

## Research Paper

# Explaining the Model of Promoting Infill Development by Urban Design in a Historical Context of Mashhad Metropolis

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**Received:** December 2023, **Revised:** July 2024, **Accepted:** July 2024, **Publish Online:** July 2024

### Abstract

The central and historical textures of cities have always been considered primary manifestations of a city's history and identity. In recent decades, such textures have received growing attention from urban designers and policymakers through infill development. This study aims to model and design infill development based on urban design and policy-making approaches. The design approach includes four dimensions: objective aesthetics, mental-cognitive aesthetics, functional, and environmental aesthetics. The policy-making method comprises three dimensions: social capital, economic infrastructure, and assessing the situation of the local area. In this study, a mixed-method approach was used to measure and analyze quantitative and qualitative data. Data collection was conducted through interviews with experts in management, planning, and urban design. The discourse analysis technique was employed to refine the data obtained from the interviews and to complete the proposed models. Subsequently, the collected and refined criteria were analyzed based on the opinions of experts using MAXQDA software. The obtained model was then analyzed using MicMac software, considering experts' opinions to understand how the components affect each other, presented in the form of charts and analytical graphs. In the final step, approaches, dimensions, components, and indicators were modeled based on the importance of the components using Sankymatic software. The findings aim to present a practical model for infill development in the central and historical areas of Mashhad, as well as valuable textures of urban hubs, especially in the metropolises of Iran. Analyzing selected components in the modeling of infill development helps to provide effective strategies for valuable and central textures of cities that embody an urban identity. This study, in terms of urban planning (policy-making) and urban design (designing), presents reviews and analyses across different dimensions. Providing a comprehensive and efficient model with proposed solutions tailored to each component with the infill approach is considered a desirable method for developing valuable central and historical textures, particularly in metropolises. To date, no comprehensive model has been presented to explain the indicators of infill development from the perspectives of urban design and urban planning. This study articulates the approaches, dimensions, components, indicators, and corresponding proposed solutions in the form of a research model.

**Keywords:** Historical Textures of Mashhad, Infill Development, Modeling, Policy-making, Urban Design.

## INTRODUCTION

The expansion of new urban structures has been proposed as a solution for efficient urban development over the past few decades, emphasizing the importance of maximizing the use of existing facilities

within the urban context. The interdisciplinary nature of infill development significantly influences the approach and guidelines of urban design. Since each discipline examines this category within its own framework and principles, and because this type of infill development occurs in historically valuable sites,

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the damage resulting from a one-dimensional approach is more evident on a larger scale compared to the other three trends, potentially causing significant harm to both the physical and non-physical aspects of the historical context.

The rapid growth of urbanization, rural-urban migration to major cities in Iran—particularly the metropolis of Mashhad—and the need to provide urban services commensurate with the demands of the urban population have underscored the necessity of utilizing the city's existing capacities. To achieve this, it is essential to present sustainable urban growth and development through a practical model rather than horizontal urban expansion. This involves infilling the existing urban texture and repurposing incongruous and interfering buildings. Additionally, the demands of modern urban life indicate that cities, as living spaces, are losing their appeal to many citizens, who often dwell in the suburbs while working or studying in urban centers.

Infill development, also known as internal development, is a policy for the growth and physical development of cities. Alongside two other policies—peripheral and external development—it defines the macro framework of planning policies for a city's physical development (Aliakbari & Akbari, 2018). Infill development can be seen as the most obvious interpretation of endogenous development (Jalilzadeh et al., 2020). This development encompasses various macro dimensions, including economic, social, physical, activity (land use), and environmental aspects, among others (SharifNejad, 2021).

Executing this development necessitates identifying suitable and desirable points for development, which requires a profound understanding of the relevant factors affecting infill development (Pourmousavi et al., 2015). This type of development addresses not only physical issues but also explores all social, economic, housing, visual, and aesthetic components (Sharifian, 2010).

In recent years, the necessity of implementing renovation and improvement projects around the Razavi holy shrine has presented many challenges. The preservation of valuable historical identity structures and efforts to redefine the development pattern to meet the needs of the local community, in response to the wishes of the citizens regarding historical identity, have underscored the importance of infill development in the context surrounding the holy shrine of Razavi.

The historical and central texture of Mashhad consists of four peripheral sectors surrounding the holy shrine of Imam Reza, which has faced numerous challenges due to extensive destruction. The development and transformation of this sector have

historically been irregular and dispersed. Moreover, neighborhoods with historical value have continually changed over time. Some of these areas were deserted and became worn-out, ineffective, and unstable. Over the decades, these processes have led to the deterioration of valuable structures, transforming neighborhoods into worn-out and unstable areas. Infill developments, in terms of building sustainability on large and small scales, are resistant and consolidate their place in the old texture by utilizing modern engineering science and construction techniques. Consequently, residents and local businesses have been motivated to rebuild the unsustainable buildings in the area.

Considering the rapid development of Mashhad city, especially in its central areas, infill development as a type of sustainable development can be a suitable solution to accelerate this process. The implementation of infill development, taking into account the dimensions of urban design planning—including mental-cognitive aesthetics, objective aesthetics, functional, environmental, and assessing the situation of the local area—can lead to cohesion in the urban fabric. This approach can create a physical environment that is responsive to the needs of citizens, improve the quality of the spatial structure, and achieve sustainable development in the surrounding context of the Holy Shrine.

Many studies have explored various dimensions of infill development, but there remains a need for a model and a coherent structure designed based on an infill development approach. This study aims to highlight the importance of implementing infill development in the historical and central areas of Mashhad city. It presents a model that outlines the urban design and policy-making factors influencing this type of development. Additionally, the study measures the interrelationships between the research indicators, demonstrating their effectiveness and interdependence. The conceptual model of the research illustrates the influential factors of urban design and planning (policy-making) in achieving infill development in the historical and central urban context of Mashhad. This study was conducted in the central and historical textures of Mashhad in 2023-2024.

## **BACKGROUND OF RESEARCH**

The concept of infill development was initially defined and used in 1979 by the American Real Estate Association for economic purposes. This type of development, first defined and explained for the economic growth of cities, gained additional prominence after being integrated with the concepts of

sustainable development at the Brundtland Conference in 1989. It then began to address other criteria, including physical, social, environmental, and cultural aspects (Asadbeigi, 2015). A key point in the literature is that measurements often aim to explain the relationship between infill constructions and historical textures. However, important issues such as evaluating the aftermath of development have rarely been discussed and appraised. Therefore, this research investigates the effects of these developments on the context.

Informed by the research topic, the relevant literature can be divided into two broad categories: international and domestic studies:

Gharebaglou et al. (2019), in their research entitled "Infill Architecture: an interdisciplinary approach for the design of historical textures," concluded that infill architecture, as an interdisciplinary approach in urban planning, considers parameters related to smart/sustainable development, modern urbanism, and specific goals in urban and architectural restoration. This approach incorporates conservative, contemporary, and moderate design in architecture. The interdisciplinary approach explores infill architecture as a reciprocal pattern between affecting domains.

Esmaelpoor and Shakibamanesh (2021) conducted research on measuring development capacity and ranking lands susceptible to infill development. They reported that the results of plot ranking were translated into a ranking map for neighborhoods in District 11 of Yazd. This study was informed by the capacity of lands prone to infill development in four areas: physical-spatial, administrative-institutional, economic, and demographic-social criteria. It highlighted the vast potential of the Mahmoudabad and Nasrabad neighborhoods compared to the Sajjadiyeh, Yazdbaf, Seyed Sahra, Jomhuri, and Kasnavieh neighborhoods.

Shafaati et al. (2022) explored the role of smart urban development in the infill development of the worn-out textures of District 8 of Tabriz. They identified seven major determinants of smart development: creativity (innovative spirit), sustainable management of resources, local access (sustainable, creative, and safe transportation), environmental protection, and flexibility.

Seyyedpour Esmaeilzadeh et al. (2022), in their research titled "Prioritizing the criteria of infill structure in historical textures in terms of economic sustainability: Case study of the vicinity of the historical market of Tabriz," found that the type of materials is a key factor underpinning the sustainable economic structure in this environment. Regional climate and cultural use were ranked second and third,

respectively. The guideline comprises 25 indicators and can assist designers in pursuing a clear path.

Rachi and Sultana (2023), in their research titled "Urban Infill Development Potential: An Approach Towards Future Urban Recovery Model (The Case Study of Kuril, Dhaka)," describe infill development as a potential method to address problems such as uncontrollable urban growth and the deterioration of the urban environment in social, physical, and cultural dimensions. The goal of this study is to tackle the identified problems in Kuril while proposing a healthy neighborhood that incorporates a variety of activities with the existing infrastructure and natural landscape. Through extensive review and site analysis, seven major problems in the Kuril area were identified. The study proposes several design solutions to address these issues, including a walkable network and accessibility, elevated walkways, and spaces for commercial and public activity integrated with a natural open setting to enliven the neighborhood.

Soveyzi et al. (2023), in their study titled "A Structural Analysis of Factors Influencing Infill Development in Brownfields: A Foresight Study Approach (Case Study: Bronsi Barracks, Mashhad)," analyzed the structural factors affecting the development of infill projects in the brownfields of Bronsi Barracks in Mashhad. They identified intervention priorities, noting that brownfield redevelopment is a strategy for reusing inactive lands and addressing land use problems in Iranian cities. This strategy not only improves the spatial and physical quality of cities but also contributes to sustainable communities and a higher quality of life, while safeguarding rural and agricultural lands. The study utilized the MICMAC method to identify factors influencing the redevelopment of these lands and their extent of influence. Additionally, it proposed and evaluated various redevelopment scenarios for the Bronsi Barracks site.

AlHasawi et al. (2024), in their research titled "Key Success Factors of Urban Infill Development: A Conceptual Framework," explained a conceptual framework based on 13 components effective for the successful implementation of infill development in dilapidated contexts and historical areas. The research methodology included a literature review and discussion of best international practices, leading to the development of a list of key success factors for infill development projects. This list was refined through expert reviews until the final version was approved. The result is a conceptual framework applicable to any city, ensuring that infill development projects are successful with the highest possible quality and have a positive impact on the city and its residents.

## MATERIALS AND METHODS

### Data Collection

This study is practical in terms of purpose, utilizing both quantitative and qualitative data. Various methods and software have been employed to collect research data through analytical techniques. In the first step, the meta-synthesis technique was applied using the systematic review method of library studies in the Scopus scientific database to analyze information from previous research. The results were then modeled and analyzed using Vos Viewer and online chart builder software.

Next, the discourse analysis technique was used to measure experts' opinions in completing the research model through semi-structured interviews. MAXQDA software was employed to model the findings obtained from these expert interviews. In the final step, using the analytical technique of MICMAC and measuring experts' opinions through a questionnaire, the extent and manner of the influences and dependencies of the research components on each other were investigated.

## RESULTS AND DISCUSSION

### Historical Texture

In Iran, historical texture generally describes urban contextures that date back to pre-contemporary periods, specifically tracing back to the Qajar period and the first Pahlavi period. These textures are inspired by the authentic and deep-rooted patterns of

Iranian architecture and urban planning. In cases where these textures exhibit greater antiquity, authenticity, historical and architectural richness, or demonstrate intact, unique, and entirely original patterns, the term "valuable" or "exceptional" textures is more appropriate (Habibi et al., 2010).

### Infill Development

The concept of infill development originated from discussions at the 1976 Habitat conference in Canada, as first proposed by Abbasi (2008). By 1979, the American Real Estate Association provided an official definition of infill development focused on economic goals (Farris, 2001). The idea gained further momentum in 1989 with the release of a report on sustainable development following the Brundtland Commission's conference. This report influenced subsequent documents like the 1990 CEC report and the 1993 Agenda 21 initiative, which were all grounded in the paradigm established in the 1970s around infill development (Ghasemi Shektai & HaghghatNaeini, 2013). These documents collectively enriched and expanded upon the concept of infill development within the framework of sustainable development.

Initially framed within an economic context, infill development acquired environmental significance through its integration with sustainable development principles. Today, one of the primary merits of infill development lies in its environmental advantages and its role in promoting sustainable urban development indicators (Steiner et al., 2006).

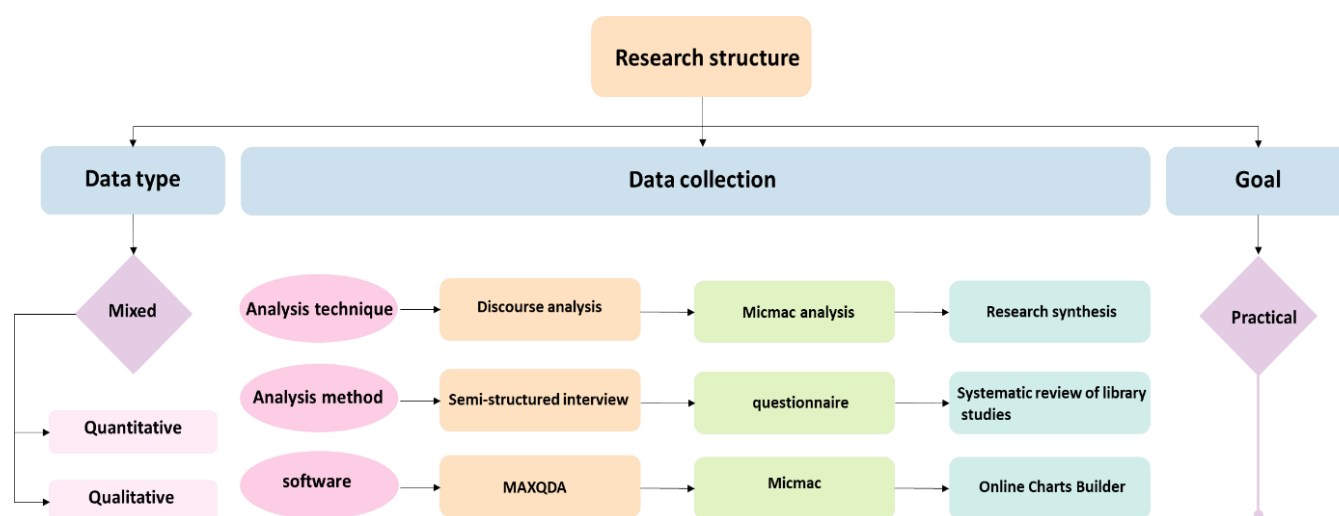


Fig 1. The structure of the research method

Infill buildings are defined as constructions that are added within the existing urban fabric and between other buildings. Simply put, when there are vacant spaces between existing structures, new constructions that fill these gaps are termed as infill buildings (Ghadiri & Arasteh, 2006). Urban infill development refers to the utilization of vacant or underused lands within urban areas. It involves the construction of new residences, workplaces, shops, and other facilities within the existing city boundaries. This development strategy can take various forms, such as building on vacant lots, introducing new functions into existing structures, or revitalizing and upgrading existing buildings (Roth, 2000). In this context, the analysis of infill development typically considers three theoretical approaches: macro, parallel, and complementary levels.

In the macro-level theoretical approaches, there is a strong emphasis on principles of sustainable development and modern urban development movements. This includes strategies such as intensifying physical density in urban areas, curbing urban sprawl, infilling existing urban fabric, promoting balanced density growth, renovating and reconstructing abandoned areas, revitalizing old buildings, reducing commuting distances, limiting motor vehicle use to cut environmental pollution, promoting walking, and diversifying uses in infill development initiatives.

In parallel theoretical approaches, the focus is on creating compact cities and promoting smart growth characterized by high-density developments, integrated land uses, collaborative decision-making, and creating opportunities for mixed-use developments. Complementary theoretical approaches center on mixed-use development and building around public transportation networks. These approaches

involve integrating various uses both horizontally and vertically within residential areas, with significant emphasis on enhancing public and pedestrian transportation networks. These strategies highlight the importance of preserving the coherent and original structure of central urban textures, particularly in historical contexts (Gharebaglou et al., 2019).

Table 1 in the study outlines these theoretical approaches to interventions in historical contexts, providing a structured overview of their respective strategies and objectives.

#### *Advantages and Restrictions of the Implementation of Urban Infill Development*

Infill development represents a significant strategy for reshaping the structure and character of cities. It brings about structural improvements by integrating new, modern buildings with resilient structures into existing urban environments. This diversity in physical structures, along with the use of varied forms and scales, can impart a fresh and distinctive appearance to urban textures, utilizing materials that harmonize with their surroundings. Furthermore, to facilitate segmented infill development, it becomes essential to delineate between fine-grained and coarse-grained areas. This segmentation alters the scale of permeability, enhancing optimal access to the urban fabric.

Infill development also serves as a revitalizing approach that promotes the preservation of authenticity within older urban textures. This type of development offers benefits and faces operational limitations across social, economic, physical, and environmental dimensions, which are detailed in Table 2.

**Table 1.** Approach of Conservation Groups to the New Structures in Historical Textures

Executive body	Charter / Congress	Date	Intervention field	Infill suggestion		
				Rejected	Probational	Accepted
CIAM	Charter of the Restoration of Athens	1931	Historical buildings		●	
	Athens Charter	1933	City			●
	Gubito Congress	1960	City	Insufficient Information to Determine the Approach		
UNESCO	Congress of Venice	1964	Historical buildings and complexes			●
	Paris meeting	1968	City			●
	Congress of Rome	1972	City			●
	Note on World Heritage and Contemporary Architecture	2005	City			●
	Recommendation on the Urban Landscape	2012	City			●
	Charter of New Zealand	2010	A single building and city			●
	Madrid Conference	2011	City			●

(Gharebaglou et al., 2019)  
*Introduction of the Study Area*

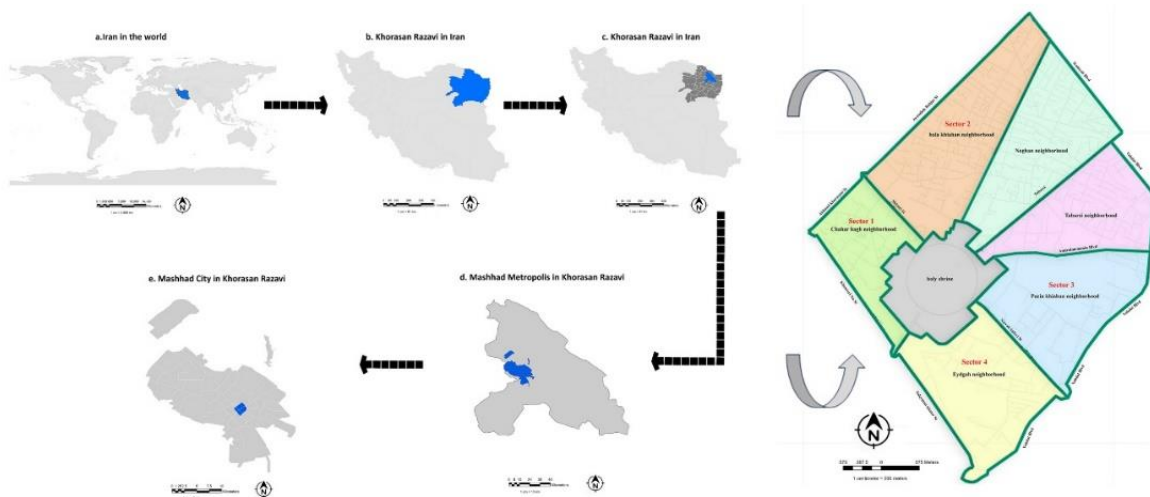
Covering an area of 366 hectares, the Samen area is home to the Holy Shrine of Imam Reza and its

surrounding area in the central area of Mashhad. This plot can be divided into 4 main sectors, as presented in Fig. 2.

**Table 2.** Advantages and Obstacles of the Execution of Infill Development

Obstacles to infill development	Dimension	Advantages of infill development	Dimension
1) People may not cooperate with the plan due to lack of information 2) Conflict between the interests of the municipality and developers	Social	1) Establish social justice 2) Promote urban identity 3) Curb crime rate 4) Enhance the sense of social belonging 5) Improve security 6) Improve the quality of neighborhood units and their renovation	Social
1) High costs of land acquisition and consolidation 2) High development costs 3) Extreme investment risk 4) Bureaucracy inherent in obtaining necessary permits	Economic	1) Cutting development costs 2) Reducing transportation costs 3) Creating job opportunities 4) Paving the way for private sector investment	Economic
1) Limiting the scale of construction due to the high cost of design and construction 2) Incompatibility of adjacent uses	Physical	1) Improving historical buildings 2) Protecting valuable sites 3) Reducing the traffic congestion 4) Fostering coordinated growth of the city by eliminating texture fragmentation 5) Contributing to the stability of the city structure and the potential of smart urban growth 6) Improving desirability and quality of neighborhood units	Physical
1) Environmental conditions and issues such as the risk of earthquakes and floods 2) Above-ground moisture 3) Weak soil and poor drainage	Environmental	1) Reducing the need for construction in greenspace and agricultural lands 2) Mitigating health issues and problems 3) Alleviating the negative effects of urban sprawl 4) Reducing traffic and transportation issues 5) Preventing indiscriminate urban development 6) Revitalizing and boosting the quality of the environment	Environmental

(Dadashpoor et al., 2014)



**Fig 2.** Geographical Location of the Study Area and Four Sectors of the Historical and Central Context of Mashhad in Iran  
The central texture of Mashhad City is defined by four sectors, with the Holy Razavi Shrine at its heart. Historically, this area has been the nucleus from which Mashhad city expanded, serving as the residential and commercial hub of the region. Over the past few decades, the development plan for the Razavi Shrine has led to substantial transformations in this texture across physical, social, environmental, and functional dimensions, often conflicting with its historical legacy. These changes have included significant physical alterations, the displacement of long-standing residents to other areas, the emergence of new commercial enterprises, and the partial destruction of its historical fabric. Consequently, these developments have resulted in notable environmental changes within this central area.

### *Structural and Functional Characteristics of the Research Area*

The term "in the vicinity of the holy shrine of Razavi" refers to the area surrounding the Holy Shrine of Hazrat Reza, situated at the heart of Mashhad's central zone. This area holds unique economic, social, historical, and traffic characteristics compared to other urban districts. It is primarily shaped to accommodate the millions of pilgrims who visit, influencing the services and activities offered in the vicinity. In contrast, other parts of Mashhad cater more to the daily needs of its residents and function accordingly within a typical urban setting. The influence of the Holy Shrine of Razavi extends throughout Mashhad, albeit with varying degrees of impact (University, 2020).

Over time, the development of the urban texture around the Holy Shrine has predominantly seen the establishment of hotels, commercial centers, and residential complexes. This development has often required measures such as demolition, leveling, and amalgamation of small plots to create space for new expansions.

The juxtaposition of new developments with the old organic texture has transformed the area, introducing a blend of modern and traditional architectural styles. Organic textures typically feature irregular access networks with winding streets and narrow alleys, resulting in low permeability. In contrast, new developments have enhanced site permeability by implementing wider and more structured access networks. The older central texture of Mashhad predominantly consists of buildings constructed from materials like stone, wood, clay, and mud, which can be less durable. In contrast, infill development has facilitated the construction of

modern buildings using robust materials, thereby contributing to structural resilience and longevity in the area.

In the central texture of Mashhad, commercial activities traditionally consisted of small-scale businesses catering to local needs. However, recent developments have introduced larger commercial complexes, bazaars, and markets. Residential usage in the area varies: some historic homes are being renovated, some are put up for sale, and others continue to be occupied as before. Conversely, new developments predominantly feature commercial complexes, hotels, apartments, and restaurants, each serving different functional scales and providing varied services across neighborhoods. Modern buildings are characterized by their uniform geometric shapes, contrasting with the organic structures of older buildings in the texture.

The significant demolition accompanying new developments has displaced many long-time residents of the central texture of Mashhad. Consequently, their established patterns of life and community relationships have diminished over time. The new constructions, catering primarily to transient pilgrims visiting the holy shrine, have not preserved the historical ways of life and livelihood patterns. This shift has led to substantial changes in the area's historical identity. Pilgrims and visitors utilizing facilities in the vicinity of the shrine typically do not develop strong ties or a sense of belonging to the neighborhoods, thereby contributing little effort to enhance local conditions.

### *Research Synthesis*

Studying the importance of research on infill development across various contexts is a significant concern in the academic community today. Researchers and experts alike are increasingly focusing on this topic due to its relevance in urban planning and development. Numerous studies have been conducted exploring different aspects of infill development, particularly in urban design and historical preservation contexts. These studies offer diverse perspectives and insights into the challenges and opportunities associated with infill development.

To assess the breadth and depth of research on infill development, the Scopus scientific database stands out as a comprehensive and reliable resource. It provides access to a wide array of scholarly articles and studies that delve into various facets of infill development. Researchers typically use keywords such as "infill development", "infill development in urban design", and "infill development in historical context" to





**Fig 4.** Graph of the Relation between Infill Development, Urban Planning, and Urban Design

The search results showed more than 300 researches conducted in connection with the research topic, out of which 240 researches were conducted from 2000 to 2023.

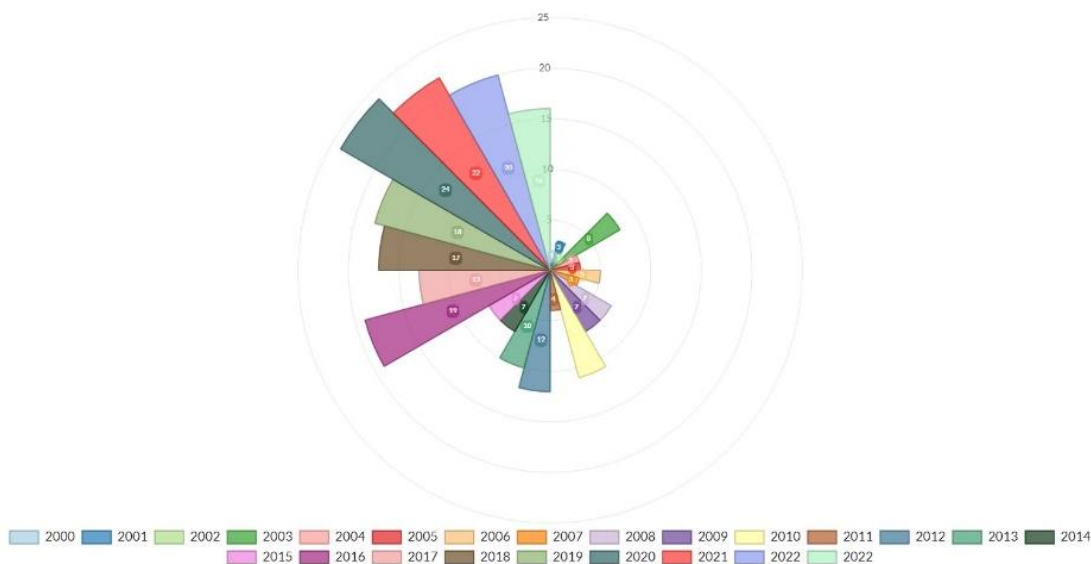
In the next step, the titles of the articles were carefully examined and monitored, based on the titles of 134 articles related to the research topic. In the next step, abstracts of selected articles were studied and reviewed, among which 46 articles are directly related to the research topic.

The results indicate that the number of researches related to infill development has increased showing an increase in attention to this issue.

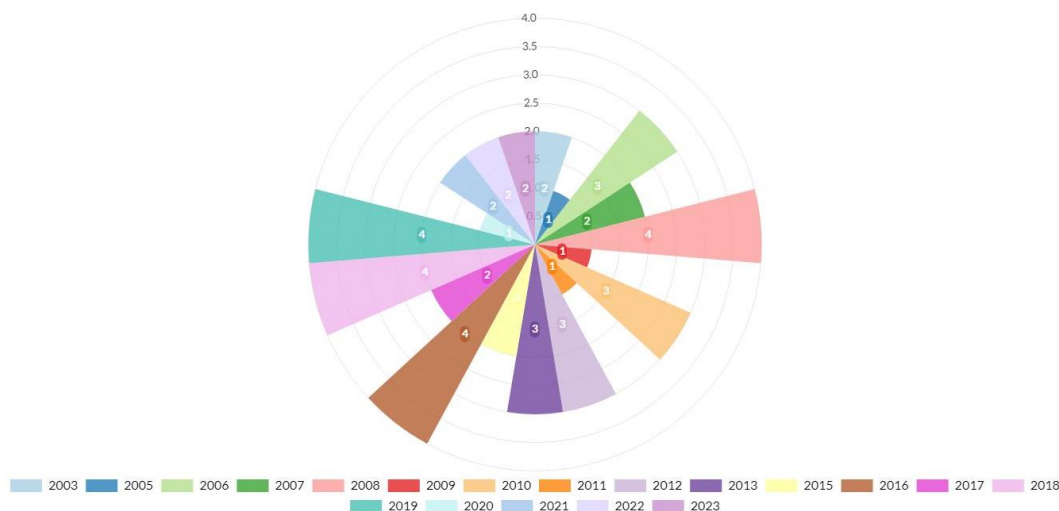
Based on the findings from the Scopus Scientific Database, research on infill development in urban design and historical contexts from 2000 to 2023 has been relatively limited globally. There is a noticeable

scarcity of studies focusing specifically on urban design, which is crucial for advancing infill development in historical settings. This research aims to fill this gap by elucidating the role of urban design and its potential in enhancing infill development within historical contexts.

Over 300 scholarly papers were systematically reviewed using the Scopus database, covering topics related to infill development, urban design, and historical contexts. The relevance of these papers was analyzed using Vos Viewer software, revealing their integration into fields such as urban planning, urban development, urban design, policy-making, and urbanization. A key novelty of this research lies in its exploration of infill development dimensions through the lens of urban design specifically within historical contexts.



**Fig 5.** The number of studies conducted on the topics of infill development, infill development in urban design, and infill development in a historical context





infill development. This study employed a survey methodology for data collection and evaluation, involving interviews with 15 experts comprising city planners, urban designers, and urban managers. The selection of interviewees aimed to ensure the

comprehensive exploration of the research conceptual model, which primarily focuses on urban design, policy-making, and urban development. The main and subcategories resulting from discourse analysis were categorized through coding, as detailed in Table 3.

**Table 3.** The model obtained from the analysis of experts' discourses using MAXQDA software

No.	Indicators(codes)	Components	Dimensions	Approaches
1	I1. Nodes			
2	I2. Paths			
3	I3. Districts	C1. Legibility		
4	I4. Edges			
5	I5. Landmarks			
6	I6. Sociocultural approaches	C2. Memorableness	D1. Mental-cognitive aesthetics	
7	I7. Symbols			
8	I8. Places for hangouts and behavioral centers			
9	I9. Color diversity in urban space	C3. Vitality		
10	I10. Age and gender diversity of space users			
11	I11. Proper and sufficient lighting	C4. Safety		
12	I12. View of the street			
13	I13. Building quality			
14	I14. Building age			
15	I15. Building structures	C5. Quality of the cityscape		
16	I16. Materials and details of façade			
17	I17. Scale and form of building		D2. Objective aesthetics	
18	I18. Diversity of urban physical structure			A. Urban design (Designing)
19	I19. Density			
20	I20. Extent of confinement	C6. Physical qualities of urban Spaces		
21	I21. Fine-grain			
22	I22. Permeability			
23	I23. Sustainability			
24	I24. Mixed-use Development			
25	I25. Optimal use of brown lands	C7. Land Uses		
26	I26. Diversity of activities			
27	I27. Distance from subway			
28	I28. Distance from the bus station	C8. Location in terms of accessibility to urban services	D3. Functional	
29	I29. Distance from public parking lots			
30	I30. Access to urban infrastructure			
31	I31. Green spaces			
32	I32. Road network and access network	C9. Qualities of Public Spaces		
33	I33. Municipal service reserve lands			
34	I34. Proper subdivision of public and private spaces			
35	I35. Residents' commitment and respect for the environment	C10. Environmental quality	D4. Environmental	
36	I36. Vegetation coverage			
37	I37. Climatic comfort			
38	I38. Land price			
39	I39. Design and construction costs	C11. Economic infrastructure		
40	I40. Size and area of land			
41	I41. Attachment and sense of belonging of residents	C12. Social capital	D5. Assessing the situation of the local area	A2. Urban planning (Policy-making)
42	I42. Cooperation and social interactions			
43	I43. Developing guidelines and instructions for urban design	C13. Considering references and sources of upstream development		
44	I44. Taking actions by redevelopment agencies			
45	I45. Updating plans, general designs and zoning codes			
46	I46. Adopting special plans and designs			

Table 3 presents a consolidated model integrating a systematic review and expert evaluation of urban design indicators and effective policymaking concerning infill development. Derived from a mixed qualitative study focused on Mashhad, this model is specifically tailored for implementing infill development in the historical and central contexts of the city.

*Assessing the Reliability and Validity of the Research Conceptual Model*

After presenting the model, it is crucial to validate and ensure its reliability. To achieve this, Scott's method was employed. Two expert coders specializing in urban design and familiar with infill development concepts were tasked with re-categorizing the open codes derived from the systematic review and expert interviews.

To measure the validity of the obtained model, between 10 and 20% of the total sample volume was selected by lottery. For this purpose, 9 indicators were selected from SPSS software using the Random Sample plugin. Then, three expert experts coded the indicators, and their agreement or non-agreement is shown in Table 4.

❖ *Observed Agreement Percentage*

After comparing the two codes, we get the sum of the cases of agreement (+), and then the percentage of these numbers is calculated. This number is called the percentage of observed agreement or Po.

$$Po = \frac{8 * 100}{9} = 88.88\%$$

❖ *Expected Agreement Percentage*

In this step, we calculate the percentage of expected agreement (Pe):

$$Pe = (0.26)^2 + (0.24)^2 + (0.24)^2 + (0.065)^2 + (0.195)^2 = 0.22505$$

❖ *Reliability*

$\pi=0.85$  means that there is an 85% similarity between the two codes in terms of categories, considering the five related subcategories. The agreement criterion between two coders fluctuates between zero and one. When  $\pi=0$ , it means there is no agreement and similarity between the coders. When  $\pi=1$ , it means that two coders have coded the same category. According to  $\pi=0.85$ , it can be concluded that the coding of the categories is comprehensive and as a result, the accuracy of the research can be assured.

$$\pi = \frac{0.8888 - 0.22505}{1 - 0.22505} = 0.8565$$

According to the number of voting codes, the observed percentage of agreement has been calculated, and then the expected percentage of agreement has been obtained according to Scott's formula. Then, according to the presented formula, the reliability test was measured, and the result of the reliability test was 85% confidence. In this step, we prepare the frequency distribution table of each variable for which we want to calculate the reliability coefficient. For example, in Table 5. the number of indicators related to the five dimensions of subjective aesthetics, objective aesthetics, functional aesthetics, environmental, evaluation of the local area, and their frequency percentage is given.

**Table 4.** The Agreement of the Coded Samples

Random numbers	The first coder	The second coder	Agreement (+) or disagreement (-) regarding the classification of codes
7	1	1	+
20	2	2	+
26	3	3	+
27	3	3	+
35	4	5	-
36	4	4	+
38	5	5	+
43	5	5	+
45	5	5	+

**Table 5.** Frequency Distribution of Content Style

No.	Dimensions	Number of Dimensions	Percentage abundance
1	Mental-cognitive Aesthetics	12	26%
2	Objective Aesthetics	11	24%
3	Functional	11	24%
4	Environmental	3	6.5%

5	Assessing the Situation of the Local Area	9	19.5%
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*MICMAC Analysis*

MICMAC analysis, which stands for Matrice d'Impacts Croisés-Multiplication Appliquée à un Classement (Cross-Impact Matrix-Applied to Classification), is a method used to graphically represent variables based on their influence and dependence in structural-interpretive modeling. It establishes a coordinate system where variables are categorized into four quadrants based on their strength of influence and dependence. This analysis allows for a deeper exploration of the extent and relationships of each variable within the model (Habibi & Afridi, 2022).

The MICMAC analysis technique is employed to assess relationships among indicators. It utilizes the Matrix of Cross-Impact Multiplications Applied to a Classification (MICMAC) method, which is a form of prospective structural analysis. This method is utilized to examine relationships between factors (Chandramowli et al., 2011; Saxena et al., 1990). In MICMAC analysis, factors are categorized into four clusters based on their influence and dependence power:

- A) Autonomous Factors (factors that are relatively isolated from the system and have a weak dependence on other factors).
- B) Dependent Factors (most dependent on other factors).
- C) Linkage Factors (factors that are unstable and affect others more).

D) Independent Factors (factors that are weakly influenced by other factors and should be given maximum attention due to strong key factors) (Ahmad et al., 2019).

MICMAC software is a freely available tool designed for structural-interpretive studies. It facilitates complex calculations involving cross-impact matrices for prospective research. The software operates by initially identifying key variables and components within the target area, which are then inputted into the matrix. In this matrix, variables in the rows impact variables in the columns, thereby indicating which variables are influential (Habibi & Afridi, 2022).

The degree of influence and dependency is calculated directly and indirectly according to each component in Table 6.

According to the results of the analysis based on the influence and dependence map of each component, land use has the most direct influence, considering references and sources of upstream development have the most indirect influence, Vitality has the most direct dependence, and memorableness has the most indirect dependence.

Also, the graph obtained from the analysis shows that the Vitality, Land Uses, and Quality of the Cityscape have the strongest influence.

**Table 6.** The Influence and Dependency of Research Components

Rank	Label	Direct influence	Label	Direct dependence	Label	Indirect influence	Label	Indirect dependence
1	C7	1133	C3	1174	C13	1242	C2	1219
2	C13	1133	C2	1133	C7	1142	C3	1189
3	C5	1052	C4	1052	C5	1043	C4	1124
4	C8	931	C11	1012	C8	980	C11	1041
5	C3	890	C12	890	C3	862	C12	919
6	C6	850	C1	769	C6	821	C1	788
7	C10	809	C9	769	C10	817	C9	756
8	C1	769	C5	728	C1	734	C5	686
9	C9	688	C7	728	C9	658	C7	668
10	C4	566	C6	607	C11	593	C10	580
11	C11	485	C10	607	C4	540	C6	564
12	C2	445	C8	445	C2	374	C8	382
13	C12	242	C13	80	C12	188	C13	78

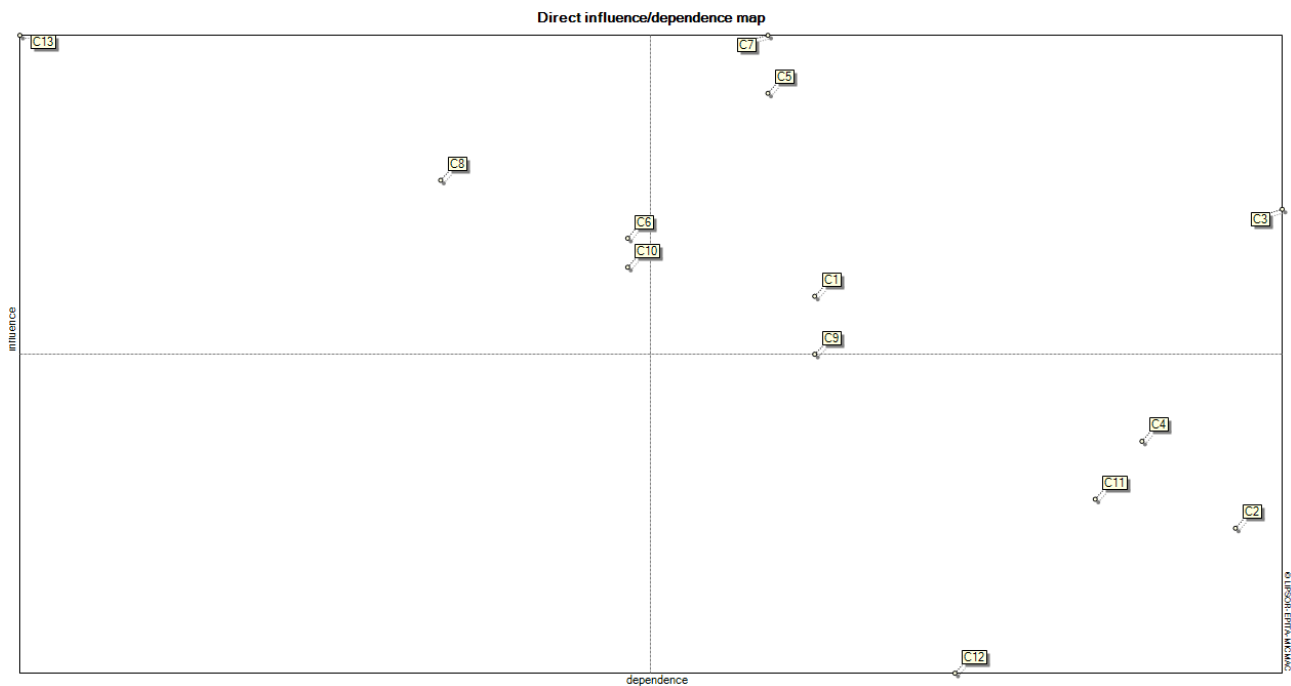


Fig 8. The Influences and Dependency of Research Components on Each Other

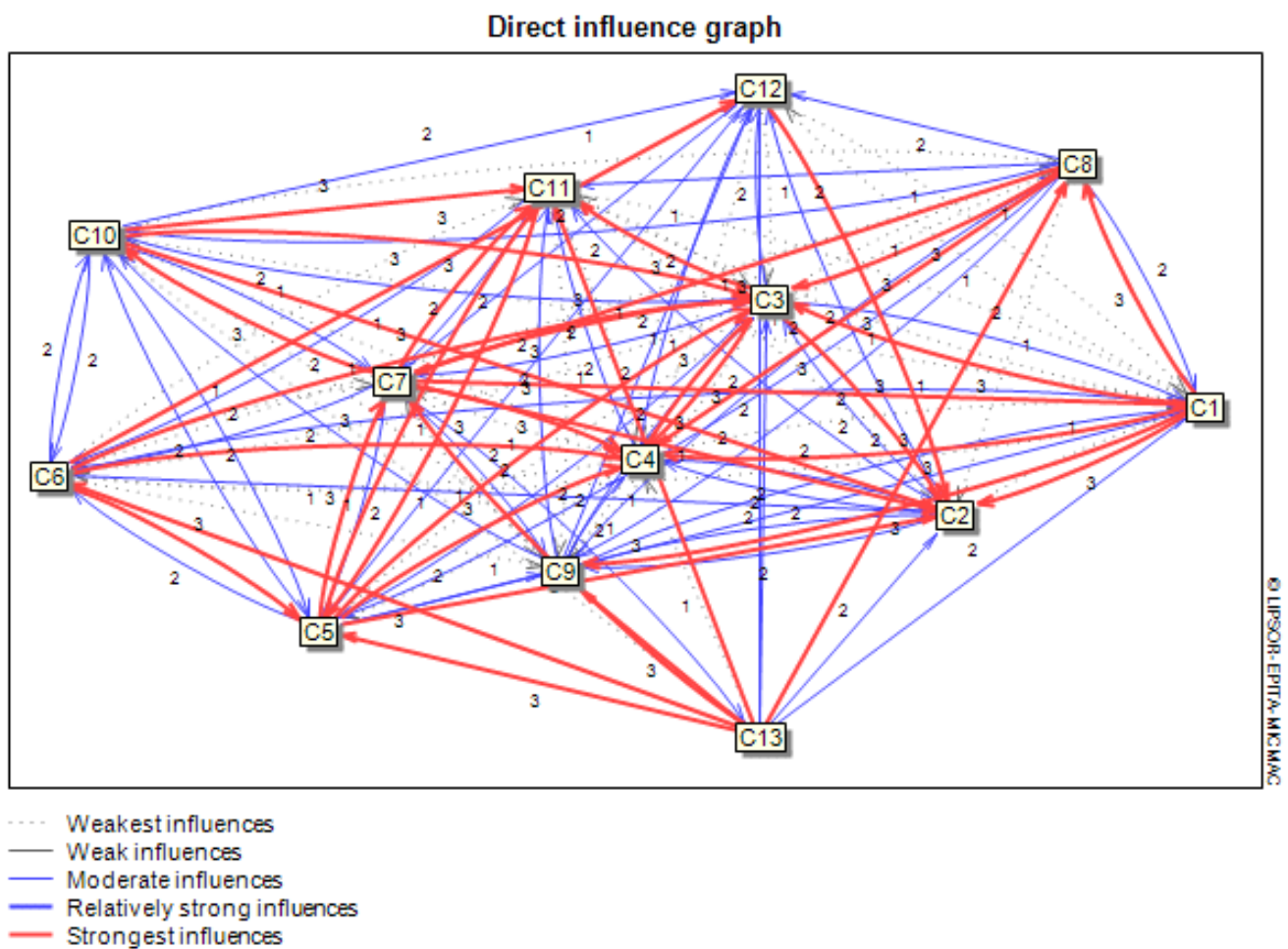


Fig 9. Graph of the Extent and Influences of the Research Components on Each Other

### *Modeling Based on Design and Policy-making Approaches*

Urban design, as a distinct and interdisciplinary field, plays a crucial role in preserving historically significant textures. Introducing a novel approach, such as infill development, can effectively consolidate these historical textures by upholding their intrinsic values. This approach not only enhances the physical structure of the texture but also promotes sustainability and elevates spatial qualities within it.

In broad terms, urban design can be categorized into planning and policy-making, with planning focusing on substantive dimensions and policy-making addressing procedural aspects (Golkar, 2008). The planning dimension generally encompasses four main criteria: objective aesthetic, mental-perceptual, functional, and environmental considerations. Specifically, when applied in the context of infill development, each of these dimensions includes distinct components and indicators, which are typically detailed in Figure 10 of relevant studies.

Objective aesthetics, particularly through the lens of urban morphology, represents a fundamental approach to studying urban structure within urban geography. Urban morphology is defined as the study of the shape, form, external structure, or organizational method of cities (Shahivandi et al., 2011). This discipline suggests that human behaviors and values are embedded within the physical fabric of cities, and investigating urban morphology can reveal underlying human values implicitly.

Urban morphology primarily focuses on understanding cities as physical environments, establishing an indirect connection between spatial and material elements and their deeper social and economic influences (Weaver & Oppermann, 2000). Key factors contributing to objective aesthetics include building quality, age of buildings, architectural styles, density, materials used, facade details, the degree of enclosure in urban spaces, scale and form of buildings, fine-grained characteristics of urban fabric, permeability of urban spaces, sustainability features, and physical diversity.

Mental-cognitive aesthetics, or perception in a broader context, encompasses human awareness and understanding of the external and internal worlds, a concept that has been fundamental to human knowledge since ancient times. Perception begins with the basic encounter of humans with their immediate surroundings and involves interpreting the environment and situations (Snaith & Haley, 1999). It is influenced by various stimuli including past experiences, expectations, emotional and cognitive

states, and the decisions and intentions of the perceiver (Pourang et al., 2020).

In urban design, mental-cognitive aesthetics goes beyond sensory perception to include how people use their senses to comprehend and interact with their surroundings (Bell, 2019). Key considerations within this indicator for planning the historical texture of Mashhad include legibility, memorability, vitality, and security. Enhancing legibility involves improving the clarity and coherence of urban elements such as nodes, paths, districts, landmarks, and edges, as outlined by Lynch's urban design principles. Strengthening identity symbols and cultural events can enhance the memorability of the urban fabric, making it more distinctive and memorable. Creating vibrant public spaces that cater to diverse age groups and genders, utilizing cheerful colors, and preserving communal gathering areas are strategies to enhance the vitality of urban spaces and improve the mental-perceptual aesthetic indicator.

In the functional dimension of urban design, service quality involves balancing customer perceptions and expectations through two key dimensions: technical quality and performance quality (Bahraini & Tabibian, 1998). A critical component of the functional dimension is the quality of access and the efficiency of public spaces in accommodating users. Land use diversity and operational mechanisms play pivotal roles in enhancing performance quality. Infill development strategies, such as integrating mixed-use developments, repurposing brownfields, and promoting diverse activities, can significantly contribute to improving performance quality.

The scale and timeliness of access to urban services, including public transportation, parking facilities, and essential infrastructure, are crucial considerations in infill development within urban textures. Emphasizing the quality of public spaces, including green areas, urban parks, road networks, and access points, and optimizing the separation of private and public spaces, are strategies that can enhance the functionality of urban areas. These efforts are instrumental in facilitating optimal infill development within urban contexts, thereby improving overall urban livability and functionality.

The environmental dimension of infill development has significantly impacted urban spaces, particularly in historical contexts, focusing on factors such as bioclimatic comfort, vegetation, and ecosystem preservation. Emphasizing vegetation types that suit the local climate, considering bioclimatic comfort across seasons, and fostering a culture of ecological stewardship among residents are crucial steps toward enhancing environmental quality at these sites.

Social capital functions as a cohesive force that binds various segments of society together, facilitating actions such as cooperation and social support (Daviran & Ahmadi, 2020). Individual social capital emerges within interpersonal communication networks, whereas organizational social capital stems from communication networks between organizations (Ballet et al., 2007). This theory encompasses several underlying indicators, including residents' attachment and sense of belonging, social participation, and interactions, all of which interact dynamically and mutually reinforce each other. An essential aspect of policymaking in infill development is the emphasis on references and sources. Key components include formulating instructions and guidelines for urban design, implementing initiatives through redevelopment agencies, updating programs, general plans, and zoning codes, as well as leveraging specialized programs and plans.

From an economic standpoint, considerations in infill development should encompass factors such as land value, estimated design and construction costs, and the scale of the planned developments.

Adopting a policy-making approach that integrates economic infrastructure, social capital, and the utilization of available resources can effectively guide urban design initiatives toward achieving successful infill development and enhancing the quality of

historical contexts. Figure 10 illustrates this policy-making modeling approach.

## CONCLUSION

Certainly, among the diverse forms of urban development, infill development stands out as one of the most crucial and efficient approaches. It serves as a practical method to foster stability within urban contexts, preserve historical identities, establish distinctiveness and clarity, curb urban sprawl, and meet the needs of local communities and residents.

Analyzing selected indicators in infill development modeling provides effective strategies for enhancing the significance of central urban textures, which embody urban identity. Modeling offers a straightforward and efficient approach for reconstructing and revitalizing historical and central urban textures, particularly in large cities. This paper presents analyses from multiple perspectives within urban planning and design. From an aesthetic standpoint, strategies include improving and renovating buildings of historical value, refurbishing deteriorated areas according to construction standards, regulating residential density to prevent overcrowding, and using materials that harmonize with the historical context of the area.

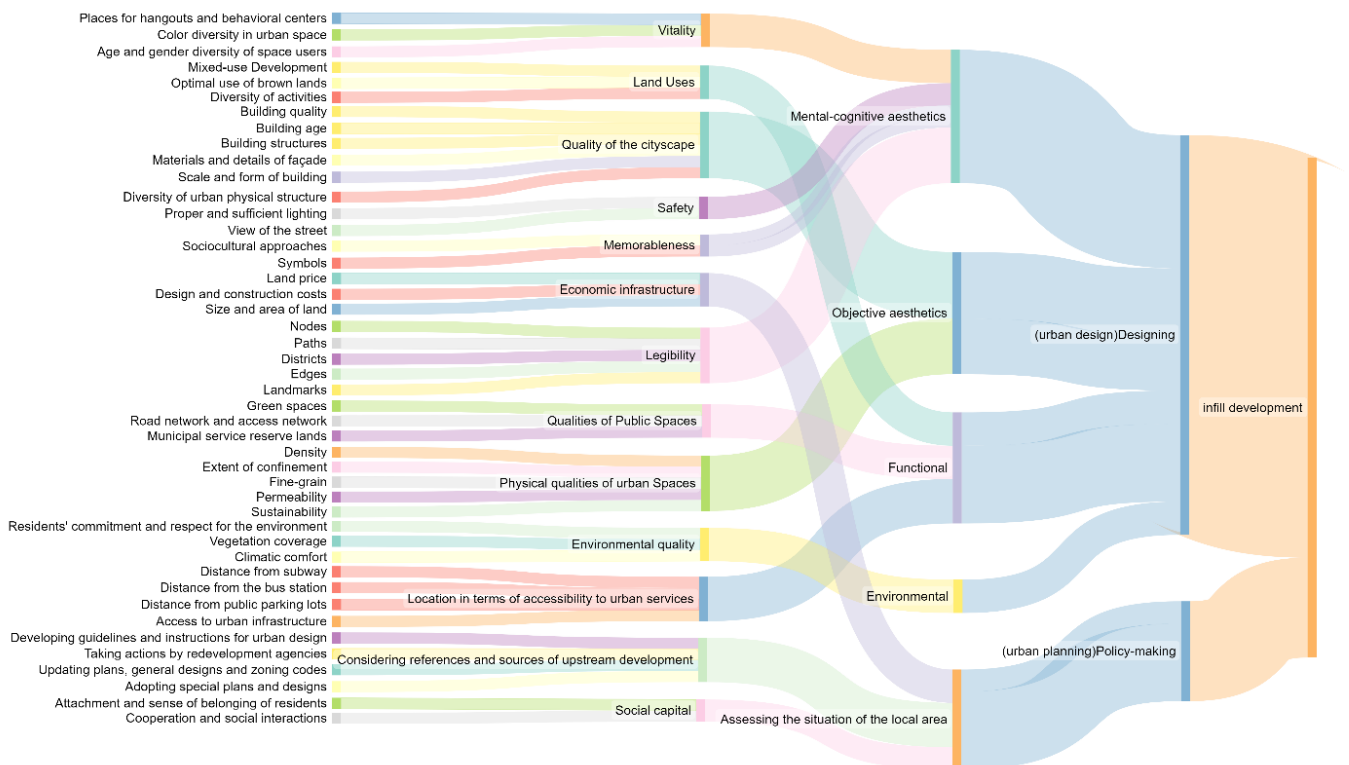


Fig 10. Conceptual Model of Research



In the aesthetic (mental-perceptual) dimension, enhancing legibility by integrating historically significant symbols that resonate with the context and creating suitable spatial platforms for events can elevate the status and characteristics of infill development within urban textures. Functions play a pivotal role in infill development within these textures, encompassing efforts to improve accessibility across all modes of transportation and prioritizing privacy in both public and private spaces.

In the environmental dimension, key solutions include designing vegetation and landscapes that are suitable for the local climate, promoting environmental principles among residents, and cultivating a culture that respects ecological values. Optimal spatial design is also crucial in enhancing environmental quality. Effective strategies for revitalizing central urban areas involve comprehensive planning and policy-making in urban design. This approach focuses on three main categories: economic infrastructure, social capital, and referencing and upstream development.

In terms of economic infrastructure, two key solutions include providing essential economic amenities like banking facilities to encourage residents to reside in urban textures, and organizing and supporting small-scale vendors.

To enhance social capital within these textures, it is vital to persuade residents to engage actively with infill development initiatives, fostering cooperation and interaction among them.

Adhering to upstream documents and regulations established by supervising authorities is proposed as a critical approach to ensure compliance with principles and rules stipulated by governing bodies and regulatory documents.

By employing the tools of urban design and policy-making, this research has advanced a comprehensive and practical model to elucidate effective factors for implementing infill development in the historical and central areas of Mashhad City. Thus, applying this model, which includes enhancing functional qualities, mental-perceptual and objective aesthetic aspects, environmental considerations, and assessing the local area's conditions, marks a significant stride towards implementing infill development while preserving Mashhad's historical identity. This study serves as a starting point for further exploration in infill development, encouraging future researchers to investigate additional dimensions of this approach for the potential generalization of development models to other study samples.

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**HOW TO CITE THIS ARTICLE**

Nazarabadian, M., Razmaramina, M., Pilehvar, A. (2024). Explaining the Model of Promoting Infill Development by Urban Design in a Historical Context of Mashhad Metropolis. *Int. J. Architect. Eng. Urban Plan*, 34(2): 1-19, <https://dx.doi.org/ijaup.825>.

URL: <http://ijaup.iust.ac.ir>

