Adaptive comparison of the connectivity of courtyards with the main living spaces in traditional and contemporary houses with the approach of space syntax: A solution to improve the position of the courtyard in new houses

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Abstract

This research deals with the relationship between the courtyard and living spaces in contemporary and traditional houses. The purpose of this research is to provide a method for spatial analysis of the house with the aim of improving spatial relations. The case study is the city of Hamadan in Iran. Three contemporary houses and three traditional houses were selected for analysis. After selecting the houses, their analysis was done in Space Syntax software, UCL Depth Map. Also, to understand the types of behavioral systems in the houses, several residents were interviewed. The results show how spatial relationships in traditional and contemporary houses have changed based on different behaviors and also changing climatic conditions. The main living room, where people spend most of their time in traditional houses, has less physical and visual connectivity with the courtyard compared to other living spaces. Meanwhile, contemporary houses pay a lot of attention to the visual relationship between the main living space and the courtyard.

Keywords: Space syntax; Spatial configuration; Isovist; lifestyle; Courtyard; Hamedan City

1. Introduction

1.1. Research background

The evolution of contemporary housing development is often marked by a profit-driven approach, overshadowing the intrinsic human necessities and the essence of living spaces. This trend has led to the neglect of fundamental architectural values, particularly those connected to comfort, tranquility, and spiritual fulfillment, as well as the integration of natural elements and open spaces. Studies highlight this oversight, emphasizing its discordance with essential architectural principles (Hassan et al., 2019; Leijten & De Bel, 2020; Azad et al., 2018).

In contrast, traditional Iranian architecture showcases a rich heritage where the concept of open or void spaces transcends mere aesthetics or functional requirements. Courtyard-centric designs, characterized by their introverted nature, form the core of this architectural philosophy. These spaces, deeply rooted in traditional principles, act as central unifiers, shaping and defining the surrounding enclosures (Mohammadabadi & Ghoreshi, 2011). They extend beyond their physical form, embodying cultural, social, and existential dimensions. Numerous studies underscore the significance of such central courtyards, highlighting their pivotal role in Iranian architectural identity (Alkhansari, 2015; Hejazi et al.,

2015; Khajehzadeh et al., 2016; Soflaei et al., 2016b; Zolfagharkhani & Ostwald, 2021).

The present study delves into the traditional housing of Hamedan during the Qajar and Pahlavi I dynasties, employing a space syntax approach to investigate the relationship between living spaces and courtyards. This research aims to elucidate the interconnectivity within traditional housing layouts, offering insights that contemporary designers can adapt to enhance modern residential environments.

The scholarly exploration of nature and visual connectivity within residential environments is extensive, with researchers emphasizing its vital role in traditional courtyards (Kelcey, 1978; Lee & Asakawa, 1992; Li et al., 2014). Efforts to revive the prominence of outdoor spaces in traditional Iranian architecture further reinforce this theme (Foruzanmehr, 2015; Khalili & Amindeldar, 2014; Soflaei et al., 2016b, 2016a). Additionally, studies examining the presence of nature in traditional homes, such as Bemanian et al. (2018), corroborate the enduring significance of nature-centric designs in Iranian architectural traditions.

From a methodological perspective, space syntax analysis has become a crucial tool in understanding spatial configurations within residential typologies. It has been employed to analyze privacy (Alitajer & Molavi Nojoumi,

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2016; Khozaei Ravari et al., 2022; Adebara, 2022; Zabihi & Mirzaei, 2023), cultural sustainability (Al-Mohannadi et al., 2019; Soflaei et al., 2017; Huang et al., 2019; Mazinanian et al., 2022; Rong & Bahauddin, 2023), spatial structure (Amiriparyan & Kiani, 2016; Hessari & Chegeni, 2021; Zolfagharkhani & Ostwald, 2021), architectural typology (Adeokun, 2013; Zhou & Zheng, 2022), and visual dynamics within various housing contexts. For instance, research on visibility within traditional textured houses reveals a sustained continuity in spatial arrangements before the modern era, with traditional influences gradually diminishing in contemporary designs (Ali Hessabi et al., 2013).

1.2. Problems and Historical Context

In the realm of architecture, man's understanding and utilization of nature are rooted in his inherent connection to it, a notion expounded by Norberg-Schulz (Krause, 1991). This connection fosters a correct understanding of time and environment, especially in traditional Iranian architecture, where the connectivity between open spaces and human habitation is exquisitely formulated. Conversely, in contemporary settings, there is an apparent dissatisfaction with the connectivity between living spaces, courtyards, and open green areas(Azad et al., 2018). Modern contexts' spatial and visual connectivity often falls short of acceptance, drawing criticism for its apparent deficiencies. Historically, integrating open space within architecture provided greater satisfaction and created unique quality concerning the open space (Karimi et al., 2020). In response to this shifting dynamic, this study seeks to explore the connectivity between spaces and courtyards in traditional and contemporary houses through two lenses: connectivity and visual connectivity. By utilizing space syntax, this research aims to uncover the differences between traditional and modern connections, culminating in a proposed model that endeavors to recapture the desired quality once prevalent in traditional design. The findings of this article contribute to a deeper understanding of the complexities of connectivity in residential architecture, bridging the gap between past mastery and contemporary challenges.

1.3. Research Question

The objective of this research is to compare the spatial and visual connectivity of courtyards with main living spaces in traditional and contemporary houses, hypothesizing that traditional houses exhibit deeper connectivity. By employing a space syntax approach, this study contributes to the existing body of knowledge and offers insights to enhance modern residential design.

2. Theoretical Framework

This section explores the theoretical foundations of spatial configuration and isovist analysis, incorporating diverse perspectives from experts. It highlights areas of consensus as well as differing viewpoints regarding the interaction between spatial structures and social dynamics.

2.1. Spatial Configuration Theory: Overview based on experts' opinion

Spatial configuration theory, introduced by Hillier et al. (1985) and further explored by Steadman (1983), conceptualizes spatial layouts as systems that influence and reflect human activity. Hillier's perspective emphasizes the role of spatial structures in shaping social interactions and behaviors, arguing that spatial organization underpins societal functioning. Conversely, Steadman places a greater focus on the mathematical and geometric aspects of spatial modeling, with less emphasis on its social implications. These differing emphases illustrate the multifaceted nature of spatial configuration theory, balancing functional and sociocultural dimensions.

The foundational work by Hillier and Hanson (1984) established space as a core medium for organizing cultural and social events. Their research underscores a bidirectional relationship: while spatial forms influence social behaviors, cultural norms also shape spatial arrangements (Makrí & Folkesson, 1999). Some experts, such as Klarqvist (2015), agree with this holistic approach, while others, like Jiang et al. (2000), argue for a more segmented focus on specific spatial metrics, such as connectivity or integration, to better suit urban planning contexts.

Spatial analysis involves three primary concepts (Klarqvist, 2015):

- Convex Space: Areas with unobstructed lines connecting any two points, minimizing fragmentation.
- Axial Space: Representations of paths or lines of sight, crucial for understanding navigation and movement.
- Isovist Space: Visual fields perceived from a specific vantage point, emphasizing the user's experience of space.

While most experts align on the importance of these concepts, their applications vary. Hillier advocates for axial space analysis as the cornerstone of urban studies, while Benedikt (1979) and Montello (2007) emphasize isovist analysis for its insights into visibility and perception. Jiang et al. (2000) suggest integrating these methods for a more comprehensive understanding, though critics argue that such integration may dilute the precision of individual analyses.

2.2. Space Syntax: Analytical Framework

Space syntax provides a framework for examining spatial connectivity, accessibility, and social interaction. Key metrics include:

- Integration: The degree of connectedness within a spatial network, with high integration linked to greater accessibility.
- Depth: Steps required to traverse between two points, reflecting spatial hierarchy.
- Connectivity: The number of direct links from one point to others.
- Traversable Depth: All points visible from a location, offering insights into openness (Benedikt, 1979).

Haq and Zimring (2003) highlight the social dimensions of space syntax, linking integration and connectivity to

patterns of human interaction. Others, like Klarqvist (2015), caution against over-reliance on numerical indices, advocating for a qualitative understanding of spatial systems alongside quantitative measures.

2.3. Isovist Analysis

Isovist analysis, introduced by Tandy (1967), examines the visible range from a single point to understand spatial perception. Derived from Gibson's ecological theory (2014), it quantifies spatial properties using metrics such as:

- Area: Total visible space.
- Perimeter: Boundary length.
- Closure: Ratio of the perimeter to the visible mass, reflecting enclosure.
- Circularity: Comparison of the perimeter to the area, indicating compactness.
- Compression: Proximity of the Isovist to convexity.

While Benedikt (1979) emphasizes its geometric dimensions for architectural analysis, Montello (2007) critiques its applicability to dynamic spaces, arguing that human perception involves more than static views. Klarqvist (2015) proposes a balanced approach, using Isovist analysis as part of a broader toolkit for understanding spatial experience.

2.4. Conceptual Model

The theoretical foundations culminate in the conceptual model below, establishing the relationship between the research indicators:

- **Spatial Configuration**: The interaction between architectural forms and social behaviors, measured through integration, connectivity, and depth indices.
- **Isovist Analysis**: Visual connectivity and accessibility within residential spaces, described through geometric and spatial metrics.
- **Social and Cultural Implications**: The role of spatial and visual arrangements in fostering interactions, cultural continuity, and functional adaptability.

This conceptual model (Figure 1) integrates the theoretical perspectives discussed, linking spatial analysis concepts with research objectives. It serves as a guiding framework for analyzing the relationship between spatial configurations and social structures in both traditional and contemporary residential architecture.
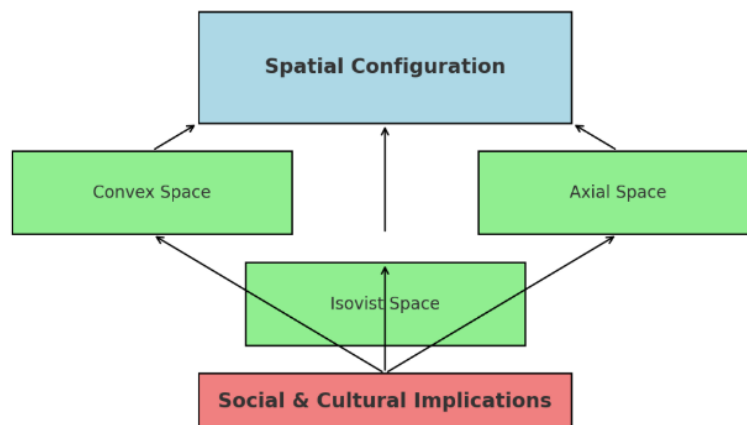
Fig. 1. Conceptual model of the research

3. Research Methods

In the present study, an examination was conducted of the traditional houses in Hamedan, focusing on their spatial and configurational properties. Initially, maps of these houses were gathered, and introverted options were systematically categorized into four distinct groups: multi-courtyard; three-sided volume; two-sided volume; and one-sided volume. Two exemplar cases were chosen for further study from each of these categories. Additionally, contemporary houses were represented by selecting four instances from the portfolios of two eminent city architects. These maps were meticulously analyzed using AutoCAD and UCL depth map software.

In order to establish a lifestyle and a behavioral system in the traditional houses of Hamedan, interviews were conducted with several residents who had lived in these houses. These dialogues identified and documented various activities and the corresponding spaces where these activities occurred. This portion of the study was conducted across hot and cold seasons, to understand the variations and similarities in usage patterns.

Subsequently, the houses were evaluated in terms of spatial configuration and Isovist properties. This analysis used space syntax software to examine integration, depth, connectivity, and other vital indicators, as well as the dimensional characteristics of Isovist. The results of this comprehensive study were synthesized and presented in the final section, elucidating the intricate relationships between architectural design and lived experience in the traditional houses of Hamedan.

3.1. *Hamedan city*

Hamedan's climate is classified within the cold semi-arid category (BSk) according to the Köppen climate system. The region's specific climatic features include a mean annual temperature of approximately 11°C, with the mean temperature of the warmest month exceeding 22°C and that of the coldest month between -3°C and 18°C. Precipitation does not exceed 40% of the weather station's threshold, with an annual average of around 318 millimeters, and the dry season typically occurs in the summer (Kottek et al., 2006).

In Hamedan's climate conditions, traditional homes typically exhibit a compact structure, often spanning two levels. Their architectural design, mirroring the city's layout, is tailored to counter severe cold weather. Central to these dwellings is a courtyard, around which the summer and winter living areas are arranged, a common feature in Iranian architecture. This layout facilitates the building's adaptability to different seasons. The influence of this climatic condition on both traditional and modern architectural styles, especially in their interaction with the courtyard space, shows significant variance, as illustrated in Figures 2 and 3 (Malekhosseini & Dargahi, 2010).
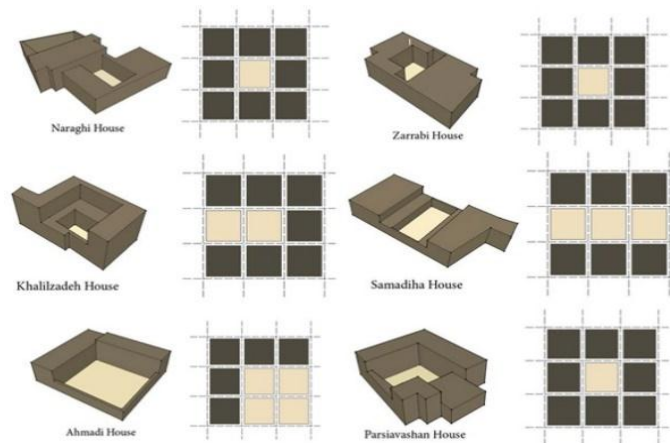

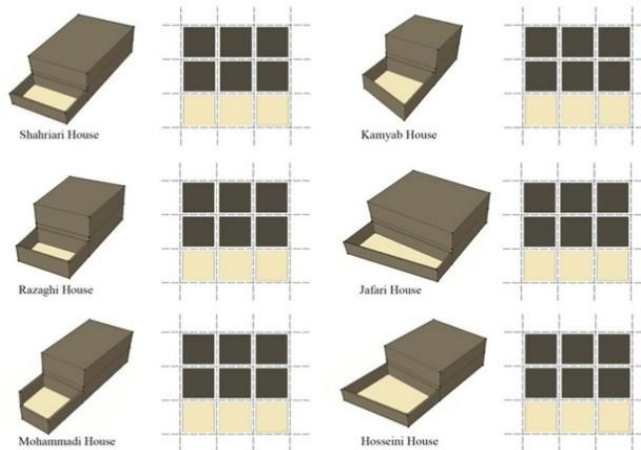Fig. 2.. 3D models of traditional houses in Hamedan

Fig. 3. 3D models of contemporary houses in Hamadan (sample of north-oriented houses).

3.2. *Selected houses*

In the selection process for traditional houses within the study, the initial identification of valuable houses was undertaken, followed by the collection of existing maps. Subsequently, site visits were conducted, where necessary, to draw and correct the maps using AutoCAD software manually. The houses were then categorized into two primary classifications: introverted and extroverted. Two distinct forms were identified within the introverted classification based on the 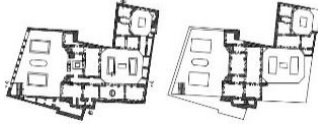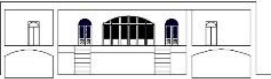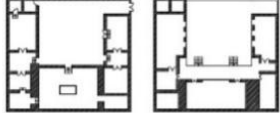courtyard: single-courtyard and multi-courtyard spaces. These forms are further subdivided into three groups based on the number of sides they have the volume on three, two, or one (Figure 2). In contrast, extroverted houses typically feature a central location within a garden setting.
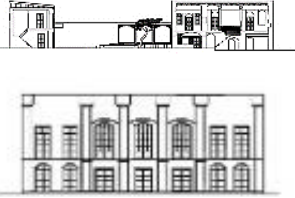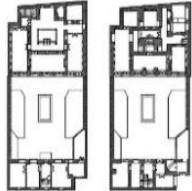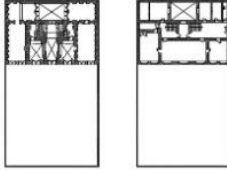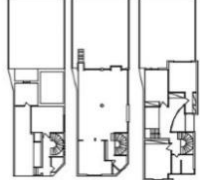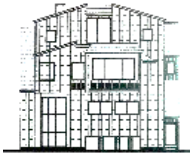
Following this categorization, the introverted form was selected for a more comprehensive examination. The selection aimed to include houses that were recognized as cultural heritage and to ensure diversity in the maps and designs. Contemporary houses were classified into

apartments and houses with courtyards. Since there is a need for more transparent connectivity between living spaces and courtyards, the second type was excluded from the study. Only houses with courtyards, specifically those designed by renowned architects, were selected for in-

depth analysis (Figure 3). Regarding this selection, consideration was given to the diversity of maps and the inclusion of both north-oriented and south-oriented houses. Detailed documentation related to the considered samples is provided in Table 1.

Table 1
Detailed documentation of the considered Houses

Multi courtyard houses	Naraghi's house	Façade and section	Floor plan
Houses with volume in three sides	Araghchian's house		
Houses with volume in two sides	Zarabi's house		
Houses with volume in two sides	Sharafi's house		
Contemporary houses	House One		
	House Two		

4. Result

The architecture of traditional multi-courtyard houses reflects a profound integration of spatial configuration and behavioral systems, creating spaces that accommodate daily, social, and subsistence activities while fostering a deep connection between inhabitants and their environment. This interplay of spatial and behavioral elements is analyzed through interviews with 14 residents (see Table 2) and advanced spatial analysis methods, revealing how these homes balance functionality, cultural practices, and social needs.

Table 2
The Relationship Between Activity Systems and the Spatial and Physical Organization of Traditional Buildings

	Warm Seasons	Cold Seasons
Activity	**Living Activities**	

Cooking	Kitchen	Kitchen, Tandoor (Under Korsi)
Bread Preparation	Oven	Oven
Breakfast and Dinner	Veranda, Roof	Tandoor, Room, Seasonal Room
Lunch	Tandoor, Room	Tandoor, Veranda, Room
Daily Rest	Veranda, Tandoor	Tandoor, Seasonal Room
Washing Dishes	Courtyard, Pool Room	Courtyard, Pool Room
Washing Clothes	Courtyard, Pool Room, Outdoors	Courtyard, Pool Room
Storing Clothes	Closet Room (Storage Room)	Closet Room (Storage Room)
Sleeping	Veranda, Courtyard, Roof	Tandoor, Room, Seasonal Room
Bedding Storage	Room (as cushions), Closet	Room (as cushions), Closet
	Subsistence Activities	
Charcoal Preparation	Courtyard	
Charcoal Storage	Charcoal Bin, Warehouse	Charcoal Bin, Warehouse
Food Storage	Seasonal Room, Warehouse, Closet	Seasonal Room, Warehouse, Closet
Preparing Preserves and Meats	Courtyard	
Pet Care	Corner of Courtyard	
Flour Preparation	Courtyard	
Wheat Storage	Seasonal Room	Seasonal Room
Bread Storage	Seasonal Room (Storage Room)	Closet (Storage Room)
Drying Fruits	Roof, Room, Seasonal Room	
Fruit Storage	Seasonal Room	Seasonal Room
	Social Activities	
Family Gatherings	Veranda, Courtyard	Tandoor
Evening Gatherings	Veranda, Courtyard	Room (around Korsi)
Guest Hospitality	Guest Room	Guest Room
Religious Gatherings	Hosseinieh, Guest Room	Hosseinieh, Guest Room
Ceremonies (Weddings, etc.)	Rooms, Courtyard	Rooms

Architects and builders of traditional homes designed spatial arrangements to serve specific functions, ensuring internal connectivity that aligns with the users' lifestyles. Spaces such as courtyards, kitchens, and guest rooms are not merely physical constructs but repositories of cultural and social values. This connectivity creates a cohesive system where architectural spaces reflect and support the activities and behaviors of their users.

Daily Activities:Cooking takes place in the kitchen throughout the year, with bread preparation centered on a stove or oven. Dining shifts seasonally, with breakfast and dinner occurring on the porch or roof in warm months and moving indoors during colder seasons. Lunch, however, consistently takes place in the main living room, highlighting its communal importance. Washing and storage activities occur in courtyards, pond rooms, and inner warehouses, while sleeping arrangements adapt to the weather, with outdoor spaces preferred in summer and indoor rooms used in winter.

Social and Cultural Activities:Family gatherings, guest hospitality, and ceremonies occur in porches, courtyards, and guest rooms, depending on the season. The courtyard serves as a multifunctional hub, hosting various events and connecting indoor and outdoor living spaces. These activities dictate the spatial organization, emphasizing flexibility and cultural values in traditional homes.

Spatial Analysis Findings:Using visibility graph analysis (VGA) and Isovist analysis, spatial characteristics such as

integration, depth, connectivity, and traversable depth are examined to understand the use of space:

- **Integration**: The outer courtyard in the Naraghi house has the highest integration, serving as the primary spatial and social core.
- **Depth**: Peripheral spaces like the guest room and summer room exhibit the highest depth, indicating their limited accessibility and specific functional roles.
- **Connectivity**: The courtyards exhibit high connectivity, acting as hubs for interaction and activity, while spaces like the entrance and summer room show low connectivity.

Behavioral Patterns and Spatial Dynamics:The spatial configuration of the Naraghi house exemplifies how courtyards act as the heart of traditional homes. These spaces combine high integration and connectivity with low depth, ensuring accessibility and versatility. Peripheral rooms, while less connected, serve specialized functions. This balance between centrality and periphery reflects the integration of behavioral and spatial systems.

In conclusion, traditional multi-courtyard houses embody a sophisticated interplay between architectural design and human activity. The courtyards' central role demonstrates how traditional architecture integrates functional, cultural, and social dimensions, providing lessons for contemporary design. Through behavioral and spatial analyses, this study

highlights the enduring value of these architectural principles.

Table 3
Characteristics of space syntax in graphs shown in traditional multi-courtyard houses (Naraghi's house).

Visibility graph			Visibility graph analysis
Integration	Depth	Connectivity	
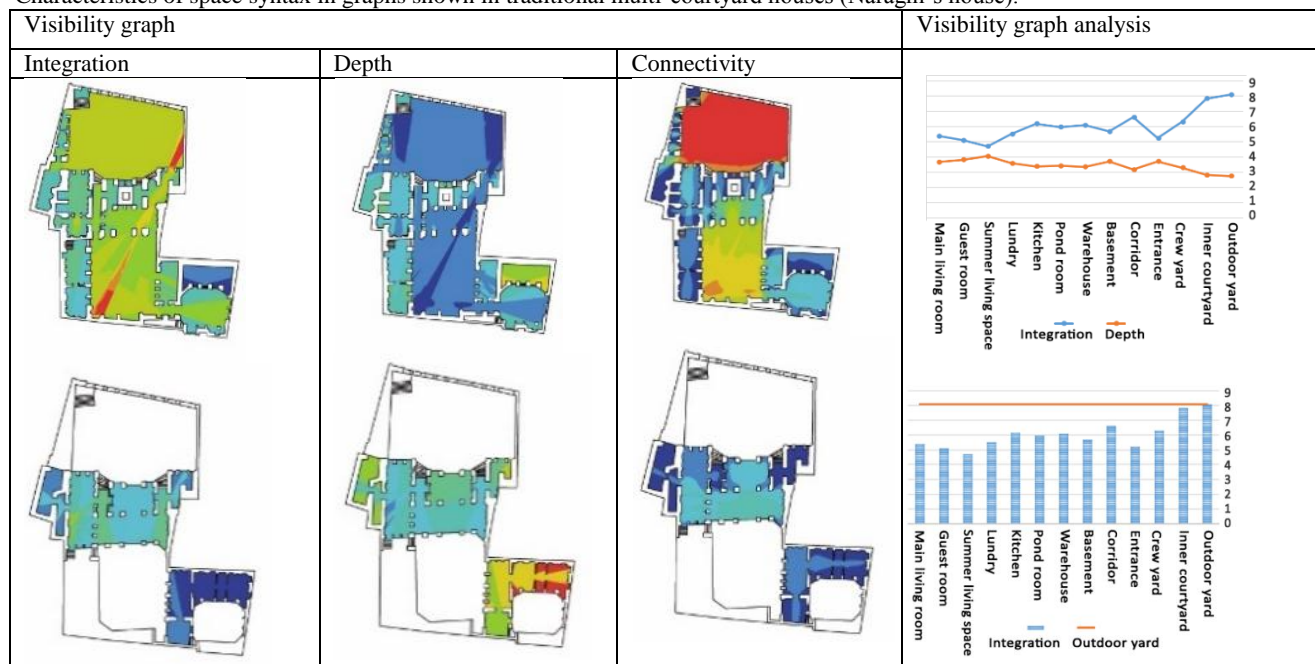
*In the plans, the red color indicates the highest level of each component.

4.1. Traditional houses with volume in three sides

In Araghchian's house, the highest level of connectivity in integration is seen, and the lowest integration belongs to the rooms; the highest level of connectivity is related to the courtyard, the lowest level is related to the main living room and the cooking room (stove) and the highest level of depth is related to the room, the main living room and kitchen are the lowest is related to the courtyard and then the porch (Table 4). So, in the house featuring a three-sided volume, the courtyard exhibits the greatest degree of connectivity and the lowest depth.

Table 3
Indices of space syntax in visibility graphs of traditional houses with volume in three sides (Araghchian's house).

Visibility graph			Visibility graph analysis
Integration	Depth	Connectivity	
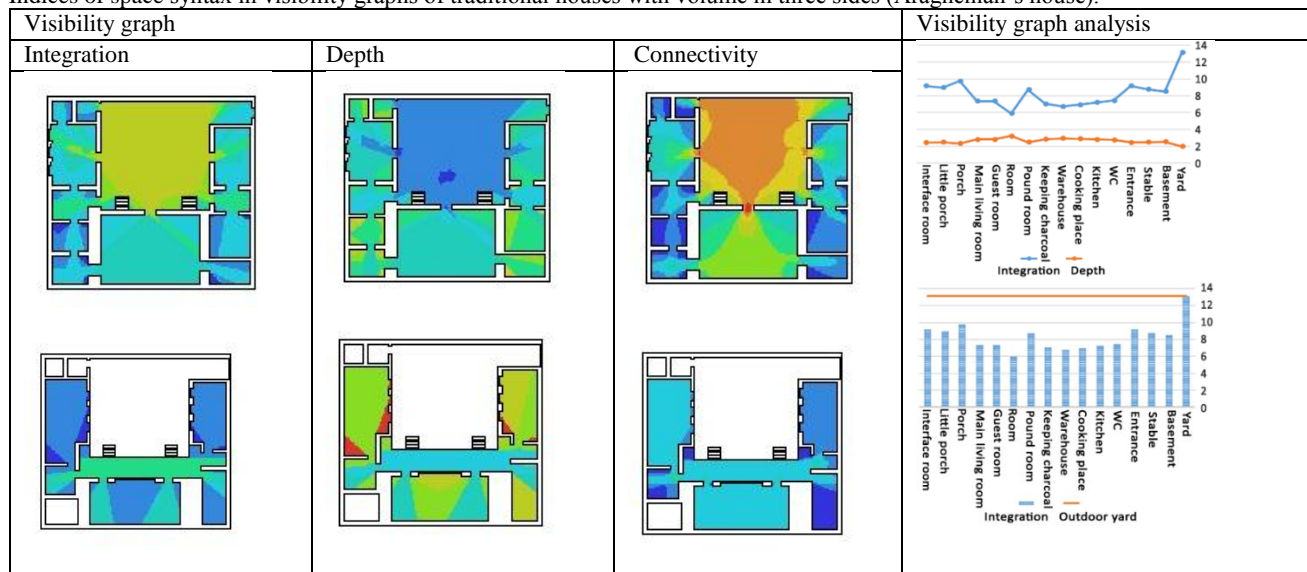
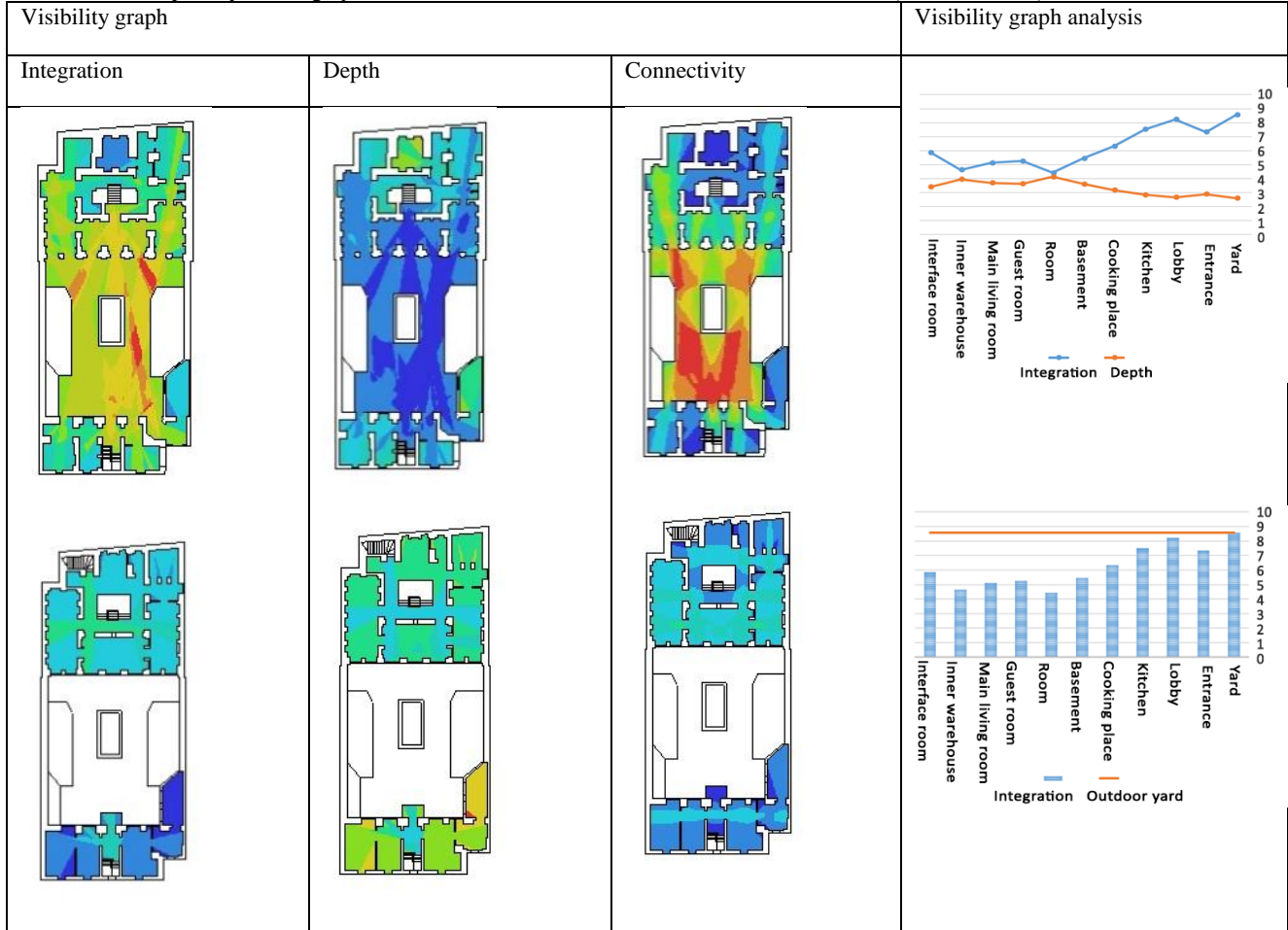### 4.2. Traditional houses with volumes in two sides

In Zarabi's house, the courtyard and the front of the entrance space have the highest level of integration, and the room and the inner warehouse have the lowest level. The courtyard and in front of the entrance have the highest level of connectivity, and the lowest belongs to the inner warehouse. The room has the highest depth, and the

courtyard in front of the entrance has the lowest depth (Table 5). In the house with volumes on two sides, the courtyard is highly integrated, has the highest connectivity, and the lowest depth. In this house, located next to the courtyard, is another space that serves as a joint. The entrance to Zarabi's house is at the front, with high integration, connectivity, and the lowest depth.

Table 4

Characteristics of space syntax in graphs shown of traditional houses with volumes in two sides (Zarabi's house).

Visibility graph			Visibility graph analysis
Integration	Depth	Connectivity	

4.3. Traditional houses with volume in one side

In Sharafi's house, in the visibility graph analysis, the courtyard has the highest level of integration, after which the corridor has the highest level of integration, and the main living room and the room have the lowest level of integration. The courtyard, summer residence, and corridor have the highest connectivity, and the room, the division space, and the main living room have the lowest connectivity. The room and the main living room have the highest depth; the courtyard and corridor have the lowest depth (Table 6). So, in this house, the courtyard is highly integrated and has the highest level of connectivity. However, it remains the lowest depth.

4.4. Contemporary houses

In house One, the bedroom and toilet have the lowest level of integration, while the living room and division space possess the highest. The living room and courtyard display the greatest connectivity, with the bathroom and toilet having the least. The kitchen holds the highest depth, with the living room and division space at the lowest. Here, the courtyard's integration and connectivity are not low, and its depth level is comparatively low.

In house Two, the division space and the living room have the highest level of integration, and the terrace and the courtyard have the lowest level of integration. The courtyard and living room have the highest level of connectivity, and the toilet, terrace, and bathroom have the lowest connectivity. The terrace, courtyard, and bathroom have the highest depth, and the living room and the division space have the lowest level of depth (Table 7). This house's courtyard is very low-integrated, the highest connected, and has a high depth.
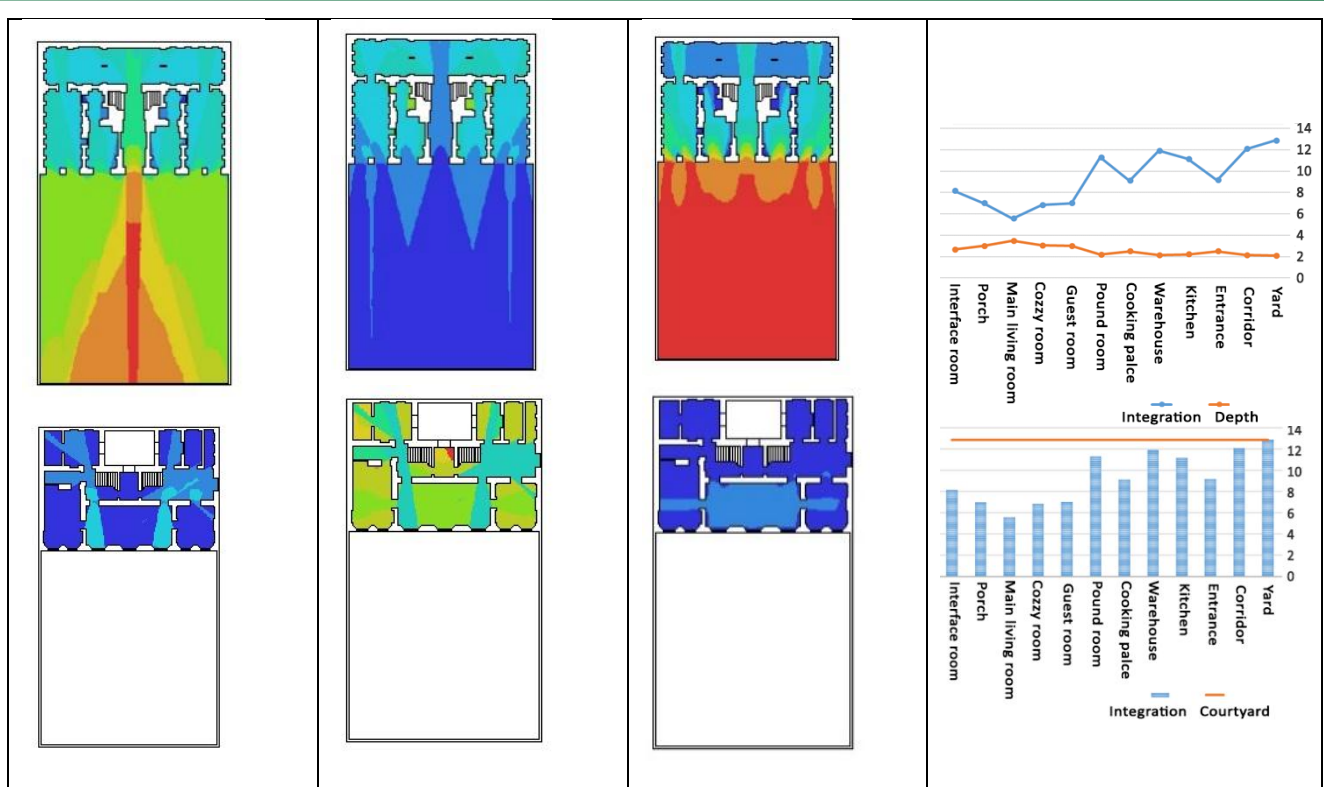
Table 5

Characteristics of space syntax in visibility graphs shown of traditional houses with volume in one side (Sharafi's house).

Visibility graph			Visibility graph analysis
Integration	Depth	Connectivity	

Table 6
Characteristics of space syntax in visibility graphs of contemporary houses (House Two).

Visibility graph			Visibility graph analysis
Integration	Depth	Connectivity	

4.5. Traversable depth

Upon analyzing the visibility graph, we will examine the traversable depth index of the living spaces with the courtyard.

In Naraghi's house, the highest level of traversable depth compared to the courtyard in the main living room, room, and guest room is the lowest in the basement and kitchen.

In Khalabani's house, the basement and kitchen have the lowest traversable depth compared to the courtyard, and the rooms, the guest room, and the main living room have the lowest traversable depth.

In Sharafi House, the guest room has the highest Isovist towards the courtyard, and the lowest Isovist to the courtyard belongs to the main living room.

The analysis of Naraghi, Araghchian, One, and Two houses are represented in Table 8. The service spaces in traditional houses have less depth than the courtyard, traversable, and the courtyard has less depth than the main living spaces, possibly due to Hamadan's extreme cold.

Table 7
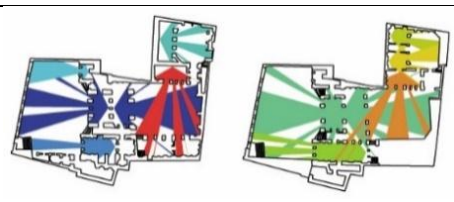Traversable depth compared to the courtyard in the visibility graph.
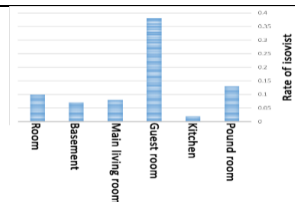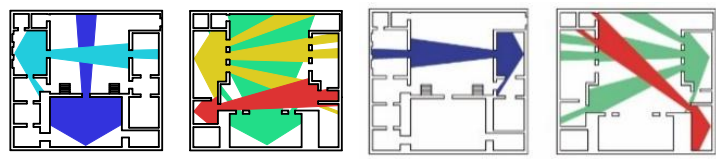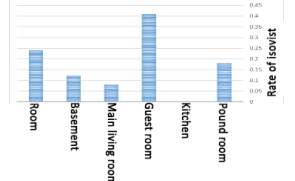
The traversable depth compared to the courtyard in visibility graph analysis	
Multi courtyard houses Naraghi's house	House One
Houses with volumes in three sides Araghchian's house	House Two

4.6. Isovist dimension

In traditional houses, the guest rooms and rooms see the highest Isovist, and the main living rooms and kitchens see the lowest (Table 9).

In modern houses, in houses One and Two, the living room sees the highest Isovist to the courtyard, and the private living room and kitchen belong to the lowest Isovist value at zero. They do not have a view of the courtyard. (Table 9).

Table 8
The Isovist dimension towards the courtyard in Isovist analysis in traditional houses and con-temporary houses

Isovist dimension in traditional houses		
Naraghi's house		
Araghchian's house		

Isovist in contemporary houses		
House One		
House Two		
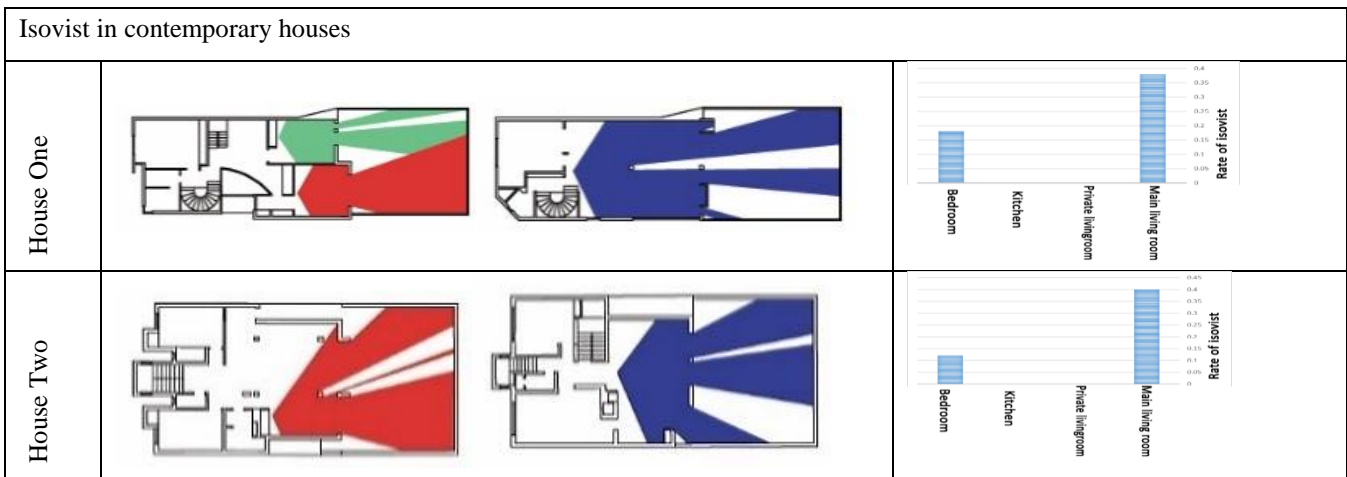
5. Discussion

5.1. Traditional versus Contemporary Homes

The intricate spatial relationship between courtyards and living spaces has always been pivotal in the architectural discourse of both traditional and contemporary houses. Several studies have analyzed this relationship from the perspectives of privacy(Alitajer & Molavi Nojoumi, 2016; Khozaei Ravari et al., 2022; Zabihi & Mirzaei, 2023), cultural sustainability(Al-Mohannadi et al., 2019; Gupta & Joshi, 2021; Huang et al., 2019; Rong & Bahauddin, 2023), and spatial structure(Hessari & Chegeni, 2021; Zolfagharkhani & Ostwald, 2021). Through syntactic analyses of Iranian residential designs from the 1970s to the Islamic Republic era, research indicates a shift towards reduced spatial hierarchy and privacy in modern homes. Despite these changes, visual privacy remains upheld, reflecting the adaptive essence of Iranian architectural evolution. The present study undertakes a comparative analysis of courtyards and living spaces relationships in traditional versus contemporary houses, harnessing spatial and Isovist configurations. The assessment is rooted in core criteria from the space syntax perspective, namely integration, depth, connectivity, and traversable depth.

A palpable distinction can be observed between traditional and contemporary homes in terms of how spaces are utilized in relation to the courtyard. Traditional houses display a fluidity in activity-based space allocation. As depicted in behavioral system section, the activities oscillate between spaces based on the season. This behavioral flexibility demonstrates the adaptability of traditional architecture to the climatic variations, particularly evident in the case of cities like Hamadan, where extreme cold demands a strategic use of space. On the other hand, contemporary houses exhibit less seasonal variation, reflecting the more controlled environments created by modern building materials and technologies.

5.2. Integration and Connectivity

Delving into the dynamics of integration, connectivity, and depth reveals the primacy of courtyards in traditional homes. Notably, the pond room emerges as an essential link between two primary organizing elements – the inner and outer courtyards, showcasing high integration and minimal depth. However, the contemporary era signifies a transformation. The courtyard's once-central role appears diminished, with decreased integration and connectivity. This shift indicates a lessening emphasis on the courtyard as a space for interaction and connectivity in modern homes.

Multi-courtyard houses present a salient feature: the inner courtyard's role surpasses that of the outer courtyard in terms of integration and connectivity. The importance of the inner courtyards as sanctuaries of privacy and warmth is further highlighted. The mention of the pond room acting as a pivotal juncture between the organizing elements of the inner and outer courtyards reinforces this.

The spatial dynamics in houses are also influenced by their structural configuration. Homes flanked by volumes on three sides predominantly rely on the courtyard as the primary connectivity nexus. This arrangement offers the dual benefits of enhanced accessibility and minimized spatial depth, promoting seamless interactions within the household. In contrast, two-sided volume homes, while continuing to accord centrality to courtyards, often incorporate additional spatial elements, like corridors or transitional spaces, to augment connectivity. This diversification of connecting elements, evident in the examples of the Samadian and Zarabi residences, introduces unique spatial narratives tailored to specific design needs.

5.3. Traversable depth and isovist dimension

Another compelling observation is the Isovist dimension in traditional homes. The relationship between traversable depth and courtyard connectivity in traditional houses is intriguing. Service areas having less traversable depth compared to the courtyard suggest that these spaces were deliberately designed for quick accessibility, possibly driven by their frequent use. The main living spaces' greater depth might be a design tactic to retain warmth during cold periods.

Isovist dimensions reveal the spaces' visual connectivity. The pronounced Isovist in traditional guest rooms might be indicative of a socio-cultural preference, emphasizing hospitality and the significance of guests. In contrast, modern houses demonstrate a more inward-focused design, evident from pivotal living spaces in certain contemporary houses lacking an Isovist to the courtyard.

Therefore, while architectural styles evolve, understanding the nuanced interplay between living spaces and courtyards remains critical. Both traditional and contemporary homes offer rich insights, echoing the shifting socio-cultural, climatic, and functional imperatives across eras. As architectural paradigms continue to evolve, integrating these insights will undoubtedly enrich the design discourse, catering to both functional needs and cultural identities. Future research endeavors might expand the sample size and delve deeper into varied climatic contexts, unraveling a more holistic understanding of the courtyard-living space dynamic.

5.4. Challenges and Limitations

Nevertheless, certain limitations underpin this study. The limited sample size and challenges in accessing contemporary house plans potentially constrain the scope of the findings. Additionally, while the research offers a lens into the life models of Hamedan's inhabitants, it underscores the inherent variability of individual experiences, shaped by personal preferences and cultural contexts. Therefore, while the findings provide an insightful perspective for Hamedan's cold climate, extrapolating them to different climatic zones might yield distinct results.

6. Conclusion

The spatial limitations of large cities have driven the proliferation of residential complexes and a corresponding reduction in private courtyards in contemporary architecture. These open spaces serve not only functional purposes, such as providing natural light, ventilation, and extending indoor spatial utility but also foster connections with nature and encourage social interactions. Given the historical significance of courtyards in traditional residential life, understanding the evolving role of outdoor spaces is essential for guiding future architectural designs toward more functional and harmonious outcomes.

The analysis of contemporary houses in Hamedan, designed by the city's prominent architects, highlights distinct spatial patterns. Primary living spaces such as living rooms and kitchens exhibit less traversable depth, making them more accessible and visually connected to courtyards. This echoes the traditional function of guest rooms in older houses, which historically prioritized extensive views and direct connections to outdoor spaces, as demonstrated in Table 3. However, bedrooms in contemporary houses, especially on upper floors, exhibit reduced visual and physical connectivity to courtyards, which diminishes the quality of interaction with outdoor spaces.

6.1. Design recommendations

Courtyard Placement and Configuration: To enhance the connection between living spaces and outdoor areas, municipal regulations should allow for flexible courtyard arrangements. Depending on land dimensions, courtyards could be surrounded on three sides by the building or segmented into smaller sections integrated within the layout.

Vertical Courtyard Integration: To address the limited interaction of upper-floor bedrooms with courtyards, it is recommended to introduce segmented courtyards at multiple levels. This design approach can facilitate better visual and physical connectivity for upper-floor spaces, ensuring a more cohesive integration of outdoor areas within the overall architectural plan (Figure 4).

These insights underscore the importance of reimagining courtyards as dynamic elements in residential design, bridging traditional values and contemporary needs to create living environments that are functional, sustainable, and enriching.
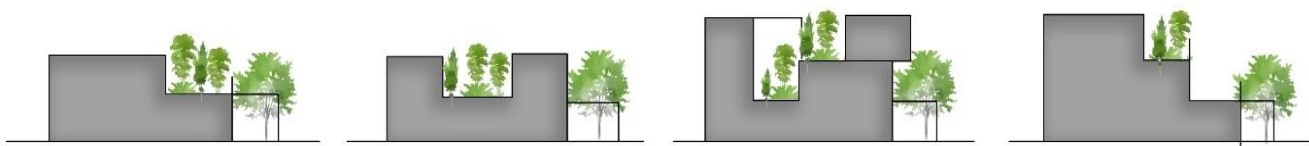

Fig. 4. Suggested solutions in the section.

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