

Comparative analysis of the spatial structure of traditional houses in Yazd using spatial syntax: A case study of the Hirani and Fateh houses

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Abstract

This study compares the spatial structure of two traditional houses in Yazd, the Hirani and Fateh houses, through spatial syntax theory. It investigates how the orientation (north-south vs. east-west) affects space organization, accessibility, and the flow of natural light and ventilation. The Hirani House, with a north-south orientation, features a linear layout where public spaces are near the entrance, and private areas are deeper inside, creating a clear spatial hierarchy with more isolation. The Fateh House, oriented east-west, has two central courtyards, promoting openness and interaction between public, semi-private, and private spaces. The courtyards act as intermediaries, reducing spatial segregation and enhancing accessibility. Key findings show that the Hirani House prioritizes privacy, with less visual connection between spaces, while the Fateh House fosters integration and social interaction through its fluid transitions. Both houses respond to Yazd's climate: the Hirani House's north-south orientation optimizes sunlight and ventilation for the hot climate, while the Fateh House uses its courtyards to balance airflow and sunlight exposure. This study highlights the cultural and climatic significance of spatial organization in traditional Yazd houses and provides insights into how these design principles can inform modern architecture. The study reveals that traditional spatial arrangements, while addressing social and environmental needs, offer valuable lessons for contemporary architecture, promoting a balance between heritage and modern living requirements.

Keywords: Spatial Syntax; Traditional Houses; Yazd Architecture; Privacy and Integration; Courtyard Design

1. Introduction

Traditional Iranian houses, especially in desert regions such as Yazd, are prominent examples of Iranian architecture that have been shaped by various factors, including climate, culture, and the social needs of their inhabitants (Rafieian & Alizadeh, 2017). In these houses, the design of spaces and their configurations not only respond functionally to the needs of residents in the face of dry and desert conditions but also reflect the culture, beliefs, and values of the society. Features such as central courtyards, wind towers, interconnected rooms, and the use of local materials like brick and plaster are characteristic of traditional houses in Yazd, designed to control temperature and light within the interior spaces (Beyraghshamshir & Sarkardehei, 2023).

Various studies have explored the role of culture and social values in shaping houses and architectural spaces. Notable works, such as those by Amos Rapoport and (Lawrence, 1987), have analyzed houses as manifestations of culture and social systems. In these studies, houses are seen not only as physical spaces but also as environments where social activities and relationships unfold, with architecture serving as a tool to address the cultural and social needs of the inhabitants (Kiaee et al., 2019). Thus, houses are not

merely physical entities but are symbolic of the culture and lifestyle of their residents, with numerous studies, particularly in traditional architecture, focusing on the role of culture in shaping the spatial configuration of homes.

The analysis of the spatial configuration of houses and the relationships between different spaces within a building is one of the key topics in architecture, referred to as "spatial syntax." This analytical method, introduced by Hillier as spatial syntax theory, examines how spaces are organized within an architectural complex and how this organization influences social interactions and the functional roles of the spaces (Hillier, 1977). Spatial syntax is a powerful tool for understanding the relationships between spaces and their functions, providing valuable insights into the impact of space on human behavior and social interaction.

This research focuses on the comparative analysis of the spatial structure of two traditional houses in Yazd, the Heirani and Fateh houses. The comparison is made using spatial syntax theory, aiming to understand how the orientation of the plans (whether east-west or north-south) affects the configuration and organization of spaces. By analyzing the spatial syntax of these houses, this study will explore the distribution of spaces, the relationships between them, and how factors like light and ventilation are managed within the homes. Additionally, the research

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seeks to examine the effects of different plan orientations (east-west or north-south) on the functionality of the homes and the organization of spaces such as public and private areas. The main research questions guiding this study are: What are the differences in the spatial configuration patterns between the Heirani and Fateh traditional houses? How does the plan orientation (east-west or north-south) affect the configuration and functionality of other spaces within the homes?

The study will also aim to prove the hypotheses regarding the socio-cultural principles embedded in the spatial configuration of these traditional houses. It will explore how the organization of space in these homes reflects cultural values, social behavior, and the environmental context, offering insights into the design principles that govern traditional architecture in Yazd. Through this approach, the research intends to provide a deeper understanding of how spatial design impacts both the daily life of inhabitants and their relationship with the built environment, with the goal of informing contemporary architectural practices while respecting cultural heritage.

2. Research Background

In the past three decades, research on traditional Iranian houses, particularly those from the Qajar era, has been relatively limited. Although a few renowned Iranian architects, such as Karim Pirnia and Nader Ardalan, have provided valuable insights, most studies have been fragmented and focused on specific regions, lacking a comprehensive comparative approach to understanding the spatial structures of these homes. This is especially true for the historical houses in Yazd (Moqadam & Nubani, 2024)., where the analysis of spatial configurations using spatial syntax theory remains underexplored. Few studies have thoroughly examined how these traditional houses, particularly the Heirani and Fateh houses, can inform modern residential design by analyzing their spatial dynamics and the influence of cultural and environmental factors on their layout. In the 1960s and 1970s, significant works were published that explored the architecture of historical houses in cities such as Dezful, Shushtar, Kashan, and Isfahan, by the Ministry of Housing and Urban Development (Tabarsa & Hoseini, 2019). More recently, in the winter of 2020, Aref Agha Safari, Hekmat Amiri, Jaber Danesh, and Mohammad Javad Beheshtian conducted a study on the quantitative and qualitative characteristics of housing within the historical fabric of Yazd (Rafieian & Alizadeh, 2017). However, the ultimate goal is to bridge the gap between contemporary housing design features and the architectural and cultural heritage of these regions, ensuring that modern designs are informed by and preserve the essence of traditional architectural practices.

This research is based on an in-depth comparative analysis of the spatial configurations and dynamics of the Heirani and Fateh houses. It examines the economic, social, and environmental factors that influenced the design and structure of traditional houses in Yazd, and how these factors have shaped the spatial organization of these homes. Through this lens, the study considers the

implications of these traditional spatial arrangements for contemporary urbanism and architectural design. The findings suggest that the spatial structures of these historic homes are not only a reflection of local culture and collective identity but also play a fundamental role in enhancing the daily lives of their inhabitants, offering valuable insights for integrating traditional design principles into modern housing solutions. This also gives credence to an argument towards ensuring assimilation of local architectural characteristics into modern-day designs to have housing that is not merely culturally relevant but also meets contemporary needs (Karimimoshaver et al., 2024). A prominent example of incompatibility can be observed in the housing typologies influenced by the Mehr Housing scheme, where repetitive and identical buildings were constructed with little regard for regional culture and architectural identities from various parts of Iran (Ghorbani et al., 2022). This highlights the importance of research aimed at rethinking traditional lifestyle patterns from cities like Yazd and incorporating them into contemporary architectural practices (Rafieian et al., 2016). By examining the rapid pace of mass culture and the spatial dynamics of these traditional houses, the study explores a housing model that balances both heritage preservation and the demands of daily living (Tavallaei & Rokhsari, 2022). It proposes designs that, while maintaining certain traditional spatial patterns, primarily address the modern needs of today's residents, thereby enhancing both functional living and cultural integrity in future housing developments.

Space Syntax: From Theory to Paradigm

What is space syntax and what is it not? This may be the simplest question that comes to mind. Currently, in the academic literature of architecture and urban design, space syntax is often regarded as a set of methods and techniques for uncovering spatial structures. Historically, the answer is that space syntax, in Hillier's view (Khozaei Ravari et al., 2024) was originally just one theory within the subset of the Man-environment paradigm. Over time, this theory evolved and became a spatial-morphological approach that understands the relationship between environment and space, and possesses its own methods, techniques, tools, and strategies. The glossary of space syntax was also introduced in the mid-1970s to collect this theory and methodology (Lawrence, 1987). At that time, the subject was treated as a separate field of research from other defined fields. Later, the book *The Social Logic of Space* in 1984 marked a theoretical turning point in the development of this theory (Siadatian & Pourjafar, 2015). By the mid-1990s, the achievements of the research team at Bartlett suggested that this area of research could extend far beyond what was previously thought. A collection of studies, titled *Space is the Machine*, was published by Hillier in 1996 and provided practical methods for discovering spatial configuration, inviting researchers to expand and develop the field further. Then, the results of the First International Symposium on Space Syntax in 1997 indicated that its expansion beyond the boundaries of architecture, archaeology, and other fields was forming into a paradigm. Today, the theoretical framework and scope of application of space syntax have turned it into a

rapidly evolving paradigm, expected to bring unique developments in its theory, practices, and techniques every two years. Due to the broad scope of this paradigm, describing all of its components in a single text is not feasible, and the reader must simultaneously study its theoretical foundations in other writings. In the remainder of this study, only spatial configuration is examined, while the other concepts are devoted to studies beyond the scope of the reader (Hillier, 1977).

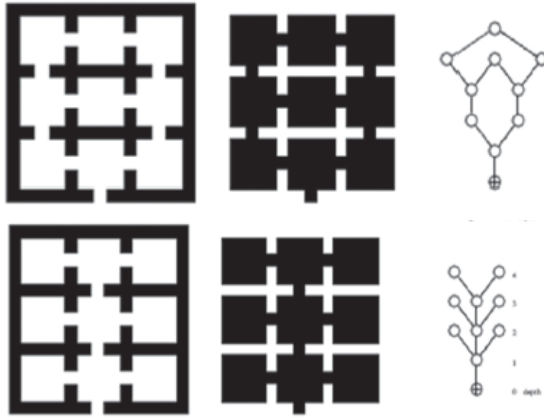


Fig. 1. an example in understanding the spatial configuration (Hillier, 1977)

2.1. Indicators of spatial structure analysis using space syntax technique

The analysis of spatial structure for every configuration in the space syntax method is performed using the following indicators:

Connectivity: Connectivity refers to the number of direct links created between a space and other spaces (Shariati et al., 2019). The connection between spaces facilitates spatial recognition, movement, and understanding of relationships between spaces (Hu et al., 2017). A space with more connections to adjacent spaces is considered more public, whereas a space with fewer connections is considered more private.

- **Depth:** Depth has two meanings in the space syntax technique:
- **Metric Depth:** Refers to the distance between two nodes, measured in terms of the number of steps (Zabihi & Mirzaei, 2023).

Step Depth: Refers to the number of spaces a person must pass through to move from one point to another (typically measured relative to the entrance of the building) (Malazi et al., 2020). The shallower the space, the lower the spatial separation, which results in a more integrated and accessible space. Increasing spatial depth leads to higher spatial privacy and more separation, creating a spatial hierarchy, reducing accessibility, and increasing control over the space, thereby enhancing privacy. **Integration:** Integration refers to the connection of a space to other spaces in the configuration. A space with higher integration is more connected to other spaces, meaning it is more

accessible. Integration is inversely related to depth, as a space becomes more integrated when other spaces have relatively lower depth. The more connections a space has with adjacent spaces, the more integrated it becomes. Integration is also directly correlated with connectivity—more connections lead to greater integration. Through analyzing both connectivity and integration, the readability of the building is determined, reflecting the complexity or ease of spatial relationships.

Access: This measure is categorized into two types:

Visual Access (Isovist): Refers to the visibility of spaces within the environment.

Physical Access (Metric Depth): Refers to the physical distance or steps needed to access a space.

Control Value: This parameter indicates the degree of selectivity a space has in relation to other spaces it is connected to. The lower the degree of selectivity of a space to others, the lower the control over that space (Tabibian et al., 2020). The study specifically examines how the connectivity and integration of various rooms and courtyards impact the movement and social interactions of the residents. Moreover, by analyzing depth and relative depth, it highlights the spatial hierarchy and privacy levels within these homes, showing how certain areas are more public and others more private. This comparative analysis reveals the inherent balance between accessibility and privacy, emphasizing the role of spatial organization in defining both functional living and cultural values. Through this approach, the research not only uncovers the spatial logic that underpins these traditional homes but also suggests how the principles of space syntax can be applied to modern residential design, ensuring that contemporary architecture respects and integrates cultural heritage while meeting the needs of modern inhabitants. In Fig. 2 it has been illustrated. The analysis of spatial structure using the space syntax method involves key indicators such as connectivity, depth, integration, access, and control. Connectivity measures the number of direct links between spaces, with more connections indicating greater public accessibility. Depth is evaluated in terms of both metric depth (distance between nodes) and step depth (number of spaces passed through to reach a destination), affecting the spatial hierarchy and privacy. Integration refers to the extent a space is connected to others, with higher integration leading to greater accessibility, while control value assesses the selectivity and control a space has over others. This study focuses on how the connectivity and integration of rooms and courtyards influence movement and social interaction, while depth and relative depth reveal the spatial hierarchy and privacy within homes.

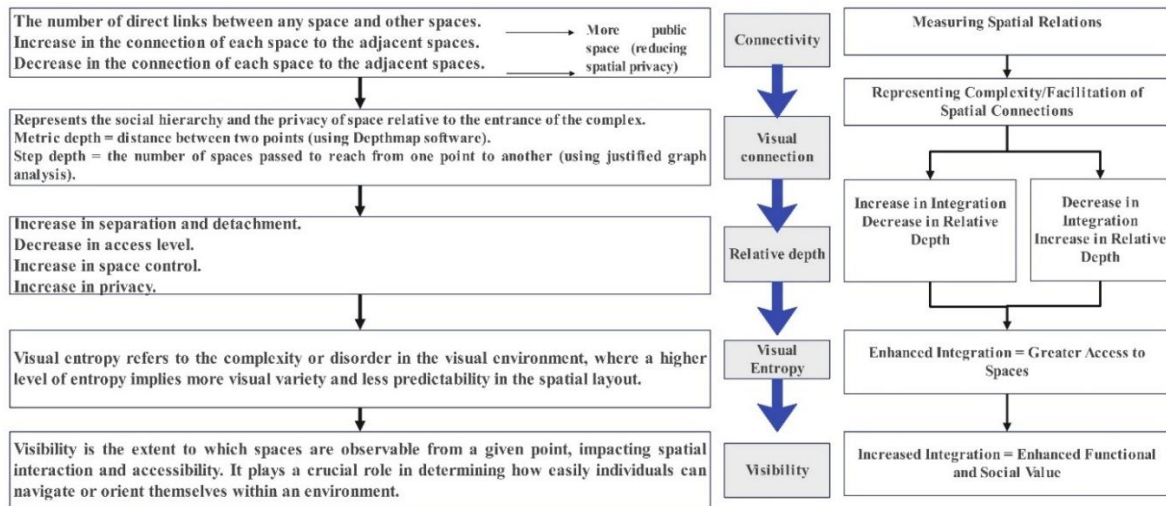


Fig. 2. The space syntax indicators and their social relations.

3. Research Theoretical Framework

Based on the previous discussion, it is clear that culture and social interactions have a significant influence on spatial characteristics that define the quality of the environment. Additionally, space syntax encompasses a set of techniques for "modeling," "quantifying," and

analyzing the structure of "spatial organization" in buildings and monuments, which are used to examine and discover the effective factors and latent patterns in vernacular settlements. By studying space organization and spatial arrangement, this theory determines how it interacts with social structures, behaviors, and the activities of its users (Hamedani Golshan et al., 2021).

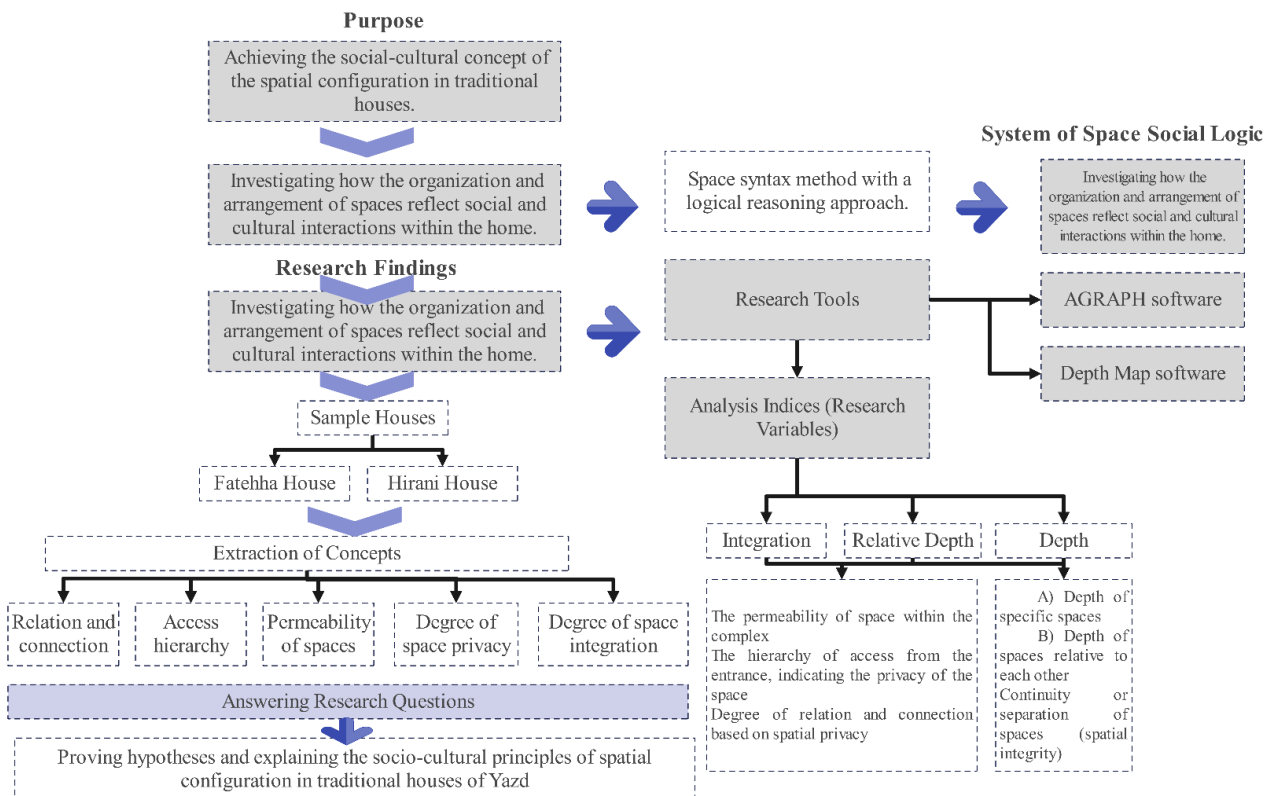


Fig. 3. Theoretical framework

In this study, the application of space syntax is aimed at discovering how the orientation of the plan (east-west or north-south) affects the configuration of different spaces in traditional houses of Yazd, particularly the Heirani and Fateh houses. This study analyzes the spatial structure of

these houses, examining the distribution of spaces, relationships between them, and how light and ventilation are managed. Specifically, it investigates the impact of different plan orientations on the functionality of the

homes and the organization of spaces such as public and private areas.

The research also conducts a comparative analysis of the spatial configuration of the Heirani and Fateh houses using space syntax indices to identify the differences and similarities in how spaces are organized, their spatial connections, and the level of accessibility and privacy within the spaces. In particular, the study explores how the configuration of plans can reveal the social and cultural influences on the spatial design of these homes. Fig 3 Theoretical Framework has been showed. The following flowchart provides an overview of the research framework for the study, It visually represents the key components and methodology of the research process. The flowchart outlines the purpose of the study, which is to investigate how the organization and arrangement of spaces in traditional houses reflect social and cultural interactions within the home. The research findings aim to analyze how these spatial arrangements contribute to the social logic of the houses. It also highlights the key tools used for analysis, such as AGRAPH and Depth Map software, which are employed to evaluate the spatial structure using indices like integration, relative depth, and depth. The research approach follows a case study design, focusing on two traditional houses in Yazd, specifically the Hirani and Fateh houses, with the goal of uncovering how the configuration of these spaces shapes privacy, accessibility, and the relationships between different areas in the house.

This visual representation helps to better understand the flow of the study, from the research objectives to the data analysis and the underlying socio-cultural principles influencing spatial design in these traditional homes.

4. Research Methodology

In this study, a case study approach was employed using estimation and evaluation methods. This section of the research is quantitative in nature. In terms of purpose, the research is a fundamental exploration aimed at discovering and describing the social logic of spatial configurations in traditional houses. To ensure repeatability, comparability, and the validity of the results, a multiple case study design was utilized.

4.1. Research variables

The independent variables are presented below.

4.2.1 Space depth

Space depth is defined as "the smallest step in the space to reach from a particular node to each of the nodes in the graph"(Khozaei Ravari et al., 2024), which implicitly includes the "concept of social hierarchy" and the "degree of privacy of a given space"(Rafieian et al., 2016)

4.1.2 Mean depth

The mean depth (MD) of a space is determined by dividing the total space depths (TD) by the number of spaces (K) minus one(Varmaghani, 2023).

$$MD = TD / (K - 1)$$

$$Mean\ Depth\ (MD) = \frac{\sum Depth\ of\ all\ spaces}{K - 1}$$

TD = Total depth of all spaces in the building.

K = Total number of spaces in the system (including the space being measured).

4.1.3 Integration

"This index has a reverse relationship with relative depth (Shariati et al., 2024). That is, the greater the value of this measure, the greater the accessibility of the space" (Shariati et al., 2019). The integration of a node represents the "continuity or separation of a space from the general system or other spaces. A space is said to have more integration when it is more connected to other spaces" (Lu et al., 2023).

4.2. Data collection method and research tools

In this study, the method of structured non-participatory observation was used to collect data. In this method of analysis, justified graphs are plotted to examine latent patterns and social relationships within the spaces. The justified graph depicts the internal communication features of the plan. It consists of nodes and edges, with each component of the graph representing spatial relationships (Hamedani Golshan et al., 2021). To plot and analyze these graphs, AGraph software and Depth Map software, based on the principles of space syntax theory, were used. Descriptive data, using frequency and percentage, were employed for analysis. In the following, the plan of each sample, along with its justified graph, integration graph, and relative depth graph, are plotted. In Fig 4. Research methodology has been showed.

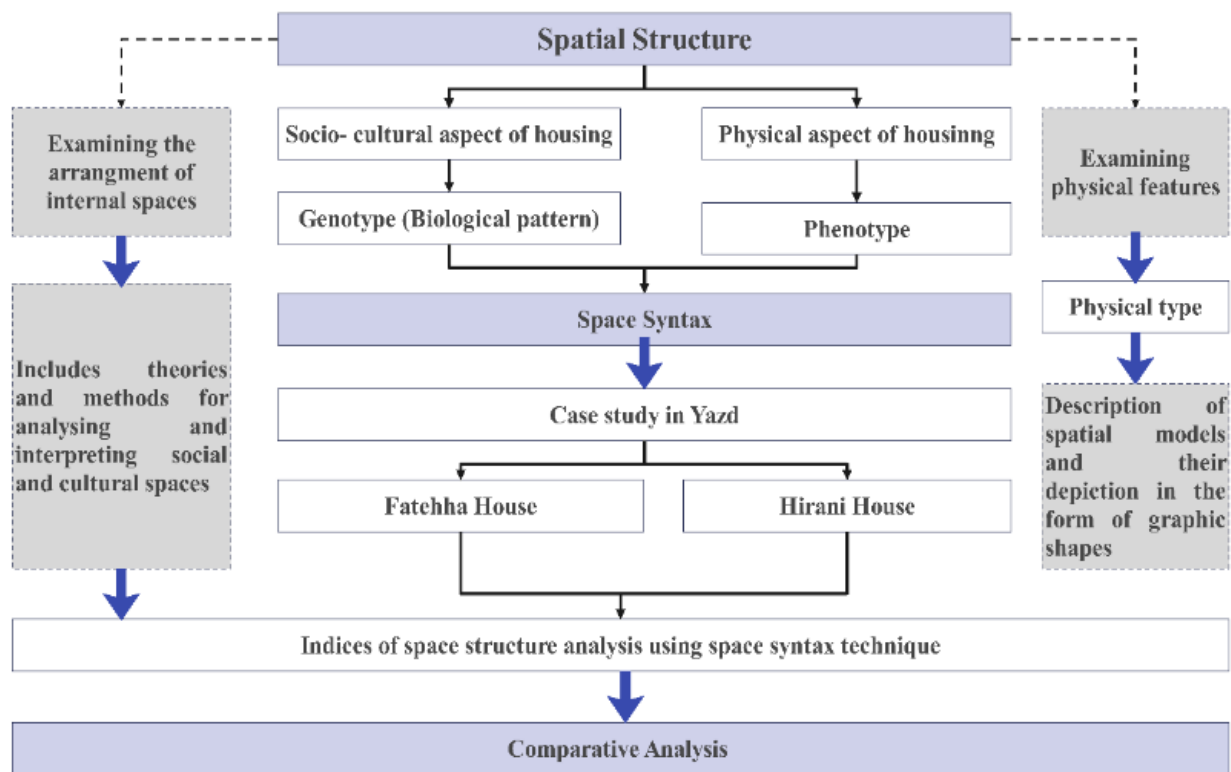


Fig 4. Research method

5. Research Findings

After plotting the justified graph and calculating the depth, relative depth, and integration indicators using AGRAPH software, the following data were obtained for each of the variables in both the Hirani and Fateh Houses:

Depth: The depth value indicates how far each space is from the entrance, with higher depth values representing spaces that are less accessible and more private. In the Hirani House, the depth of spaces shows a distinct spatial hierarchy, with areas closer to the entrance being more accessible, while deeper spaces are more isolated. In contrast, the Fateh House exhibits a slightly different

Table 1

Houses pictures and graph

House	Plan	Graph	Picture
Heyrani		1.Entrance 2.Dividing Space 3.Living Room 4.Room 5.Services 6.Pre-Space (or Anteroom) 7.Corridor 	
Fateh		1.Entrance 2.Dividing Space 3.Living Room 4.Room 5.Services 6.Pre-Space (or Anteroom) 7.Corridor 	

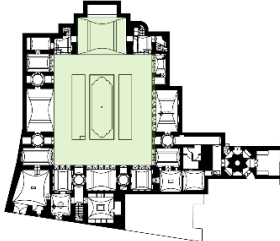
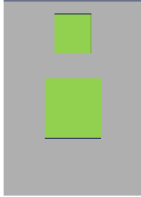
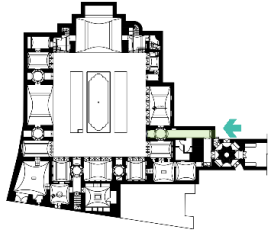
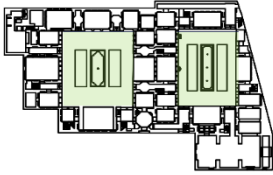
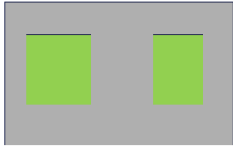
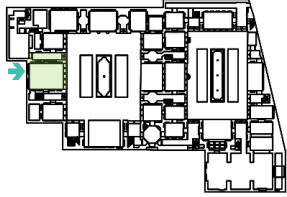
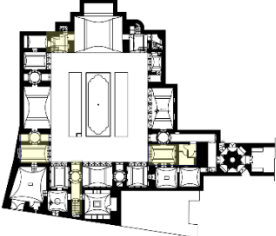
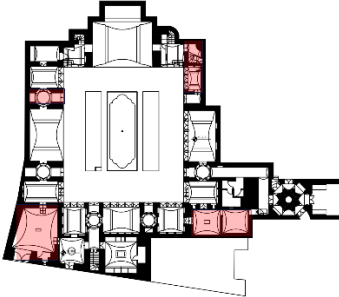
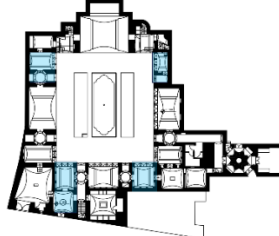
Integration: Integration reflects the level of connection between spaces. In the Hirani House, spaces with higher integration values are more centrally located, making them easily accessible and influencing the movement flow within the house. The

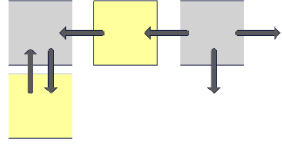
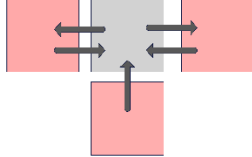
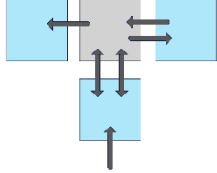
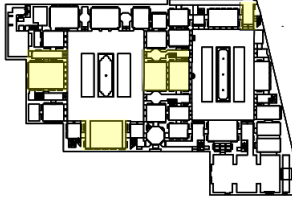
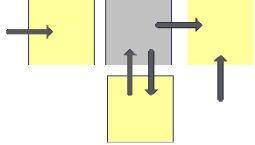
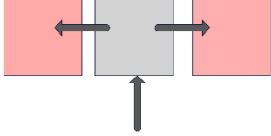
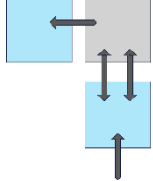
Fateh House, however, displays a more segregated layout, with certain areas being more connected to central spaces, while others are less integrated, suggesting a more complex social and functional structure. These indicators provide valuable insights into how the spatial organization in both houses affects accessibility, privacy, and movement flow. The results highlight the differences and similarities in the spatial configuration of the Hirani and Fateh Houses, revealing how these layouts reflect cultural and social patterns within the homes. Table 1 Houses pictures and graph has been showed.

The traditional houses of Yazd, particularly the Hirani and Fateh houses, each present unique spatial configurations that reflect the deep influence of culture and social needs on architectural design. The Hirani house, with its north-south orientation, takes advantage of natural sunlight and ventilation. The spaces are arranged longitudinally along the north-south axis, with northern areas typically being cooler and southern areas warmer and sunnier. This configuration results in public spaces being oriented toward the north and private spaces toward the south, with accessibility to the spaces arranged linearly and with

distinct separation. As a result, privacy and social interactions are effectively separated in this house. In contrast, the Fateh house, with its east-west orientation and two central courtyards, offers a different spatial design. The two central courtyards effectively separate public and private spaces. This design naturally divides the house into two main sections: one for public activities and the other for private spaces. The courtyards serve as central points for social interactions and connections to other areas of the house, while the east-west orientation maximizes the use of natural light throughout the day. This arrangement facilitates movement and the free flow between spaces, creating closer connections between them. In comparison, the Hirani house, with its north-south orientation, has a clear spatial hierarchy, with spaces closer to the entrance being more public and deeper spaces being more private. In contrast, the Fateh house, with its two central courtyards, simplifies accessibility and provides more flexibility in organizing the spaces. These features highlight the fundamental differences in how public and private spaces are separated and how social interactions are facilitated in these traditional Yazdi homes

Table 2
Houses mass, space and heritage

House	Plan	Mass and space	Entrance
Heyrani			
Fateh			
House	Public area	Semi-Private	Private Spaces
Heyrani			

			
Fateh			
			

The following table, Table 2: Houses Mass, Space, and Heritage, provides a comprehensive comparison of the spatial characteristics and architectural features of the Hirani and Fateh houses. It highlights essential spatial indicators such as the mass of the houses, the distribution of space, and the way these elements reflect the cultural and historical heritage embedded in the design. By analyzing these variables, the table aims to shed light on how the spatial organization of each house influences the experience of the inhabitants, as well as how these traditional houses embody the social and cultural values of Yazd. This analysis is crucial for understanding the broader implications of architectural design in relation to both functionality and cultural identity.

Ultimately, the design differences between the Hirani and Fateh houses reflect the adaptability of traditional Yazdi architecture in responding to social, cultural, and climatic needs. The orientation of the plans and the organization of spaces in these homes significantly impact privacy, social interactions, and the functionality of spaces, showcasing design principles that are deeply connected to the culture and lifestyle of the inhabitants.

1. Public Areas:

Hirani House: In the Hirani house, the public spaces (colored in yellow) are generally located near the center or the entrance. These areas are intended for social interactions and receive the most frequent traffic. The spatial arrangement here shows a clear distinction between spaces used for public and private functions. The public areas are relatively open and easily accessible, supporting a welcoming atmosphere for guests and visitors.

Fateh House: The Fateh house, with its east-west orientation, also has public spaces located near the central courtyard (colored yellow). However, due to the two courtyards, the public areas may be more dispersed. This layout influences the flow of movement and helps in the differentiation of spaces. The presence of two courtyards can provide a sense of separation and privacy even in the

public areas, depending on the layout and the specific usage of each courtyard.

2. Semi-Private Areas:

Hirani House: The semi-private spaces (marked in red) in the Hirani house are located adjacent to the public spaces, which allows for easy access while still maintaining a degree of separation. These areas are transitional, often used for activities that require some privacy but are still part of the public flow, such as family gatherings or informal meetings.

Fateh House: The semi-private spaces in the Fateh house (also marked in red) are similarly positioned near the public areas but are more divided due to the house's dual courtyard layout. These spaces might function as buffers, providing more intimacy and separation from both the public and private areas. The design of these semi-private spaces in the Fateh house is influenced by the two central courtyards, offering flexibility in how the space is accessed and used.

3. Private Spaces:

Hirani House: The private spaces (colored in blue) are positioned further from the central circulation areas, reflecting the house's hierarchical organization. These spaces are dedicated to the more intimate activities of the family and are designed to offer privacy and seclusion. The north-south orientation of the house influences the amount of natural light and ventilation in these spaces, with the southern rooms likely being warmer and sunnier, enhancing the comfort and privacy of family members.

Fateh House: The private spaces in the Fateh house (also colored in blue) are located in a more separated manner. The two courtyards contribute to the spatial privacy of the rooms, and the east-west layout helps in optimizing sunlight exposure. The distribution of these private rooms is influenced by the orientation of the plan, offering varying levels of sunlight and ventilation depending on their position relative to the courtyards. These private spaces are

likely designed for rest and privacy, shielded from the public and semi-private areas.

Implications of Plan Orientation on Space Configuration:

Hirani House (North-South Orientation): The north-south orientation of the Hirani house leads to a more linear organization of spaces, with a clear distinction between public and private areas. The deep structure of the house ensures that spaces like private rooms are well-separated from the entrance, contributing to a more secluded and private atmosphere. The house's orientation also influences the spatial hierarchy, with spaces closer to the entrance being public and spaces further away offering more privacy.

Fateh House (East-West Orientation): The east-west orientation in the Fateh house introduces a different approach to spatial organization. With two central courtyards, this house offers more flexibility in how spaces are accessed and used. The east-west direction affects the house's exposure to sunlight and airflow, with rooms located on the east side receiving morning light and those on the west side benefiting from the afternoon sun. The courtyards act as mediators, influencing how spaces are divided and accessed, creating a balance between public, semi-private, and private areas.

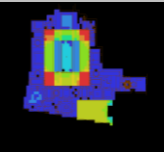
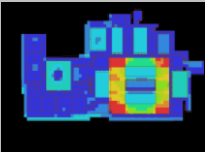
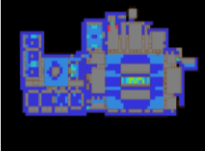
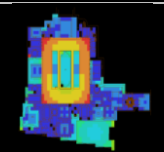
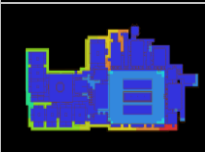
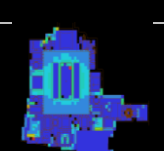
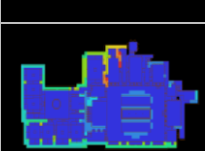
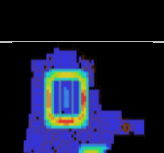
The comparison between the Hirani and Fateh houses reveals key differences in their spatial configurations based on their plan orientations. The Hirani house, with its north-

south orientation, offers a clear separation between public and private areas, emphasizing privacy and a linear arrangement. In contrast, the Fateh house, with its east-west orientation and dual courtyards, provides more flexibility and interaction between the spaces, with courtyards playing a significant role in separating and connecting public, semi-private, and private areas. The different orientations affect the functionality, accessibility, and overall experience of the spaces within each house, shaping the way residents interact with their environment. In Table 4 comparing the spatial characteristics of the Hirani and Fateh houses based on the output from the Depth Map software, focusing on key spatial indices such as Visual Connectivity, Visual Entropy, Integration, Relative Depth, and Visibility:

In fig 5 scatter plot Fateh House presented above shows the relationship between Visual Connectivity and Relative Depth for the Hirani and Fateh houses. Here's an interpretation of the data based on the chart:

Relative Depth (on the X-axis) refers to the depth of spaces within the building, representing the number of steps or transitions required to reach a space from a reference point (usually the entrance). Higher values indicate greater spatial separation and reduced accessibility, while lower values suggest more accessible and interconnected spaces

Table 3
Comparative analysis of the spatial configuration in hirani and fateh houses

Spatial Features	Hirani House	Results	Fateh House	Results
Visual Connectivity	8.40		57.29	
Visual Entropy	1.26		1.09	
Integration	11.61		16.99	
Relative Depth	1.86		1.74	
Visibility	16.0		24.89	

Visual Connectivity (on the Y-axis) shows how connected the spaces are visually within the house. Higher values

indicate more visible links between spaces, suggesting a greater sense of openness and interconnection between

different areas. Lower values suggest more isolation between spaces.

There is a negative correlation between Visual Connectivity and Relative Depth, as indicated by the fitting line on the scatter plot. As the relative depth increases, visual connectivity tends to decrease, and vice versa. This suggests that in both the Hirani and Fateh houses, more isolated (deeper) spaces tend to have fewer visual connections to other spaces.

The R^2 value of 0.198 indicates a weak correlation between these two variables. This means that while there is a general trend, the relationship between Visual Connectivity and Relative Depth is not very strong. Other factors beyond

depth and visual connection likely influence the spatial configuration of these houses. The Hirani house, which has a north-south orientation, appears to have higher Relative Depth values, particularly for more private spaces. As these spaces are located deeper in the house, they have lower Visual Connectivity, indicating that they are more isolated and private. The spaces near the entrance and those with lower Relative Depth tend to be more visually connected, which is consistent with the general trend observed in the scatter plot. The functions of Fateh House are detailed in Table 5, and the analysis of its spaces will be discussed further.

Table 5

The functions of fateh house

Fateh House	Visual Connectivity	Visual Entropy	Integration	Relative Depth
Bathroom	1.171	0.96	1.198	1.8
Stairs	0.491	0.77	1.076	2.2
Veranda	0/671	0.74	1.1	1.9
Kitchen	1.404	1.04	1.261	1.8
Pantry	0/846	0.97	1.086	1.94
Room with two doors	0.451	0.82	0.927	2.11
Hall	1.321	1.02	1.229	1.83
Summer sitting room (often a room designed for warmer weather with three doors)	2/297	1.06	1.74	1.59
Winter sitting room (a room designed for colder weather with three doors)	0.824	0.87	1.098	1.93
Royal room (Shah Neshin	0.79	0.94	1.064	1.95
typically a formal or ceremonial room)	2.613	1.06	1.934	1.52
Inner courtyard	2.356	1.06	1.74	1.57
Outer courtyard	2/968	1.04	2.19	1.45
Eight-sided room (possibly a unique-shaped room)	0.688	0.92	1.01	2.04
Main entrance	2.539	1.18	0.16	1.55

Fateh House: The east-west orientation of the Fateh house, with two central courtyards, suggests that the spaces are organized more openly and may have higher Visual Connectivity. However, there is still a noticeable separation between the public and private areas, especially

in deeper spaces, resulting in lower Visual Connectivity for spaces with higher Relative Depth.

Despite the more open central courtyards, the relationship between Visual Connectivity and Relative Depth remains consistent with the overall pattern seen in the scatter plot.

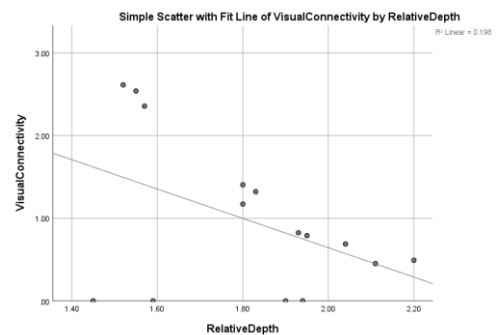
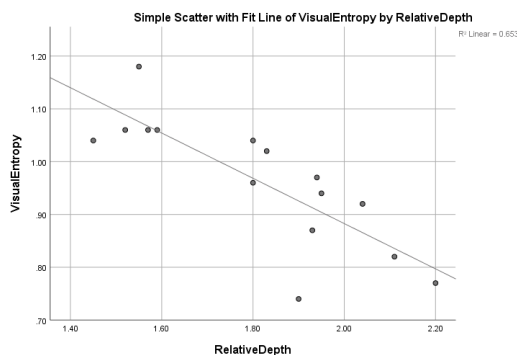


Fig 5- scatter plot relative depth with visual connectivity & visual entropy fateh house

The Hirani and Fateh houses demonstrate a similar pattern where the deeper, more private spaces (higher Relative Depth) are less visually connected, indicating a separation between the spaces. The more accessible areas (lower Relative Depth) tend to have higher Visual Connectivity, allowing for better interaction and connection between spaces. Although the scatter plot suggests a weak correlation, the trend reflects an important design principle in traditional Persian houses: the further a space is from the central axis (entrance or courtyard), the more private and less interconnected it becomes visually. This spatial arrangement supports both functional needs and cultural norms related to privacy and social interaction. In summary, while the scatter plot reveals a general trend, it also suggests that other design factors, such as the use of courtyards, the number of spaces, and the spatial hierarchy, significantly influence the relationship between Visual Connectivity and Relative Depth in these two traditional houses. The scatter plot analyzing Visual Entropy and Relative Depth in the Hirani and Fateh houses shows a negative correlation, meaning that as Relative Depth increases, Visual Entropy tends to decrease. This indicates that deeper, more private spaces have simpler, more predictable visual relationships, while more accessible spaces are visually more complex and interconnected. In the Hirani House, with its north-south orientation, spaces further from the entrance (private areas) have higher Relative Depth and Visual Entropy, suggesting more isolation and complexity in visual connections.

Conversely, the Fateh House, with its east-west orientation and two central courtyards, features more interconnected spaces, reducing Visual Entropy despite having deeper private areas.

The R^2 value of 0.653 suggests a moderate correlation, showing that while depth and visual complexity are linked, other design elements like courtyards and room layout also influence spatial organization. Both houses reflect the traditional Persian architectural principle of balancing privacy and social interaction, though the Fateh House offers more integration and visual connectivity compared to the Hirani House.

The kernel smooth density plot shows the relationship between Visual Entropy, Integration, Relative Depth, and Visual Connectivity in Fateh House. Visual Entropy (black curve) shows a bimodal distribution, indicating spaces with both low and high visual complexity. Lower Visual Entropy corresponds to more interconnected spaces, while higher values indicate isolated, private areas. Integration (red curve) peaks around 2.2, suggesting that most spaces in the house are moderately integrated, facilitating easy movement and access. Spaces with higher Integration are less complex visually, which corresponds to lower Visual Entropy. Relative Depth (blue curve) has a peak around 1.1, showing that most spaces have moderate depth, meaning they are not overly private but still somewhat separate from the entrance. Higher Relative Depth tends to align with higher Visual Entropy.

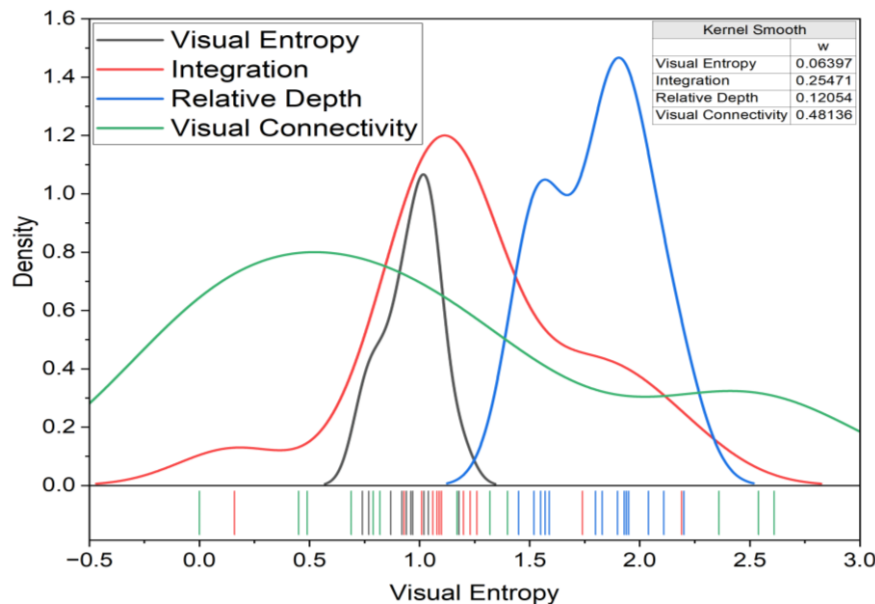


Fig.6. kernel smooth density fateh house

Visual Connectivity (green curve) peaks at 0.8, indicating that the visual connections between spaces are moderate. More connected spaces have lower Visual Entropy, meaning they are more visually predictable. In summary,

Fateh House demonstrates a clear relationship between visual complexity and space connectivity. Spaces with higher depth tend to have higher Visual Entropy, indicating

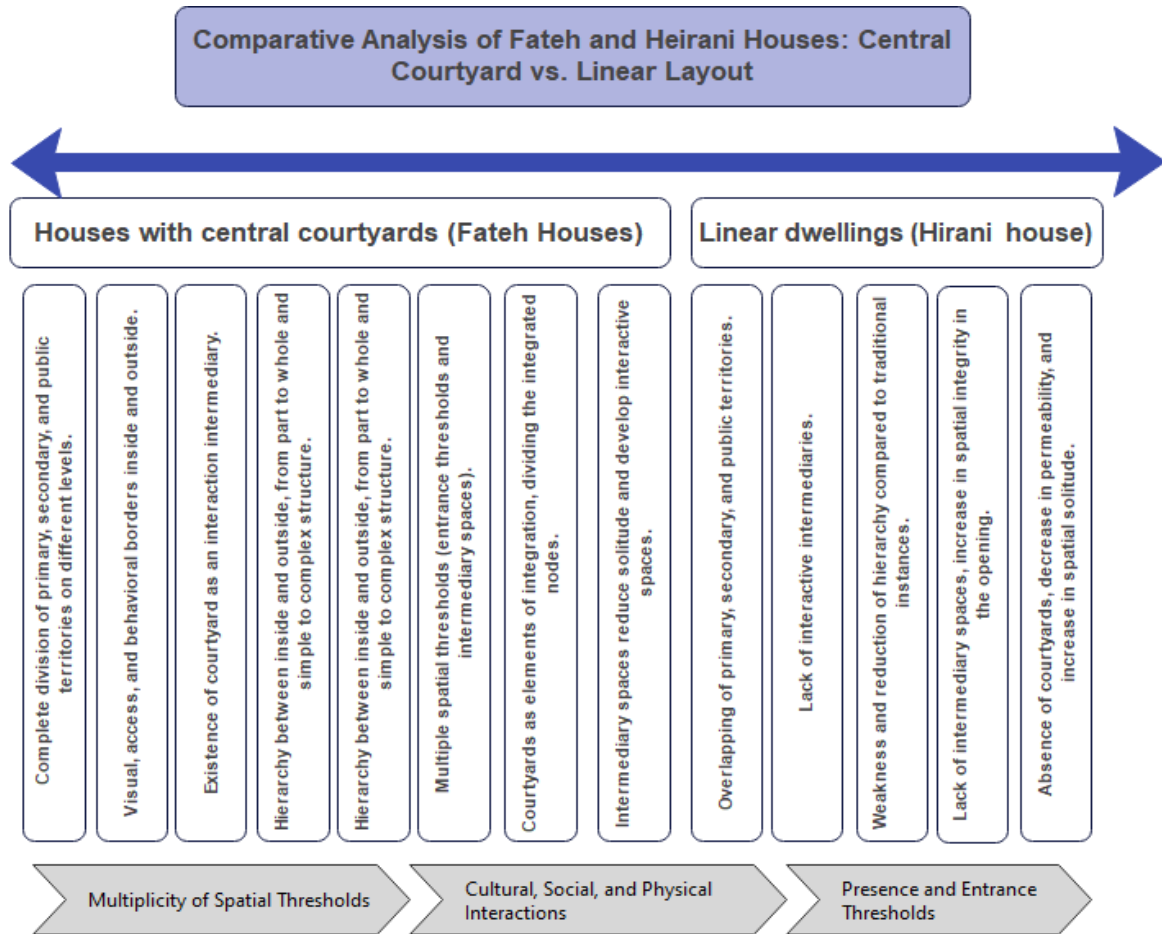


Fig. 7. Comparative analysis of fateh and heirani houses: central courtyard vs. linear layout

They are more isolated and private, while more integrated spaces with better visual connectivity are simpler and more connected visually. In Fig 7 Comparative Analysis of Fateh and Heirani Houses: Central Courtyard vs. Linear Layout has been illustrated.

6. Conclusion

This study offers a comprehensive comparative analysis of the Hirani and Fateh houses in Yazd, focusing on their spatial configurations and the influence of architectural layout on accessibility, privacy, and social interaction. The analysis, based on spatial syntax theory, sheds light on how the north-south and east-west orientations impact the organization of spaces within these traditional homes. Through tools like AGraph software and Depth Map, the research explores how spatial indicators such as Depth, Relative Depth, Integration, and Visual Connectivity vary between the two houses, revealing the underlying design principles that cater to the social and cultural needs of the inhabitants.

The Hirani House, with its north-south orientation, presents a more linear, hierarchical design. Public spaces are located closer to the entrance, while private spaces are positioned deeper within the house. This arrangement emphasizes privacy and seclusion, with spaces farther from the entrance exhibiting higher relative depth and lower visual

connectivity. These deeper, more isolated spaces encourage a sense of privacy and separation, reflecting the cultural importance of privacy in traditional Iranian domestic architecture. The linear structure of the house also contributes to the organization of social interactions by clearly separating public and private domains, thus controlling access and interactions between inhabitants and visitors.

In contrast, the Fateh House, with its east-west orientation and two central courtyards, adopts a more open and integrated layout. The central courtyards act as intermediaries, creating a sense of fluidity between different areas of the house. The courtyards reduce the spatial segregation typically found in linear houses and promote more interconnectedness between public, semi-private, and private spaces. This spatial integration allows for more social interaction, as the courtyards serve as focal points for family gatherings and other communal activities. The east-west orientation also optimizes the use of natural light, with the courtyards playing a key role in improving ventilation and maintaining comfortable indoor climates throughout the day. A key takeaway from the comparative analysis is how the orientation and design of each house shape the daily life and cultural interactions of its inhabitants. The Hirani House emphasizes solitude and privacy by keeping the more personal spaces isolated,

whereas the Fateh House fosters greater social interaction and connectivity through its courtyard-centered layout. While both houses provide a functional response to the social needs of their time, they reflect differing priorities: the Hirani House values separation and hierarchy, while the Fateh House embraces openness and fluidity.

The results of the spatial analysis demonstrate that integration and visual connectivity are higher in the Fateh House, which allows for greater movement and interaction between spaces, while the Hirani House offers more seclusion and privacy. The central courtyards in the Fateh House help reduce visual entropy, allowing for a more cohesive and interactive spatial experience. On the other hand, the Hirani House's linear design creates higher visual entropy in deeper, more private spaces, contributing to a greater sense of separation and isolation.

Additionally, the spatial hierarchy in the Hirani House, with its clear distinction between public and private spaces, aligns with traditional values of privacy in Iranian architecture. This is in contrast to the Fateh House, where the central courtyards break down the separation between spaces, creating a more integrated environment that encourages interaction and the blending of different functional areas. Both layouts reflect the cultural context of Yazd, where climate, privacy, and social interaction are fundamental considerations in architectural design.

The comparative study also highlights how the social and cultural behaviors of the inhabitants are reflected in the spatial organization. For example, the Fateh House's use of courtyards promotes communal living and a sense of openness, suitable for the more collective social norms of the time. Meanwhile, the Hirani House allows for greater individual space and private retreats, aligning with more introspective or family-centered modes of interaction.

Moreover, the findings reveal how these traditional homes adapt to climatic conditions. The north-south orientation of the Hirani House optimizes natural light and ventilation, making it ideal for Yazd's hot, arid climate, where controlling temperature is crucial. The east-west orientation of the Fateh House, with its courtyards, maximizes airflow and sunlight exposure, ensuring thermal comfort and improved ventilation throughout the day.

Overall, this study emphasizes that the design principles of traditional Persian architecture—especially those found in Yazd—are deeply tied to cultural and functional needs. The Hirani House and Fateh House each showcase how spatial layout can reflect the social structure and daily routines of a community. The Fateh House, with its integrated courtyards and more fluid layout, offers greater social interaction and connectivity, whereas the Hirani House, with its more isolated spaces, emphasizes privacy and individual autonomy.

By comparing these two houses, the study also offers valuable insights for contemporary architectural practices. The use of courtyards as intermediary spaces and the emphasis on integration and privacy provide lessons for creating modern living environments that respect both cultural heritage and functional design principles. These findings contribute to a better understanding of how traditional Persian architecture can inform and inspire

future housing solutions, combining the best of historical practices with modern-day needs.

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