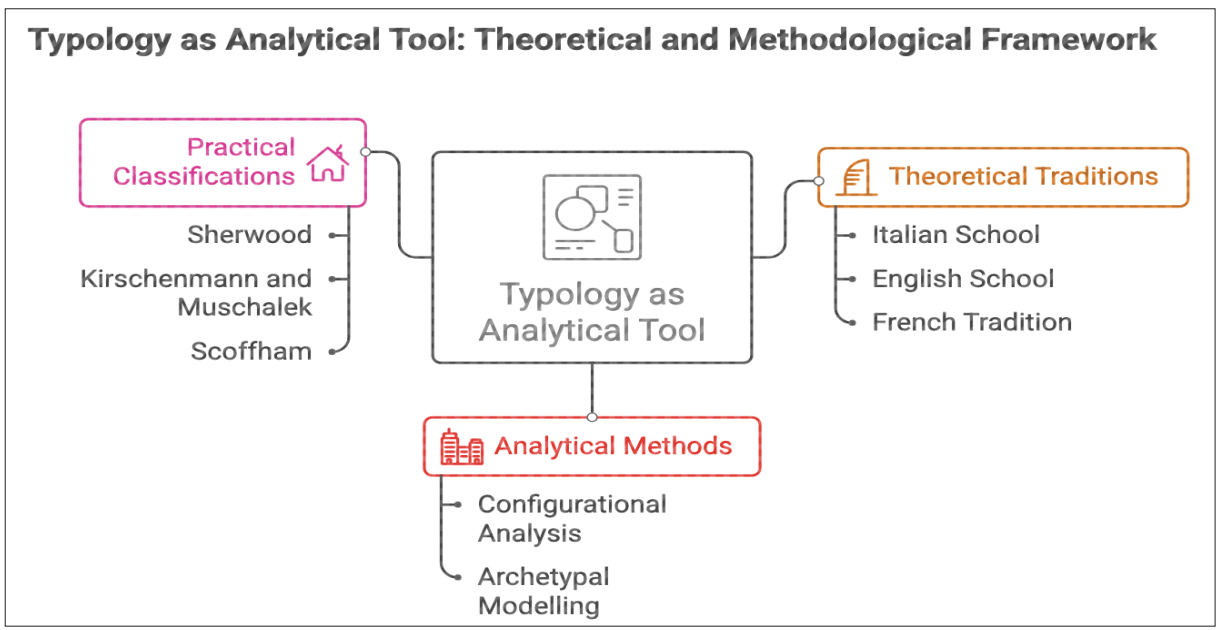


Figure 3. Typology as analytical tool, theoretical and methodological framework.

Granada, 1977).

21. Ernie Scoffham, Sustainable Housing: *Principles and Practice* (London: E & FN Spon, 2000).

22.Bill Hillier, *Space Is the Machine: A Configurational Theory of Architecture* (Cambridge: Cambridge University Press, 1996).

23. Philip Steadman and Stephen Marshall, 'Archetypal Layout: Extending the Concept of the Archetypal Building to Streets and Block Layouts', paper presented at the Solutions Conference, London, 2005.

24. Shayesteh and Steadman, 'The Impact', 92–107, quoted in John Smith, *Urban Design in London* (London: Routledge, 2020).

of direct Western architectural influence, the emergence of a modern way of life - most notably the widespread adoption of car ownership - would have necessitated significant adaptation in housing form. The pace of change was sufficiently rapid that social adjustment lagged behind spatial transformation, yet this accelerated rate of evolution itself became the prevailing condition and continues to shape Tehran's residential development. The analysis is both explanatory and generative. At the urban scale, Tehran's residential fabric is shown to have evolved from irregular, fine-grained blocks into larger and more regular grids. At the architectural scale, housing types shifted from inward-looking courtyard houses to terraced houses with south-facing courts, and ultimately to multi-storey apartment buildings. The central analytical concern is the relationship between these two processes: whether changes in urban layout and housing typology constitute a co-evolutionary process, or whether they represent parallel developments brought together by contingent social, economic, and regulatory forces.

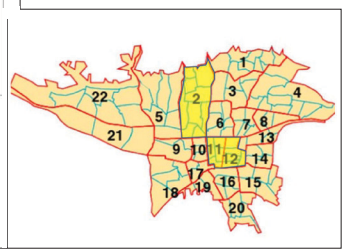
Building on Steadman's archetypal approach and its subsequent extension by Shayesteh and Steadman, the study develops an integrated analytical model linking parameters of urban structure - such as block and plot size, density, and ground coverage - with parameters of built form, including access frontage, daylit depth, and building configuration (courtyard, C-shaped, L-shaped, and linear forms). To operationalise this model, GIS-based analysis was conducted on three 500 × 500 m areas of Tehran representing successive stages of urban growth. Dominant values for each parameter were extracted and used to construct archetypal representations of typical residential blocks and housing forms.

Then archetypal models of possible plots and blocks with the similar dimensional and density measurements generated. The results demonstrated that these archetypal models closely approximate observed conditions, validating their use as analytical tools for understanding Tehran's housing fabric. More significantly, design experiments using blocks of identical dimensions reveal that multiple housing forms can satisfy similar requirements for density, daylight access, and street frontage. These finding challenges deterministic interpretations of Tehran's urban form and indicates that the relationship between block morphology and housing typology is probabilistic rather than fixed.

The analysis further shows that generic functions - particularly access and daylight - systematically influence block and plot dimensions, while certain dimensional ranges make specific housing forms more likely. These relationships, however, are consistently mediated by planning regulations, which emerge as a critical force shaping typological outcomes. Regulations governing plot coverage, building placement, and density do not merely constrain architectural form; they actively steer the evolution of housing types and produce long-term morphological consequences that were often not explicitly anticipated.

By focusing on the intermediate scale between the city and the individual dwelling, this study addresses a significant gap in Tehran's urban scholarship. Existing literature has tended to privilege macro-scale narratives of modernisation and Western influence or micro-scale

Figure 4. Analysis of plot sizes in Tehran.



analyses of individual houses, leaving the relationship between block structure and housing form underexamined. Through the combined use of GIS analysis and archetypal modelling, the research demonstrates that housing typology and urban morphology in Tehran are tightly interrelated yet not uniquely determined, and that alternative evolutionary paths were - and remain - possible within similar spatial and regulatory conditions.

6. Planning Regulation as a Morphological Driver

Building on the finding that housing typology and block morphology in Tehran are related but not deterministically fixed, the analysis identifies planning regulation as a decisive mediating force in this relationship. While regulations were initially treated as one among several factors shaping residential form, their cumulative and structuring impact became increasingly evident. In this respect, the Tehran case aligns

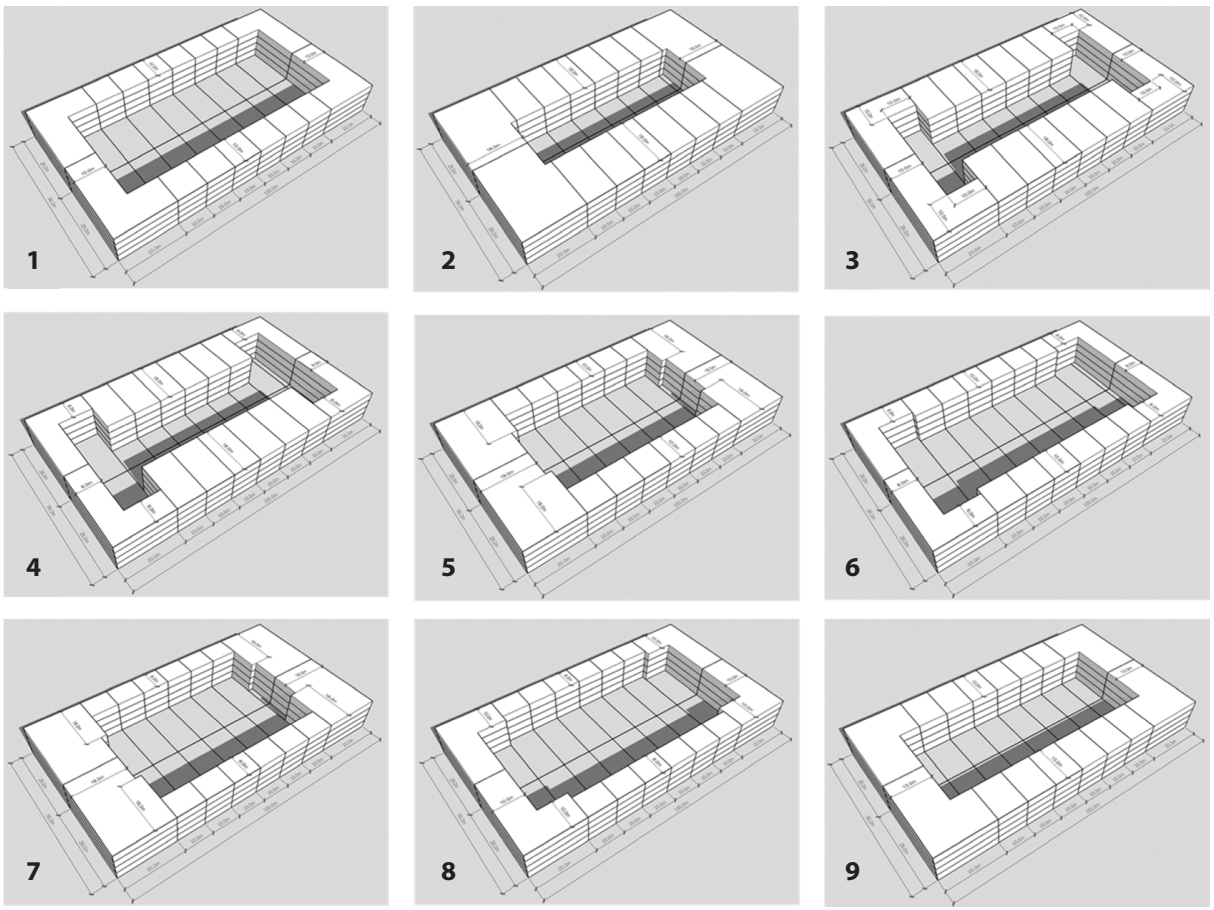


Figure 5. Archetypal model of alternative blocks for Tehran

with the argument that planning codes operate not merely as constraints on individual buildings but as configurational mechanisms that systematically shape spatial outcomes across neighbourhoods and cities.

Comparative references to regulatory frameworks in cities such as New York and Paris illustrate how relatively simple physical codes can generate coherent morphological and aesthetic effects when applied consistently[25]. In Tehran, however, a small number of seemingly straightforward regulations - most notably those governing building placement within plots and limits on ground coverage - have had disproportionately strong and often unintended consequences for housing typology, block form, and streetscape continuity. The absence of coordinated redevelopment, particularly in the piecemeal replacement of single-family or low-rise terraced housing with apartment buildings, has resulted in fragmented skylines and visually incoherent residential streets.

These regulatory effects intersected with powerful economic, social, and technological forces. The shift from single-family housing to apartment living, combined with the transition from load-bearing masonry to steel and reinforced concrete construction, facilitated vertical densification, accelerated redevelopment cycles, and increased profitability through thinner structural walls and higher floor area yields. As Shayesteh[26] & Shayesteh & Steadman's[27] configurational analyses suggest, such interactions between regulation, construction technology, and economic logic tend to reinforce specific spatial patterns over time, even in the absence of explicit design intentions. Particular attention is drawn to two regulations with far-reaching morphological implications: the requirement to locate buildings on the north side of plots and the restriction of ground coverage (initially 40 per cent, later increased to 60 per cent). Although these rules can be interpreted as environmentally motivated - seeking to maximise solar access and climatic comfort - they have produced a distinctive urban condition in which many north–south streets lack continuous façades. This pattern, now widespread across both residential and commercial areas of Tehran, demonstrates how environmental logics, when narrowly applied, can override broader considerations of urban continuity and public space.

At the level of housing typology, regulatory constraints interacted with cultural practices to shape internal layouts. The brief dominance of two-up, two-down terraced houses reflects a misalignment between imported spatial models and local lifestyles. Their deep, sequential plans proved poorly suited to Iranian domestic patterns, leading to their rapid replacement by apartment types organised around a central hall. This space effectively reinterprets the social and symbolic role of the courtyard within a compact, multi-storey form, illustrating how typological adaptation occurs within regulatory and dimensional limits rather than through stylistic change alone.

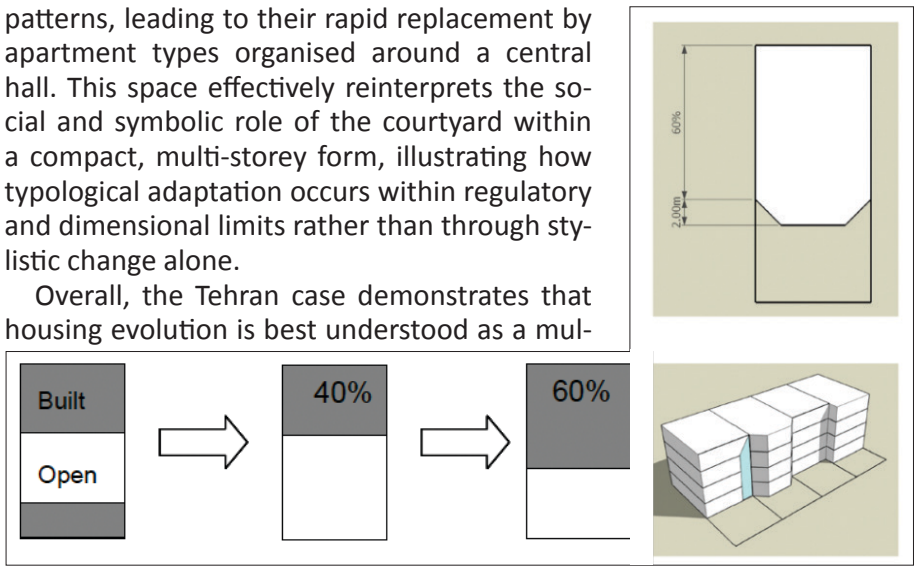
Overall, the Tehran case demonstrates that housing evolution is best understood as a mul-

25. Shayesteh and Steadman, 'The Impact', 92–107.

26.Shayesteh, 'Typo-Morphological Approach'.

27.Shayesteh and Steadman, 'Coevolution', 1124–47.

Figure 6. regulations and planning policies governing built form and open space on plots.



ti-variable, evolutionary process in which planning regulations play a primary structuring role. Consistent with Shayesteh & Steadman's[28], the findings show that regulations shape not only density and land use but also the configurational logic of access, frontage, and internal spatial organisation. Rather than producing a single inevitable outcome, these codes narrow the field of possibilities, making certain housing types more probable while foreclosing others, and in doing so leave a lasting imprint on the city's morphological structure.

7. Geographical Constraints and Generic Functions

Following the identification of planning regulation as a key mediating force between housing typology and block morphology, the analysis turns to the role of geographical and spatial constraints - specifically street access and daylighting - as generic functions shaping residential form.[29] To investigate these constraints empirically, the study examined three boroughs of Tehran representing successive phases of morphological growth. Measurements of plot size, building footprint, frontage width, depth, and density were undertaken at both the borough scale and within selected 500 × 500 m samples using GIS. In parallel, a detailed analysis of thirty-one representative dwellings was conducted using Steadman's archetypal representation method, enabling systematic comparison between observed built forms and theoretically possible alternatives under similar dimensional conditions[30].

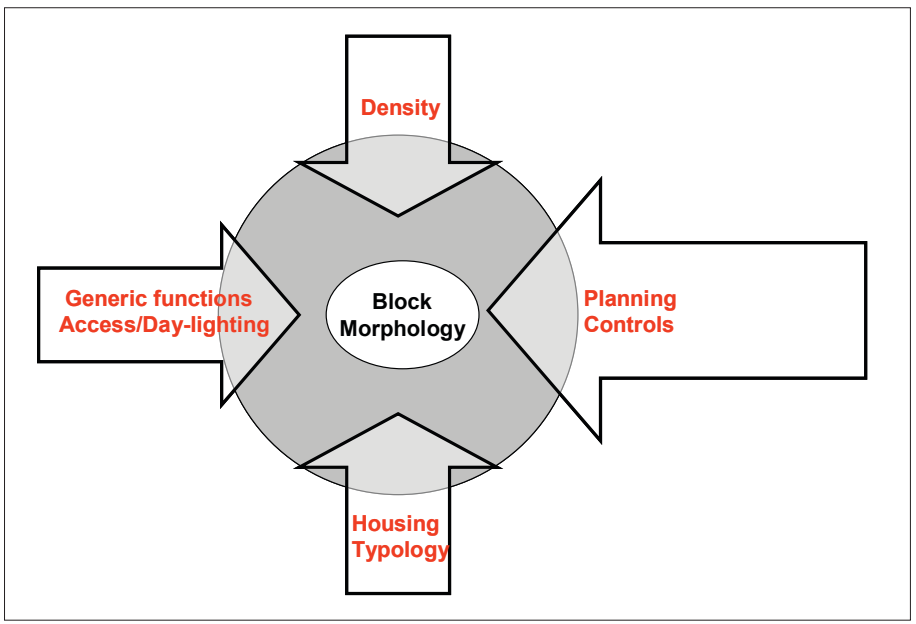
Comparative analysis of average plot widths, depths, and building envelopes revealed consistent relationships between daylighting requirements and block structure. Habitable rooms require direct access to external space, placing clear limits on building depth and, by extension, on block thickness. In Tehran's post-Qajar expansions, this constraint has resulted in blocks typically no more than two plots deep, a configuration that simultaneously satisfies daylighting standards and ensures direct street access for each plot. This finding is consistent with broader morphological research demonstrating how environmental requirements stabilise certain block dimensions across different cultural contexts[31].

By contrast, the length of urban blocks proved less directly constrained by environmental factors and more dependent on access-related considerations. Block length was found to be shaped by a combination of factors, including the proportion of land allocated to streets, the need to minimise travel diversion, and the

28. Ibid.

29.Philip Steadman, 'How Day-lighting Constrains Access', in *Proceedings of the Fourth Symposium on Space Syntax* (London: University College London, 2003), 05.1–05.12; Caniggia and Maffei, *Architectural Composition and Building Typology*.

Figure 7. The factors involved in block morphology.



distribution of plot frontages along the street. These findings resonate with configurational studies in Space Syntax, which show that access economy and movement efficiency exert strong influence on street segmentation and block articulation[32].

At the level of housing typology, the analysis demonstrates that the transition from courtyard houses to terraced houses cannot be explained solely as a cultural or ideological shift associated with Westernisation. While modernist influences were significant, the change also reflected functional adaptation to increased car ownership and the growing importance of direct street access to individual dwellings. Terraced houses offered a more effective interface between plot, street, and domestic space than inward-facing courtyard houses aggregated into irregular blocks. This functional explanation complicates narratives that frame typological change primarily as a symbolic rejection of traditional forms.Nevertheless, the analysis also raises unresolved questions. In principle, courtyard houses could have been reaggregated into accessible, two-plot-deep blocks while retaining their introverted spatial logic. That this did not occur suggests that regulatory frameworks, plot subdivision practices, and market pressures collectively narrowed the range of viable typological options - an issue that warrants further investigation. Density emerges as the dominant driver in the subsequent transition from single-family terraced housing to multi-storey apartment buildings. Rapid population growth, economic centralisation, and rising land values rendered horizontal expansion insufficient, shifting planning priorities toward vertical densification. In this context, increased allowable densities - rather than changes in plot size alone - became the principal mechanism guiding housing form. The archetypal modelling demonstrates that, given prevailing plot dimensions, multiple housing configurations could theoretically achieve similar density, daylighting, and access ratios, reinforce the argument that observe forms were not inevitable outcomes but the result of specific regulatory and economic choices[33].

Overall, the findings underline the importance of generic spatial functions - access and daylighting - as stabilising forces in urban form, while also showing how their interaction with regulation and density targets shapes the probabilistic emergence of particular housing types. This reinforces the broader argument of the paper: that Tehran's residential morphology evolved through a constrained field of possibilities structured by geographical requirements, regulatory codes, and economic pressures, rather than through deterministic cultural or stylistic trajectories.

8. Architectural Form, Plot Geometry, and Functional Fit

Building on the analysis of geographical constraints and generic functions, this section focuses on the architectural scale, examining how plot shape, block dimension, and regulatory parameters condition the emergence of specific housing forms. The central concern is the relationship between architectural layout and functional performance, and the extent to which certain spatial configurations lend themselves more readily to particular building types under given dimensional and regulatory constraints.

30. Philip Steadman, *Linear City: A Morphological Approach*, vol. 1 (Hong Kong: University of Hong Kong, 2005); Shayesteh and Steadman, 'Coevolution', 1124–47.

31. Moudon, 'Urban Morphology as an Emerging Interdisciplinary Field', 3–10; Steadman, 'How Day-lighting Constrains Access', 05.1–05.12.

32. Hillier, *Space Is the Machine;* Shayesteh and Steadman, 'The Impact', 92–107.

33.Steadman, *Linear City*, vol. 1; Shayesteh and Steadman, 'The Impact', 92–107; Shayesteh and Steadman, 'Coevolution', 1124–47.

A key question addressed here is what defines the dimensions of plots and blocks in contemporary urban development. Unlike medieval towns - where construction techniques and structural modules directly determined plot width and building depth - modern urban form is shaped by a more complex interaction of factors, including access requirements, daylighting standards, density controls, land value, and planning regulation. As a result, no single variable can be identified as determinative; rather, housing form emerges from the relative weighting of multiple constraints that vary over time and context. To disentangle these relationships, the study combined GIS-based measurement of urban fabric with Steadman's archetypal representation method. Ground coverage, Floor Space Index (FSI), plot frontage, building depth, and density were analysed across three boroughs of Tehran representing successive phases of urban growth. This approach made it possible to relate observed housing types to both their dimensional conditions and to alternative configurations that could theoretically have occupied the same plots[34].

The analysis demonstrates a clear sequence of typological transformation associated with progressive plot narrowing. At larger plot widths, four-sided courtyard houses were viable, allowing inward-facing layouts with adequate daylight and ventilation. As plot widths decreased - largely in response to subdivision pressures aimed at maximising street access - this configuration became untenable. Three-sided and two-sided courtyard forms (C- and L-shaped buildings) emerged as adaptive responses, preserving some courtyard qualities while accommodating reduced frontage. When plot widths narrowed further, typically to around six metres or less, even partial courtyard arrangements became impractical. At this threshold, narrow and elongated plots favoured terraced housing forms, which maximised frontage efficiency and facilitated direct street access. The widespread adoption of two-up, two-down terraced houses reflects this morphological logic. However, despite their formal efficiency, these houses proved poorly aligned with prevailing domestic practices in Tehran, particularly due to their deep, sequential internal layouts. As a result, they were rapidly supplanted by terraced apartment buildings, which offered greater internal flexibility and better accommodated social patterns of living, gathering, and privacy. While narrowing plots made certain forms more probable than others, multiple configurations remained theoretically possible within similar dimensional envelopes. Archetypal and configurational analysis revealed systematic changes in key parameters - such as ground coverage and daylit depth - across different housing types, demonstrating how architectural layouts respond to functional thresholds rather than stylistic preference alone[35]. This reinforces the argument that the dominance of particular forms in Tehran was not an inevitable outcome of plot size or density requirements, but the result of how planning regulations, market forces, and cultural preferences converged at specific historical moments[36]. Taken together, these findings position archetypal modelling as a powerful analytical and generative tool. By systematically relating architectural form to plot geometry, density, and functional performance, the method bridges planning criteria with typological and formal design considerations. This

34.Steadman, *Linear City*, vol. 1.

35. Steadman, *Linear City*, vol. 1; Shayesteh and Steadman, 'Coevolution', 1124–47.

36. Steadman, 'How Day-lighting Constrains Access', 05.1–05.12.

integrated approach offers a basis not only for retrospective morphological analysis, but also for exploring alternative residential layouts capable of meeting contemporary planning objectives while expanding the range of architectural possibilities in dense urban contexts.

9. Synthesis and final evaluation

This study makes a twofold contribution to knowledge. First, it advances understanding of the reciprocal relationship between housing-built form and urban structure in Tehran, demonstrating that these are not parallel but causally interrelated processes. Second, it contributes methodologically by extending and operationalising archetypal and typo-morphological modelling as a rigorous analytical and generative framework for linking architectural form, plot morphology, and urban layout. The methodological extension - particularly the adaptation of archetypal modelling to blocks more than two plots deep - enables the simultaneous analysis of architectural and urban scales. This addresses a persistent gap in typo-morphological research, which has often privileged either building typology or urban structure in isolation[37].

Empirically, the study extends existing accounts of Tehran's urban development by quantifying the historical evolution of housing typologies and block morphologies across successive phases of growth. In doing so, it reinforces and deepens earlier qualitative arguments regarding the role of vehicular access and regulation in shaping Tehran's residential fabric[38], while also demonstrating how planning codes acted as primary morphological drivers rather than merely administrative instruments. The findings show that changes in housing form - from courtyard houses to terraced houses and subsequently to apartment buildings - were tightly coupled with shifts in plot dimensions, density allowances, and block structure, revealing clear causal links between urban layout and architectural typology.

A further contribution lies in the study's generative dimension. By using average dimensional parameters derived from empirical analysis to construct theoretical blocks, the research tested whether archetypal modelling could reproduce densities and spatial characteristics comparable to those observed in reality. This procedure functions as methodological validation rather than circular reasoning. This makes it possible to evaluate not only what was built, but what could have been built, thereby situating Tehran's housing evolution within a wider field of theoretical possibilities[39]. The synthesis of planning, geographical, and architectural dimensions is a central strength of the study. By explicitly linking access, daylighting, density, and plot geometry to architectural form, the research provides a framework through which planning objectives can be more directly translated into spatial and typological outcomes. This has practical implications for urban regulation, suggesting that performance-based criteria - such as street frontage continuity or daylight access - may offer greater formal flexibility and improved urban aesthetics than rigid plot-based controls. In the context of Tehran, revisiting regulations governing building positioning within plots could enable more coherent street façades and skyline conditions while accommodating comparable densities.

More broadly, the study proposes a shift in

37. Conzen, 'Alnwick, Northumberland', iii–122; Moudon, 'Urban Morphology', 3–10.

38. Ali Madanipour, 'Urban Planning and Development in Tehran', *Cities* 23, no. 6 (2006): 433–38, https://doi.org/10.1016/j.cities.2006.08.002.

39. Steadman, 'How Day-lighting Constrains Access', 05.1–05.12; Shayesteh and Steadman, 'Coevolution', 1124–47.

typo-morphological inquiry from static description toward an explicitly evolutionary and transformational perspective. Rather than treating urban form as a snapshot divorced from its history, the analysis situates housing morphology within a temporal process shaped by regulation, technology, lifestyle change, and economic pressure. This approach aligns with calls for more explanatory and model-based urban morphology capable of testing hypotheses and comparing alternative configurations[40]. The research also opens several avenues for further investigation. One promising direction concerns the relationship between block morphology and environmental performance, particularly energy demand. Given that the archetypal models already quantify building volumes and envelope surfaces, they could be extended to evaluate the thermal implications of alternative block layouts. This would resonate with recent comparative studies linking urban morphology and residential energy consumption in European and Middle Eastern cities[41]. Such work would be especially relevant in Tehran, where planning regulations have historically been justified on climatic grounds.

Finally, while the analysis focuses on physical form, it does not imply physical determinism. Built form is understood here as the spatial embodiment of cultural, social, and regulatory processes rather than their replacement. Ordinary housing is treated as an evolving artefact shaped by residents, markets, and planning frameworks alike. By establishing a robust morphological baseline, the study provides a conceptual framework within which socio-economic and political influences on Tehran's urban development can be more systematically

40. Leslie Martin and Lionel March, 'The Grid as Generator', in *Urban Space and Structures*, ed. Leslie Martin and Lionel March (Cambridge: Cambridge University Press, 1972), 6–27; Steadman, *Linear City*, vol. 1.

41. Philipp Rode and Ricky Burdett, 'Cities: Investing in Energy and Resource Efficiency', in *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication* (Nairobi: United Nations Environment Programme, 2011), 453–92.

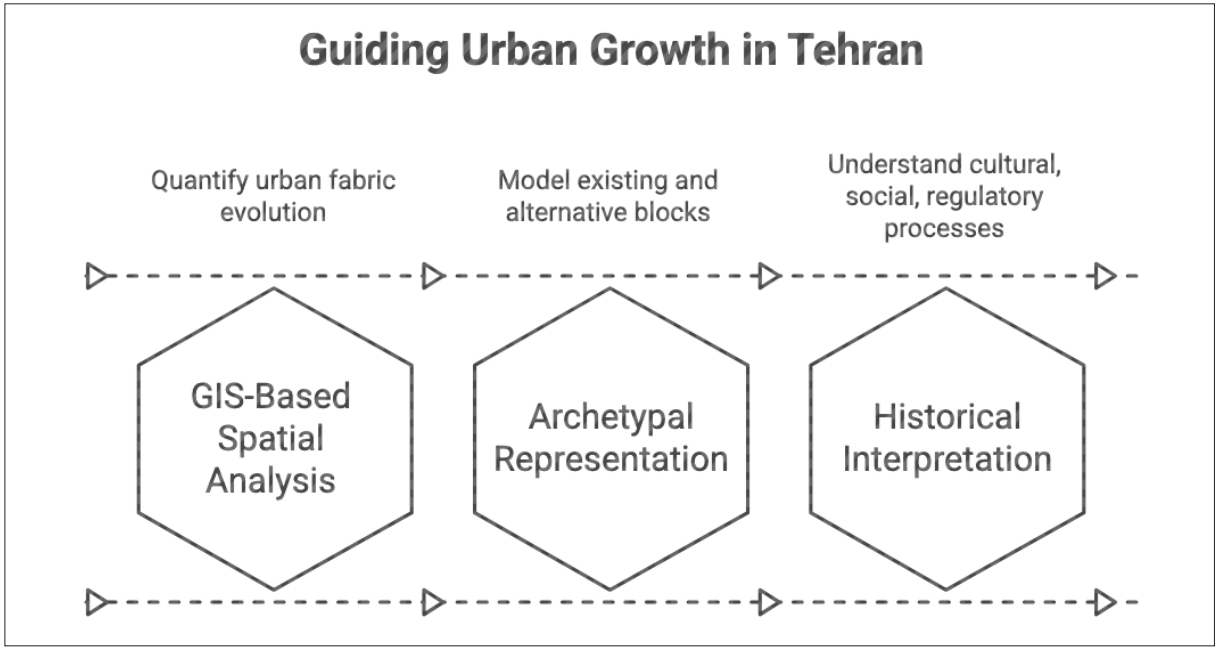


Figure 8. Guiding framework for urban growth in Tehran

examined in future research. Taken together, the findings demonstrate the value of integrating archetypal modelling, GIS analysis, and historical interpretation in understanding housing transformation. Using Tehran as a case study, the research illustrates how a relatively stable urban structure of streets and blocks can accommodate - and constrain - changing architectural forms over time. Recognising these limits and possibilities is essential for designers, planners, and regulatory authorities seeking to guide urban growth toward more coherent, adaptable, and sustainable residential environments.

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