International Journal of Architecture and Urban Development
Vol. 14, No. 2, P .Spring 2024

E-ISSN 2345-2331
Applied Research Article

Evaluation of the Spatial Structure Transformation in Traditional Iranian Houses, in Combination with Urban Space of Tehran's First Modern Streets

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Recieved 2023.09.22 ; Accepted 2024.05.26

ABSTRACT: Iranian traditional architecture has been changed by modernity during the era of Naser al-Din Shah Qajar. This led to a combination of residential context and the first modern streets of the capital. In addition, this development creates new residential spaces above commercial functions, challenges traditional values, and responds to residents' activities and interactions. The main goals of the research are, firstly, achieving residential patterns in combination with urban space and, secondly, changing the concept of traditional values in Iran in this era. Residential spaces in the streets of Lalezar, Ala-al-Dawa, and Sani-al-Dowleh and the passageways between them are studied. Four mansions with traditional residential patterns and six modern-style apartments were selected as deliberate case studies. The residential plans are based on field surveys and reports from the cultural heritage ministry. The connectivity, integration, and depth measurement components were conducted using quantitative analysis tools such as E-Graph and DepthMap software, which are space syntax analysis instruments. The comparative assessment led to some changes, such as omitting traditional elements like the courtyard and entrances and altering the nature of some spaces like the living room. The result of research via deductive reasoning explains changes in the qualities of some values in Iranian traditional architecture. These qualities are privacy and hierarchy. The main reasons for these changes are having the balconies in the first floor like the older model but facing the street and locating most spaces in similar depths.

Keywords: *Traditional and Modern Residential Patterns, Space Syntax, First Modern Streets of Tehran, Values of Traditional Architecture.*

INTRODUCTION

The city's spatial structure in Iranian society until the mid-reign of Naser al-Din Shah Qajar should be characterized as a traditional phenomenon. During this period, houses were designed strictly to the prevailing Islamic society's principles and moral standards. The preservation of privacy and the hierarchical order were important in urban planning. The connections and arrangement of spaces were thoroughly woven into the culture and relationships in Iranian families (Jalili & Akbari, 2015). Consequently, the architectural designs of residential houses up to this point are often denoted as conforming to the traditional settlement pattern. Modernism began to expand during the Naseri era, exerting deep influences on urban elements and paving the way for fundamental changes. The boundaries of the capital expanded, with narrow alleys evolving into wide streets, areas such as Lalezar Gardens and Negarestan, previously situated outside the city, were integrated into the urban fabric, and then north-to-south streets of Lalezar, Ala al-Dowleh (Ferdowsi) and Sani al-Dowleh (Sadi) were constructed parallel to each other. Due to substantial changes in the street network, two major features of the urban structure occurred during this period: 1. The gradual and continuous growth of the previous pattern, 2. The initial stages of significant alterations in the primary city's core structure, shifting from the previous pattern to a modernized one. Analyzing these traits through the study of affected residential spaces unveils a profound transformation in how individuals within society inhabit their environments, subsequently shaping their behavioral patterns and conduct. This, in turn, reflects the novel preferences of space users and represents a fresh lifestyle. Hence, one of the fundamental requirements of contemporary

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architectural research in Iran involves investigating shifting the settlement pattern from tradition to modernity. In this context, the houses under examination can be categorized into two primary groups within the mentioned three streets: A) Spacious houses located within the passageways, experiencing minor alterations to the traditional pattern due to modernity. B) Compact houses positioned above street-level shops are undergoing significant changes and introducing new spatial definitions. This research aims to identify alterations in spatial configuration and arrangement during the transition from the traditional pattern to the modern pattern within this transient period. To achieve this goal, the investigation focuses on the increase or decrease in spaces in the floor plan, considering house size, the separation of private and public areas, the presence of service spaces in the two desired patterns, and the extent of changes in space utilization, which are regarded as the most significant factors. The primary question revolves around how alterations in the definition and quality of traditional Iranian architectural space arrangements have given rise to a new residential pattern. We investigate houses located within passageways and along street edges to address this. We then apply space syntax analysis to connectivity, depth, and integration concepts. The objective is to understand the new spatial configuration and changes introduced into the traditional housing pattern, thereby exposing modern elements and altered concepts. The reduction in spatial area has had a significant influence, resulting in the closing of private and public spaces, a change in certain areas, fundamentally affecting traditional values. In this study, we aim to investigate and prove this hypothesis.

Research Background

To get to know traditional Iranian architecture, specifically the physical characteristics and the function of house elements, many researchers have delved into analyzing the spatial shifts from older eras until the contemporary period. (Habibi & Choulaei, 2015) Conducted a comparative analysis of Islamic and modern elements in Iranian urban settings and studied the qualitative aspects of form, function, and meaning in transitioning from traditional houses to apartments. They identified the weakening of certain attributes, such as architectural values, social interactions, livelihood, and comfort, while enhancing visual aesthetics and privacy and preserving previous elements, such as accessibility, comprehensibility, and efficiency. In the other research conducted by (Maddahi & Memarian, 2017), the manner of alterations in the configuration and spatial organization of native-traditional houses was obtained using instruments such as activity (i.e., behavioral systems) and passage of time. As a consequence, there was a significant reduction in the functional role of courtyards, decreased integration, and a diminished relationship between the porch and other spaces, the transformation of the living room from semi-private to semi-public, along with the omission of alcoves and vestibules at entrances starting from the Pahlavi era. (Jalili & Akbari, 2015) Identified the influential factors in housing changes and studied alterations in the form of residential plans from the Qajar to the Second Pahlavi era. It was observed that introducing Western culture to Iran and its infusion with traditional and native architecture brought about changes in privacy, a shift from extroversion to introversion, shrinkage of interior home spaces, integration of private and public spaces, and changes in access methods. These transformations indicate a shift in consumer mentality from tradition to modernity. Clinging to the privacy principles of Qajar layouts while tending to adhere to Western cultural patterns and mixing them with tradition gave birth to modern Iranian architecture. Minimal extroversive forms in layouts characterize it during the Pahlavi period. Furthermore, the article published (Zarei & Yeganeh, 2018) recognized the influential factors affecting spatial integration and social relationships within spaces using the space syntax technique in traditional houses in Kashan. The results, obtained from the Space Syntax and DepthMap software, indicate that The presence of four categories, including public, semi-public, semi-private, and private spaces, along with deep micro spaces with appropriate integration, lead to the creation of an effective model for interactions within these areas. Spaces with higher levels of privacy present greater depth with lower integration, while more public and crowded spaces present shallower depth and higher integration. The courtyard exhibits the highest level of integration, followed by an arcade, an anteroom leading to the hall with greater depth, the five-door space as a semi-private area, then the three-door and two-door, and finally, the private room. The research paper authored by (Bagheri et al., 2015) discusses the investigation of architectural patterns across three scales: macro, intermediate, and micro. The analysis includes spatial aspects (interactions with the environment, spatial diversity, architectural and furnishing details) and perceptual-behavioral aspects (interactions with nature, sensorial, behavioral, and emotional impact on residents). The findings indicate that traditional housing in Zanjan, up to the Qajar period, exhibited dynamic and active spatial-behavioral patterns, while contemporary housing (comprising Pahlavi-era villas and present-day apartments) has transitioned towards static and inactive patterns. The study suggests that by identifying efficient contemporary residential patterns and designing homes based on natural and human behavioral models, it is feasible to create stable resident-compatible houses, and by deeply considering the residents' cultural patterns, the residency pattern language is retrievable. These studies have investigated the spatial configuration of residential homes during different eras, offering valuable insights. However, little attention has been paid to the spatial arrangement within compact houses, especially along the initial modern streets of the capital, to explore the changes from traditional to modern patterns. Therefore, addressing this research gap is essential for finding significant solutions for contemporary housing architecture in Iran.

Theoretical Framework

Residential Space Components (Shell Elements of Traditional Iranian Houses)

In the architectural aspect of Iranian houses, the harmony between spatial elements and establishing a hierarchical structure, along with factors like culture and individual and communal psychological needs, have contributed to developing a cohesive framework and an organized system. Therefore, this section aims to define certain shell elements in traditional houses.

Traditional house spaces are arranged both horizontally and vertically. Horizontally, they are structured based on a hierarchical access system from the exterior (public domain) and layers of illumination

relative to the courtyard's central core. Vertically, their configuration is determined by the flow of water and elevation. The entrance portal, vestibule, corridor, and courtyard form a sequence of spaces that, while preserving the inner garden's privacy, allow access to the house's inner space. Consequently, the entrance area exhibits limited connectivity and integration, and the courtyard has the highest level of control, choice, and connectivity among the various spaces. The layers surrounding the courtyard are primarily occupied by various room spaces that have direct contact with light, water, plants, air, and, more broadly, the inner garden. These spaces include the three-door room, five-door room, two-door room, single room, hall, windcatcher, sash window, the upper chamber, squinch, and estrade, and they are located around the courtyard. The hall (or Korbal) could be found in winter and summer chambers. A series of columns are placed in front of the halls to ensure structural stability. On average, the hall exhibits the highest level of connectivity, followed by the five-door, three-door, two-door, and single rooms. Adjacent to the hall are wide corridors known as "estrades," leading to a staircase that provides access to the basement and the upper chamber.

The upper chamber is located above the estrade. It is a cozy space with a low ceiling of the three-door room type, suitable for various activities such as sleeping, working, and dining. The upper chambers facing the hall were commonly known as "squinches." The hall had a double-layered ceiling design, and large three-piece sash windows structures were installed in specific locations. Within most households, the hall and the five-door room were designated for guest gatherings and semi-private functions, while the three-door, two-door, and private chambers offered the highest level of privacy. The alcove is a room section resembling a porch but lacking direct courtyard access. It is located slightly above the room floor level and typically features a five-door arrangement. This space was often used for large gatherings or served as the grand living area of the house. Access to the alcove could be obtained through side corridors or one of the smaller adjacent rooms. In the second layer from the courtyard, spaces primarily relied on ceiling lighting due to their distance from the courtyard. This layer included the kitchen, vestibule, backroom, storage room, and water reservoir. The kitchen consists of sections for water, a pantry, a storage room, and a house well, typically structured in square and rectangular formats (Ekhlas, Maryam & Ekhlas, Milad, 2014). The kitchen was connected to the vestibule and the winter chambers, ensuring its accessibility to the guest room and a water source via a water stream, so it was positioned beside the vertical axis of the downstream. The latrine was constructed beneath one of the corner rooms within the courtyard, typically beneath the three-door room or the estrade. The latrine means "a place to pour sewage water" and was positioned beside the toilet.

The springhouse is a kind of summer chamber, often characterized by its octagonal design. It played a significant role in shaping the overall spatial layout and adding aesthetic appeal to specific houses. They acted as connectors between summer and winter chambers or between multiple courtyards, functioning as transitional, semi-open spaces bridging the gap between open and closed areas or between the indoors and outdoors. The role of these chambers was to provide a delightful space and interior comfort. Rooms were built around the summer chambers, typically raised about one meter above the inner summer chamber's floor or the pool's surface. These rooms served as seating areas and were connected to the inner summer chamber through wooden doors. Occasionally, they received natural light from the surrounding springhouse space through windows (Nakhaipour Tazeraj et al., 2016).

Architectural Space Syntax

The space syntax approach became popular in England during the early 1970s. Initially introduced by Stephen Bill Hillier and Julian Hansen, it gave birth to a novel morphology approach to architectural discourse. Researchers in this field aim to find social relationships within spaces, such as boundaries and the privacy/public characteristics of spaces. They have harnessed explanatory diagrams (Memarian, 2008). This methodology includes investigating people's movement patterns, interactions, density, land usage, and land value. According to Brown, one of the best advantages of explanatory diagrams is their visual clarity. This diagram simplifies and presents buildings' architectural structures and layouts straightforwardly (Soheili & Arefian, 2016). Memarian suggests that space syntax is a methodology that has been somewhat employed in analyzing various building spaces, especially residential ones. He believes that the primary concern of these scholars is to find the generative factors and concealed patterns or genotypes that exist beyond the shapes or spatial forms (Memarian, 2008). Hillier, on the other hand, aside from defining the relationship between activity and space within the individual characteristics of space, mostly finds it comprehendible in the existing connections between spaces, also referred to as spatial configurations, and the connections between the audience and social interactions (Hillier, 2007). Beyond assessing the specific characteristics of individual spaces, spatial configuration in architectural research and urban planning centers on their interconnection. To provide a more professional interpretation of spatial configuration, Hillier utilizes the illustration of three houses with central courtyards, with the only apparent difference among these three structures being the placement of openings and the connections between spaces. In his perspective, this mere distinction is enough for these three residences to display fundamental spatial layout and configuration differences. This fundamental distinction becomes bolder when we investigate its impact on how a viewer experiences a space. Hillier introduces space using nodes, represents the connection between two spaces with edges, and refers to the combination of nodes and edges as graphs. These graphs fundamentally illustrate how spaces within each house relate to one another and serve as a pattern for how a viewer can engage with each house. Consequently, he identifies the most influential characteristic in experiencing a house as how spaces interconnect and labels it as spatial configuration. He then proceeds to claim that this perspective on space lets social behaviors, usually interpreted as qualitative factors, be interpreted as quantitative ones. He states that spatial configurations in a building or a city can be graphically analyzed, and this approach enables the transformation of a qualitative phenomenon into a quantitative one through mathematical graph analysis (Hillier, 2007). The space syntax perspective employs five key indices to examine the cultural and social features of patterns: the connectivity index, which counts the direct connections between points; the integration index, measuring the level of cohesion or

separation of a point from the overall system or a lower-level system; the control index, which defines a point's degree of authority over connected points; the choice index, offering a general measure of the number of shortest path links connecting spaces; and finally, the depth index, which calculates the number of steps required to be taken from one point to others. There is a linear relationship between the integration index and connectivity index, such that increased integration of space equals a higher level of connectivity with other spaces. This principle also applies to the control and choice indexes, meaning that as a point has a lower level of choice than another point, the level of control over it is also lower (Latifi et al., 2017). E-Graph software is used to design and study these graphs. Also, three primary concepts in space syntax analysis include convex space, axial space, and visible space. Convex space is an area where no line connecting two points within it cuts through the surrounding space. Hence, a "concave space" should be divided into fewer smaller convex spaces. On the other hand, axial space is characterized by an understandable pedestrian path, while visible space includes all the areas that can be observed from a specific point. Accordingly, three analysis systems for space syntax are identified: axial, convex, and visible (Maddahi & Memarian, 2017). This analysis is carried out using DepthMap software, and in this article, convex space analysis is specifically used. It is defined as a method employed to investigate social interactions within spaces, and the spaces are assumed in such a way as to display non-linear behavior (similar to a room) and contain spaces within them (similar to the arrangement of elements within a room) (Maddahi & Memarian, 2017). Spatial integration leads to adjusting the interactions among residents and between residents and guests, creating an efficient and permeable space (Ataei et al., 2022). In the convex space analysis approach, all points within a convex space can be connected to other points within that area without crossing spatial boundaries. In other words, two individuals standing at any point within a convex space can see each other. Convex space is employed for spatial functions and human activities such as standing and sitting (Heidari & Farhady, 2017). Visual Graph Analysis (VGA) is utilized to assess visual interactions using a chessboard network map based on an Isovist analysis (Ataei et al., 2022). In the output graph of each index, a color spectrum from red to blue represents the range from maximum to minimum values (Kamalipour et al., 2012).

MATERIALS AND METHODS

Methodology

In this endeavor, two research approaches, historical-interpretative and descriptive-analytical, have been employed, serving both fundamental and practical objectives. The study involves collecting library data and consultation with primary documents and sources to define the components of pre-Qajar residential spaces in Iran, offering insights into traditional settlement patterns. Furthermore, it explores the concepts and terminologies of space syntax theory for investigating the relationships between spaces. This information is presented in Table 1. Table 1 defines these spaces and their importance and then examines the components of connection, integration, and depth in these spaces. We relied on historical and architectural resources such as photos, documents, reference books, articles, and research to complete this report. Afterward, we conducted field research and collected information from residents while analyzing the floor plans of existing buildings. These actions significantly enriched our study with knowledge. All these efforts were instrumental in properly designing a thorough path for interpretation. The research focuses on selected samples categorized as "inside the courtyard" and "above the shop" in three streets, Lalezar, Ala al-Dowleh, and Sani al-Dowleh, the first modern streets of Tehran. This research investigates four cases of traditional houses with unaltered floor plans from their initial construction period and six cases of modern houses in a purpose-oriented manner. For the modern houses, in case they have been renovated, the original floor plan sketches were obtained by interviewing the current owners. All floor plans are quantitatively evaluated and analyzed in the next stage using E-Graph software. We used graphs and mathematical relationships that govern the data to evaluate the configuration and connections between elements. This involved assessing the cores' positions and connecting vertical and horizontal lines. Each core represents a space, while each line indicates its relationship with other spaces. Ultimately, tables generated from this graph will provide numerical reports that convey the relationships and distances of each core concerning the input source on a spatial scale. Using tables generated by comparative assessment, changes in the role of Iranian architectural spaces in modern habitation and the transformation of concepts and values of traditional patterns influenced by Western culture.

Furthermore, DepthMap software is used based on the convex space map analysis approach and Visual Graph Analysis (VGA) to confirm the change in the quality of the sociability concept in the syntactic integration components and spatial depth. These analyses reveal the evolving interactions of space users. To achieve the results of this software, the croquis related to each building's plan is partitioned into sections placed at open and hidden viewing angles, using a color spectrum from blue to red (highest to lowest). Quantitative analysis was performed on these images using respective tables. Through deductive reasoning and analysis of the collected information, we can assess how much the settlement pattern has changed from traditional to modern. Lastly, based on contemporary residents' behaviors, functions, and needs, we develop innovative solutions and principles.

Table 1: The spatial structure of Iranian traditional houses by investigating some indexes of space syntax theory.

Space	Definition	Aspect of Importance	Space Syntax Components
Entrance	Including the portal (the inviting element), the vestibule (dividing the entranceway into two or more directions), the corridor (Enabling connection between two locations)	Principle of privacy and hierarchy, a space for entering the house	Low level of integration and connectivity A space for a resident to traverse from public space to private space
Courtyard	Providing organization and connectivity between enclosed and half-open spaces	Forming different sorts of courtyards according to hierarchy, public, and private areas of the House (Orangery, Inner area, Outer area)	Serves as an element enabling various actions that rely on this space directly or indirectly High level of connectivity, choice, and control A public and semi-public space
Chamber	Defined in various forms with specific features according to space organization (Summer Chamber, Winter Chamber, Alcove, Upper Chamber.)	Determination of the purpose according to the number of openings (doors and windows), their positions relative to the courtyard entrance, and the type of module system	Two categories of private and semi-private: Private application with lower connectivity and higher depth (Upper Chamber, Squinch, Three-door room) and lower integration Semi-private application (Hall, Alcove (Five-door)) with high connectivity and choice, lower depth, and the highest integration
Porch	A roofless space in front of a room, smaller than a hall	Temporary, seasonal living room and the corridor connecting several semi-private and semi-public spaces	The highest level of integration and connectivity The lowest level of depth after the courtyard
Living Room	A space beside the hall, but less significant	A private space with prominent privacy and hierarchy principles	The lowest level of connectivity and integration A semi-private space for family gatherings after the courtyard
Springhouse	A half-open space resembling the summer chamber with two or four rooms around it	Accessed via corridors and side-paths	High level of connectivity and integration
Kitchen	Including water reservoir, pantry, storage room, well, ovens, and fireplace	Connected to the vestibule and the winter chamber areas, close to the guest room, with access to a water source	A space specified for servants

Introduction of the Studied Whereabouts

The order to construct an avenue in Tehran similar to Paris's Champs-Elysees, passing through the Lalezar garden in Daulat Parish, was given by Naser al-Din Shah Qajar. Figure 1 shows Daulat Parish, located in the northern part of Tehran city limits. Both sides of the garden were converted into two avenues, one being Lalezar Avenue and the other being Sadi Avenue. Over time, the establishment of banks, embassies, prestigious mansions, and houses with beautiful European-style stone and brick facades by the politicians and wealthy people turned this avenue into a modern luxurious neighborhood of its time with a European theme. Afterward, Ferdowsi Street and the neighborhood became the subject of attention (Iran Hotel, 2023). Figure 2 shows the first modern north-south streets of Tehran, which include Lalezar, Saadi, and Ferdowsi streets, which are studied in this research. From an architectural standpoint, this street obtained a significant role within the urban context, redefining the concept of habitation by locating the residential spaces beside the urban ones, encompassing the new behavioral and social needs of its residents. The mansions within the passageway and the houses above the stores in the three streets mentioned above were purposefully chosen for investigation. Four houses with the traditional plan are in Table 2, and 6 houses with the modern plan are in Table 3. Table 2 shows the plan for the basement, ground floor, and first floor, and Table 3 shows the plan for the first floor.

Fig. 1: The map of the Dawlat area in 1898, drawn by Mirza Abdal-Razzaq Kahn (Reference: Old Tehran Book)

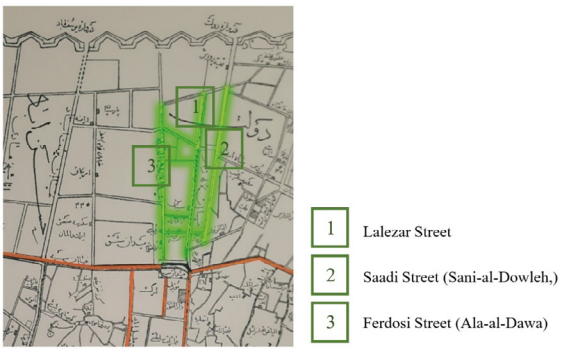


Fig. 2: Drawing of the three streets mentioned in the 1922 map of the Old Tehran book

Table 2: The plan of traditional houses in the crossings of Lalezar, Ala al-Dawleh, Sani al-Dawleh streets

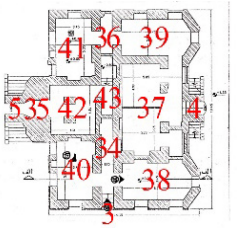
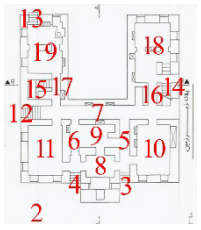
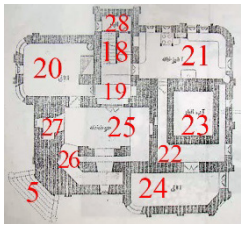
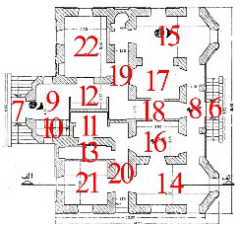
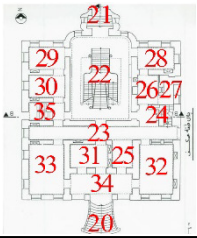
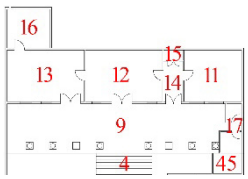
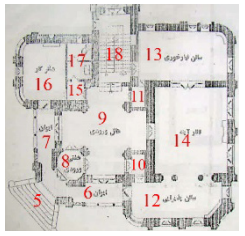
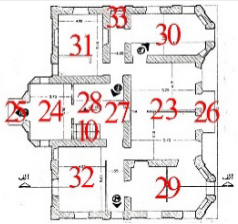
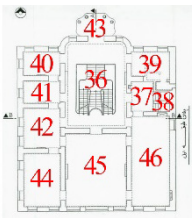
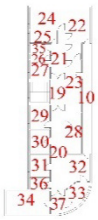
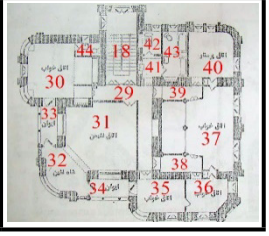
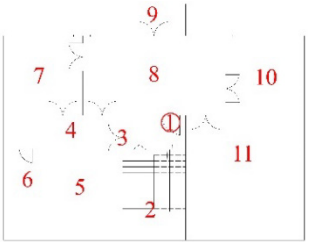
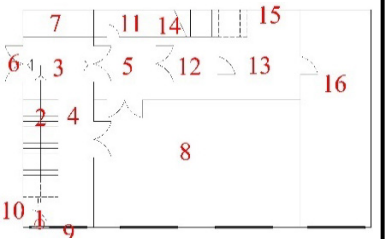
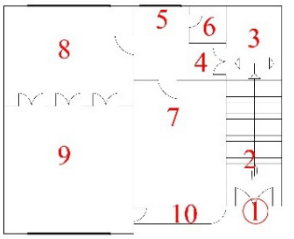
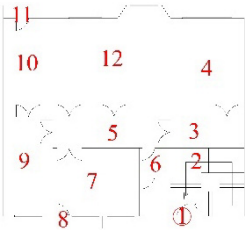
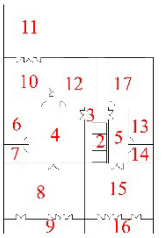
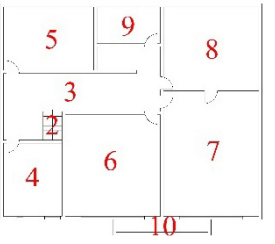
	Rahavi's House On Saadi Street Belveder & Extroverted	Pirnia's House On Lalezar Street Map drawn in Paris	Mirza Nasrollah Khan's House No.3 On Lalezar Street	Shaqaqi's House On Ferdowsi Street Belvedere
Floor Plan				
Underground				
Ground floor				
First Floor				

Table 3: The manual plan of modern houses located on the edge of Lalezar, Ala al-Dawleh and Sani al-Dawleh streets, above the shops

Bernardi's House, Ferdowsi St. With office room	House No.150, Ferdowsi St. With four units on the First floor	Gohar al-molok azod's House, Lalezar St. With three units on the First floor
		
		
House No.4, Lalezar St. Includes a separate room	**Kashef's House, Saadi St. With two units on the First floor**	**House No.514, Lalezar St.**
		
		

It is necessary to explain that the plans of Rahavi (Registration Report, 2003), Pirnia (Registration Report, 1996), and Shaqaqi (Registration Report, 1993) houses that follow the traditional pattern were prepared from the reports of the Cultural Heritage Organization. At the same time, the plan of the houses with a modern pattern was obtained by field observations and hand drawing.

RESULTS AND DISCUSSIONS

Investigating the Components of Space Syntax in Houses with Traditional and Modern Patterns

After investigating the floor plans, we chart spatial arrangements using E-Graph software. These charts are shown in Table 4, which express the depth and integration between the numbered spaces by the communication lines. Then, we will analyze the components of communication, integration, and depth using respective tables. Tables 5,6,7 and 8 show these analyses. Table 5 shows the parameters of space syntax in Pirnia's House. Table 6 shows the parameters of space syntax in Shaqaqi's House. Table 7 shows the parameters of space syntax in Bernardi's House. Table 8 shows the parameters of space syntax in Gohar al-malek azod's house. It is worth mentioning that, considering the numerous spaces distributed across the floors, we have chosen the most influential and high-value spaces for our analysis. Also, in the display of tables, only two tables related to two houses with a traditional plan and two tables related to two houses with a modern plan were stated. The analysis of the tables of the rest of the studied samples was used only in the comparison and conclusion section.

Table 4: Space configuration Graph of selected houses

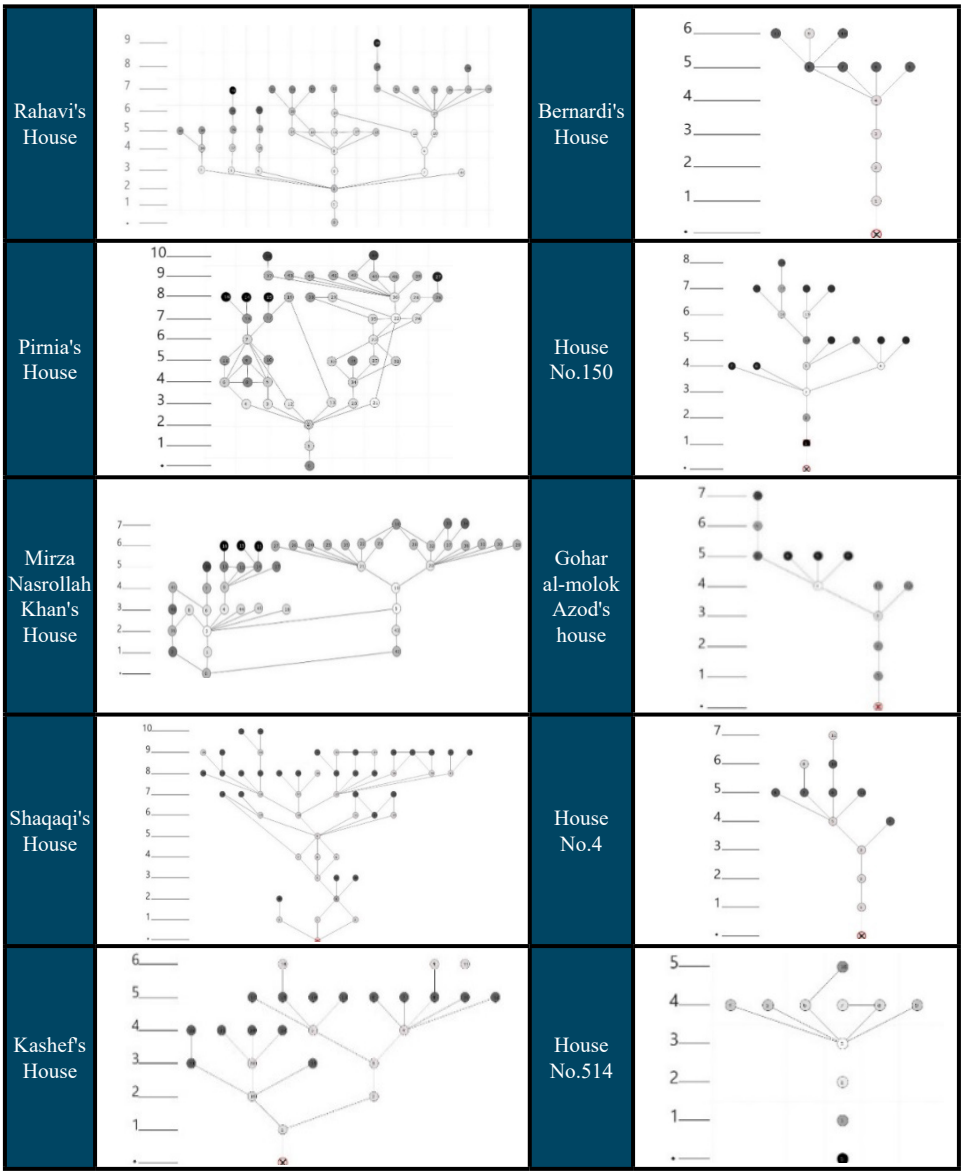


Table 5: Parameters of Total Depth(TD), Mean Depth(MD), Node Connection(NC), Integration Value(I) in Pirnia's House

	First Floor							Ground Floor							Basement				Access	
	Small Bedrooms	Large Bedroom & Workroom	East Stairs of the ground floor to the first floor	Hall	WC & Balcony	Living Room	Central Stairs around Space	Bathroom	Pause-rest Space	Porch	Joint Stairs of first and ground floor	All round hall	Small Bedrooms	Big Bedrooms	Traditional Kitchen	All round hall	Inside access Stairs	Bedrooms	Courtyard	Entrance
NC	1	2	1	3	1	2	9	1	2	5	7	6	2	2	2	7	1	2	7	2
I	6	6	5	6	6	5	8	4	7	7	11	8	7	7	6	7	4	5	11	7
TD	207	205	250	204	207	247	162	258	185	181	137	166	180	185	200	180	266	221	136	179
MD	4	4	5	4	4	5	3	5	4	3	2	3	3	4	4	3	5	4	2	3
MIN I= 4		MEAN I=7		MAX I= 11		MIN TD= 13		MEAN TD= 19			MAX TD= 26			MIN MD=2		MEAN MD= 4		MAX MD= 5	

Table 6: Parameters of Total Depth(TD), Mean Depth(MD), Node Connection(NC), Integration Value(I) in Shaqaqi's House

Second Floor	First Floor								Ground Floor							Underground					Access		
	Reception hall	Pre-entry	Bathrooms	Porch	Alcove	Living Room	Small Bedrooms	Big Bedroom	Nannys Room	Internal Stairs	Work Room	Lateral Spaces of the Hall	Mirror Hall	Pre-entry	Entrance Hall	Porch	Division Space	Traditional Kitchen	Spring House	Room with Cistern access	Entrance Sideroom	Courtyard	Landlord and Crew Entrance	Car Entrance
NC	1	3	1	2	3	2	2	4	2	4	2	2	3	2	8	3	5	2	3	1	1	5	2	2
I	6	7	6	6	6	7	7	6	6	13	6	6	8	8	11	9	9	7	7	4	7	6	5	3
TD	242	213	263	258	257	214	215	258	260	148	234	252	204	206	158	188	180	224	226	320	230	254	298	390
MD	4	4	5	5	5	4	4	5	5	2	4	4	4	4	3	3	3	4	4	6	4	4	5	7
MIN I= 3 MEAN I=7 MAX I= 13									MIN TD= 14 MEAN TD= 24 MAX TD= 44							MIN MD=2 MEAN MD= 4 MAX MD= 8							

Table 7: Parameters of Total Depth(TD), Mean Depth(MD), Node Connection(NC), Integration Value(I) in Bernardi's House

First Floor										Access	
	Balcony	Work Room	Living Room	Large Bedroom	Small Bedroom	Bathroom	Kitchen	Internal Corridor	Pause Space	First Floor Staircase	Entrance from the Edge of the Street
NC	1	1	5	1	2	1	1	5	2	2	2
I	2	2	4	2	3	2	2	6	4	2	2
TD	33	33	23	33	26	30	30	20	24	30	38
MD	3	3	2	3	2	2	2	1	2	2	3
MIN I= 1 MEAN I=3 MAX I= 6				MIN TD= 20 MEAN TD= 30 MAX TD= 48				MIN MD=1 MEAN MD= 2 MAX MD= 4			

Table 8: Parameters of Total Depth(TD), Mean Depth(MD), Node Connection(NC), Integration Value(I) in Gohar al-molok azod's House

First Floor									Access	
	Pre-entry	Balcony	Reception Hall	Small Bedroom	Bathroom	Kitchen	Living Room	Division Space	First Floor Staircase	Entrance from the Edge of the Street
NC	5	1	2	1	1	1	2	4	2	2
I	6	1	2	3	3	3	3	5	3	2
TD	23	50	39	34	34	34	30	24	31	40
MD	1	4	3	2	2	2	2	2	2	3
MIN I= 0 MEAN I=2 MAX I= 3				MIN TD= 23 MEAN TD= 35 MAX TD= 51				MIN MD=2 MEAN MD= 4 MAX MD= 13		

Investigating The Integration and Depth Graph In Houses With Traditional and Modern Patterns

As the last stage, to confirm and clarify the alterations introduced to the residential pattern, we analyze integration and depth factors with DepthMap software, using convex space mapping and visual graphs. We utilize tables derived from E-Graph and DepthMap visual maps to achieve the most robust result. Table 9 shows the information related to the integration parameter with the help of convex space map analysis in houses with traditional patterns. Table 10 shows the information related to the depth parameter with the help of visual graph analysis(VGA) in houses with traditional patterns. Table 11 shows the information about the integration and depth parameters in the Pirnia's House and Shaqaqi's House with the help of numbers. Table 12 shows the information related to the integration parameter with the help of convex space map analysis in houses with modern patterns. Table 13 shows the information related to the depth parameter with the help of visual graph analysis(VGA) in houses with modern patterns. Table 14 shows the information about the integration and depth parameters in Bernardi's House and Gohar al-molok Azod's House with the help of numbers.

Table 9: Syntax of Integration Value Factor in Houses with a Traditional Pattern by Information Extracted from Depth Map Software, convex Space Map Analysis Approach

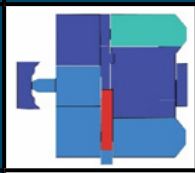
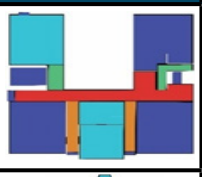
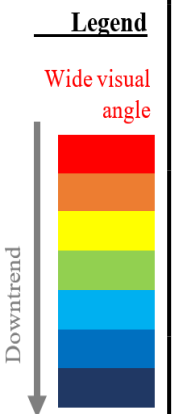
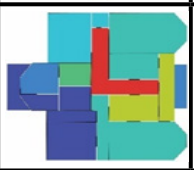
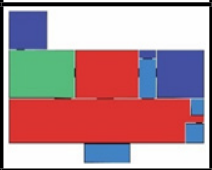
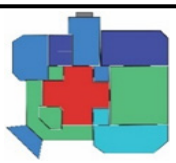
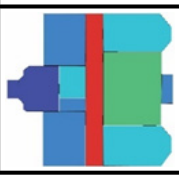
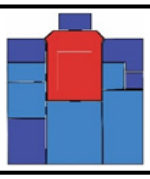
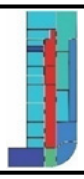
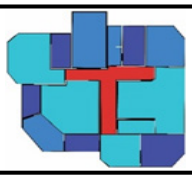
Plan	Rahavi's House	Pirnia's House	Mirza Nasrollah Khan's House No.3	Shaqaqi's House	
Underground			—		
Ground floor					
First floor					

Table 10: Syntax of Depth Value Factor in Houses with a Traditional Pattern by Information Extracted from Depth Map Software, Visual Graph Analysis (VGA) Approach

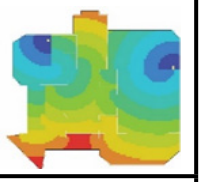
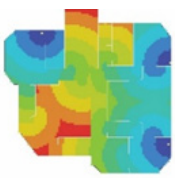
Plan	Rahavi's House	Pirnia's House	Mirza Nasrollah Khan's House No.3	Shaqaqi's House	
Underground			—		
Ground floor					
First floor					

Table 11: Numerical Characteristics of Integration Value & Depth Value

of Integration Value		Pirnia's House	Shaqaqi's House	Depth Value		Pirnia's House	Shaqaqi's House
Minimum	Underground	0.62	0.554	Minimum	Underground	0	0
	Ground floor	0.653	0.79		Ground floor	0	0
	First floor	0.78	0.784		First floor	0	0
Average	Underground	1.152	0.922	Average	Underground	1.362	1.125
	Ground floor	1.283	1.323		Ground floor	1.205	0.742
	First floor	1.875	1.463		First floor	1.34	0.688
Maximum	Underground	2.688	1.774	Maximum	Underground	2.621	1.959
	Ground floor	2.615	2.597		Ground floor	2.115	1.469
	First floor	6.635	3.922		First floor	2.281	1.413

Table 12: Syntax of Integration Value Factor in Houses with a Modern Pattern by Information Extracted from Depth Map Software, convex Space Map Analysis Approach

Table 13: Syntax of Depth Value Factor in Houses with a Modern Pattern by Information Extracted from Depth Map Software, Visual Graph Analysis (VGA) Approach

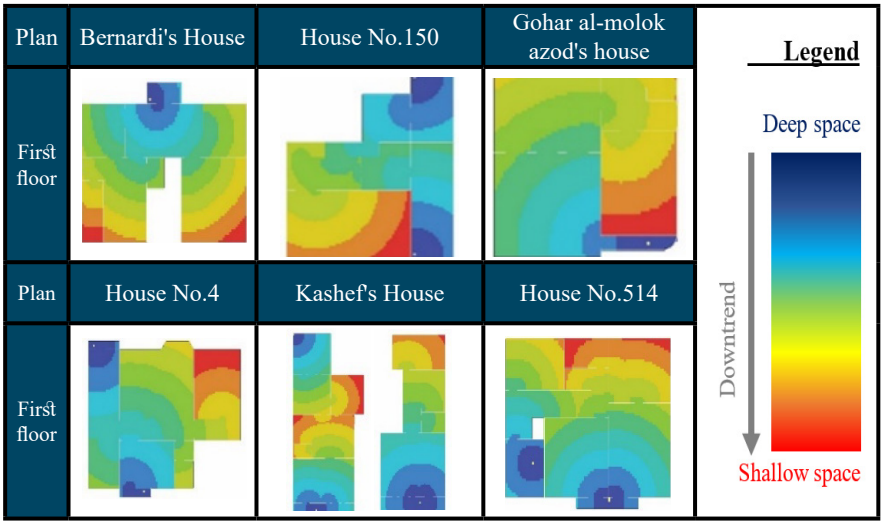


Table 14: Numerical Characteristics of Integration Value & Depth Value

Integration of Value	Bernardi's House	Gohar almolok's house	Depth Value	Bernardi's House	Gohar almolok's house
Minimum	0.636	0.387	Minimum	0	0
Average	1.607	0.734	Average	0.753	1.22
Maximum	5.094	1.163	Maximum	1.385	2.146
Std Dev	1.461	0.316	Std Dev	_	_
Count	7	6	Count	_	_

Analysis of the Results

When analyzing and comparing the architectural graphs of buildings and street-edge houses, the numbers associated with the entrance components (connectivity 2, integration 5-7, and depth 2-3) are almost identical. Courtyards within the houses in the passages display connectivity 7, integration 11, and depths varying from 2-4. In contrast, the dividing spaces in street-edge houses exhibit connectivity values between 2-5, integration 3-6, and mostly a depth of 2. The living rooms, characterized by connectivity 2, integration, and a depth of 5, are relatively deep and serve as semi-private areas. With the emergence of modernity, the connectivity values span from 2 to 6 and generally feature depths of 2-3. Based on these components, the courtyard and dividing space elements within the spatial layout are positioned similarly.

Consequently, in the modern pattern, connecting different spaces has shifted from the courtyard to the dividing space. Furthermore, some visual activities and interactions among residents, formerly associated with the courtyard as a semi-public area, have been relocated to the living room. However, due to insufficient functionality, there has been a significant overall transformation in the definition of this space. Bedrooms in traditional houses are arranged with depths of 7-4, whereas in modern houses, they typically have depths ranging between 5-4. Balconies in these houses are regarded as the deepest layer, similar to the balconies on the upper floors of mansions. The hall, having connectivity of 4-3 and a depth of 5-4, is similar to the living room, as the numbers in the table indicate consistently high levels of connectivity and integration of 2 and 3, along with a depth of 4, in this space.

CONCLUSION

Spatial relationships within traditional Iranian households have been carefully defined by effectively classifying public, private, and service domains. These relationships prioritize interactions, hierarchical arrangements, privacy sanctity, and spatial utilization efficiency. However, this pattern underwent significant changes as modernity spread into the urban layouts and architectural designs during the mid-Qajar period. Concurrently, the influx of Western culture into society began to reshape the behaviors and functionality of residents. This ongoing process has left contemporary architects puzzled when designing residential layouts that adequately address Iranian consumers' psychological and physical needs. On the other hand, recognizing that residents' living spaces and activities should be treated as a unique entity emphasizes the crucial importance of designing residential environments based on social relationships and the collective activities of all family members. So, in addressing the fundamental question concerning how shifts in the definition and quality of traditional Iranian architectural space arrangement have contributed to the establishment of a novel housing paradigm, our research entailed an investigation of the spatial configurations of four prominent buildings situated along three primary modern streets in the capital city during the early stages of modernization. By employing space syntax analysis software and its associated components, we have understood the importance and significance of human values in Iranian architecture. In the second stage, we applied the same research and analytical methodologies to the houses above the shops on these three streets, all conforming to modern design and construction principles. The differences identified in our analysis are as follows: The most significant observation in these transformations is the complete removal of several traditional Iranian architectural elements, such as the entrance vestibule, inner and outer courtyards, summer chambers and winter chambers, the springhouse, and specific rooms like the upper chamber and the squinch, within the buildings nestled within passageways. This transformation resulted in the combination of areas linked to both the internal and external domains into a shared courtyard, the arrangement of private and public spaces, as well as service areas in a vertical arrangement, and the gradual integration of workspaces into the residential space as separate chambers within the semi-public area, a strong focus on the central staircase as an internal connector between floors, and incorporation of adapted traditional elements to address today's needs and increase the level of independence, including sanitary facilities and open balconies, which are virtually an equivalent of projecting porches but without a roof and with a smaller area. In the houses at the street's edge, the building's entrance comprises the main door and a narrow staircase granting access to the first floor. Passing through this staircase introduces an additional layer, enabling deeper access to the primary living area. The role of organizing and unifying different elements and spaces, traditionally attributed to the courtyard, has shifted in the modern pattern. As a result of its elimination, this role has been assumed by the dividing space above the staircase, serving as a connection point for multiple independent residential units. Additionally, due to a significant reduction in space and a decrease in the number of rooms, the courtyard has given its function of facilitating residents' behavioral interactions in the living room. In the

modern architectural approach, the balcony, an architectural element borrowed from the traditional model, prefers the street view over a view of the garden surrounding the mansion. It primarily occupies a deeper layer than other spaces, while it serves as a medium and a connection between the enclosed living or reception area and the open space facing the street. Therefore, it no longer signifies an increase in depth, confirming the privacy of this space thereby reducing the importance placed on privacy values. Due to the significant reduction in building space and the elimination of anterooms and intermediate spaces, modern floor plans have been simplified. Spaces are arranged side by side based on size requirements and lighting without adhering to any uniform or suitable pattern. This arrangement places nearly all spaces at the same depth level. Moreover, a convex space is considered the access point to other areas. In contrast, the traditional model classified spatial layers based on depth due to the diversity of spaces and anterooms, highlighting the importance of private spaces. In the modern architectural approach, there is an obvious absence of emphasis on providing a singular functional definition for a specific space via its connection through one or more mutual doors with the adjacent spaces to enable the increasing of the area when needed and the uniformity of shape and area of the two or three spaces. This serves to emphasize the flexibility of these spaces in terms of functionality. As the last point, in half of the studied cases, there is also an independent space relative to the rest, suggesting a room dedicated to work within a residential setting.

Providing The Optimal Solution With a Comparison of The Results of The Literature Review

Continuing with the examples mentioned in the literature review, it is necessary to summarize comparative results. For instance, elements like interactions, liveliness, comfort, and tranquility that were prominent in the traditional design pattern have now transformed into visual aesthetics, accessibility, and efficiency in modern design patterns. The courtyard and porch no longer play a role in the layout of modern design. Instead, they have been replaced by the living room. The concepts of privacy and hierarchies that used to represent introversion have undergone a massive transformation into extroverted forms.

In the traditional design pattern, there were four categories for spatial arrangement: public, semi-public, semi-private, and private spaces, with micro-spaces offering proper arrangement and connections among them. However, in the modern pattern, these spaces have been combined to create flexible areas with concise plans and expanded spaces with a different yet simpler layout. At last, the traditional residential patterns offered dynamism and activity in spatial arrangement, establishing a connection with nature for residents and the sensory, emotional, and behavioral influence of the surrounding environment, while with the advent of modernity, the patterns transformed into static and inactive ones. Considering the explanations indicating changes in the needs and behaviors of today's society, alongside the importance of cultural values and traditional living patterns in Iran, in this section, it was deemed necessary to present solutions as fundamental and upgradable principles for the generalization of contemporary residential patterns, in line with the stated conditions. Based on the understanding of the relationships and activities within Iranian families, it is essential to define and design new high-quality spaces that create a proper understanding of connection and depth in residential spaces. These spaces should also align with society's values by incorporating spatial arrangements. One way to achieve this is by blending traditional architectural elements with modern applications. For instance, a vestibule can be utilized as a corridor in front of apartment entrances, effectively ensuring the privacy of each unit through separation and proper rotation.

Another example would be integrating inner and outer courtyards with independent access points for more private and public areas within each residential structure. An alternative solution would be to use separated covered terrace-like spaces accompanied by green areas at the entrance of each apartment unit. This design requires much less space than traditional courtyards but also allows for ventilation through openings, harnesses natural sunlight, and provides thermal comfort and an inviting atmosphere. It would mainly be connected to areas like bedrooms, kitchens, and living rooms, making it a valuable contribution to the family's group activities. The entrance of the reception area on each floor is independent of the corridor, and if necessary, it is also accessible from a section in each apartment unit. This reception area is a modern equivalent of a traditional hall. It is commonly shared among multiple units and serves as a place for guests. Partition doors offer flexibility in terms of space, allowing them to be converted into a larger area when needed by individual families. Since this versatile space has its independent entrance, it can be used as a guest room or even as an accommodation for service personnel. Lastly, working is becoming increasingly popular in society, so every apartment must have small and independent workspaces. It's more practical to have these workspaces defined and integrated on one floor to meet residents' needs.

AUTHOR CONTRIBUTIONS

Overall, the authors contributed to all aspects of the research. N. Ramezani collected, analyzed, and interpreted the data and the conclusions. Prepared the manuscript. J. Soheili managed the team and identified the right strategy to achieve results. M. Khatibi revised the research method and revised the literature of the text.

ACKNOWLEDGEMENT

This article is extracted from the Doctoral thesis of the first author in the field of Architecture with code 44405 and titled "Explaining the Configuration of the Residential Pattern in the Transitional Period of Qajar Streets in Combination with Contemporary Urban Space (Case Study: Laleh Zar street)," with the guidance of the second author and the advice of the third author, which was done in 2023. This study was entirely self-funded. The authors would like to extend their appreciation to those who assisted in the data collection process and the anonymous reviewers whose judgments helped advance and promote the scientific level of this research.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the authors have witnessed ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and submission, and redundancy.

REFERENCES

Nakhaipour Tazeraj, H., Safavi, A., & Litkohi, S. (2016). Evaluation of the architectural features of traditional houses. *The fourth international research conference in science and technology.* 17 march. Saint Petersburg: Russia.

Maddahi, M., & Memarian, Gh. (2017). Analysis of the spatial configuration of native houses with the approach of spatial syntax (Case study: Beshravieh City). *Housing and Village Environment Magazine,* 35(156)49-66.

Bagheri, M., Hojjat, I., & Dashti, M. (2015). Evaluating the transformation of pattern language in housing architecture (Case study: Qajar period houses and contemporary housing in Zanjan City). *Journal of Architecture and Urban Planning of University of Arts,* 7(14)141-156.Doi:10.30480/AUP.2015.88

Zarei, S., & Yeganeh, M. (2018). Analyzing the role of interconnectedness of spaces in the social relations of Kashan traditional houses. *Urban Management Quarterly,* 17(52)81-91.

Jalili, T., & Akbari, S. (2015). Investigating the evolution of residential plans from the Qajar period to the second Pahlavi period. A*nnual conference on architecture, urban planning, and urban management research.* 19 December.Yazd: Iran.

Ekhlas, M., & Ekhlas, M. (2014). A reflection on the manifestation of Islamic thought in Iranian architecture with an emphasis on the architecture of traditional Iranian houses. *National conference of architecture, construction, and modern urban development*. 20 May. Tabriz: Iran.

Memarian, Gh. (2008). *Review of the theoretical foundations of architecture.* Tehran: Soroush Danesh.

Vice President of Conservation and Restoration. (1993). *Registration report of Shaghaghi's old house.* Tehran: Organization of Cultural Heritage, Handicrafts and Tourism.

Cultural heritage management. (1996). *Registration report of (Moshir Al-doleh) Pirnia's old House.* Tehran: Organization of Cultural Heritage, Handicrafts and Tourism.

Vice President of Conservation and Restoration. (2003). *Registration report of Rahavi's old house.* Tehran: Organization of Cultural Heritage, Handicrafts and Tourism.

Habibi, K., & Rohani Choulaei, E. (2015). Qualitative evaluation of the change of the elements of the old Iranian city to the modern city in order to revive urban places with Iranian-Islamic identity. *Iranian Islamic City Studies Quarterly,* 6(21)5-18.

Heidari, A., & Farhady, M. (2017). Analysis of the relationship between the computer modeling the space syntax software and the cognitive maps in recognition of sociability behavioral camps (Faculty of Architecture at the University of Bu Ali Sina and Shahid Beheshti University). *Scientific Quarterly of Fine Arts – Architecture and Urbanism,* 23(2)1-30. Doi: 10.22059/jfaup.2019.244088.671846

Ataei, A., Soheili, J., Armaghan, M., & Heidari, A. (2022). Explaining the effectiveness of the perception of the quality of the quiet spectrum from the spatial configuration (Case study: a comparative comparison of the house in the garden of the cities of Dehkade and Mehrshahr). *Architecture and Sustainable City Magazine,* 10(2)185-200.

Latifi, Gh., Faizi, Q., & Bajlal, R. (2017). Comparative Analysis of the Emergence From of spacial Organization of Iranian Cities in Safavieh Period or Qajar Era. *Khorasan Bozorg magazine,* 8(26)59-76.

Soheili, J., & Arefian, E. (2016). Analysis of Socio-Human Relations in the School Mosque spaces in Qajar Majesty, Qazvin. *human geography research journal,* 48(3)475-491. Doi:10.22059/JHGR.2016.52321

Hillier, B. (2007). *Space is the machine, A configurational theory of architecture Space Syntax.* England: CreateSpace Independent Publishing Platform

Kamalipour, H., Memarian, Gh., Faizi, M., & Mousaviyan, F. (2012). Formal Classification & Spatial Configuration in Vernacular Housing: A Comparative Study on the Zoning of the Reception Area in Traditional Houses of Kerman Province. *Journal of Housing and Rural Environment,* 31(138)3-16.

Iranhotelonline (2023). Retrieved May, 2023