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Socio-cultural transformations in modernity and household patterns: a study on local traditions housing and the impact and evolution of vernacular architecture in Yazd, Iran

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Abstract

The study investigates the impact of vernacular architecture in Yazd, Iran, focusing on traditional housing and its influence on the socio-physical aspects of homes. The central challenge lies in balancing cultural heritage preservation with the need for modern housing that promotes environmental sustainability and social well-being. Employing a qualitative approach, the study compares four historical houses to four modern homes in Yazd city. Its novelty lies in highlighting the importance of incorporating traditional elements into new developments. The research offers practical recommendations for achieving compatibility between house form and lifestyle, designing spaces for communication and social contact, and integrating cultural continuity with change. Additionally, it emphasizes the importance of considering architectural elements and environmental conditions during residential unit design and planning. The study reveals the negative effects of modernization on residential transformation, particularly in historical areas where rapid construction neglects cultural heritage. It recommends incorporating traditional architectural elements while adapting to current needs to achieve sustainable urban living. This contribution to the discourse on urban development provides nuanced insights into the complex dynamics shaping residential landscapes in the modern era. The study's findings suggest that traditional houses offer essential benefits often missing in modern homes, such as improved well-being, privacy, stability, and a stronger sense of community. This can lead to feelings of alienation, physical discontinuity, and socio-economic inequality in modern developments. The study concludes by recommending a reevaluation of housing dynamics and emphasizes the need for further research comparing traditional and modern houses.

Highlights

- The study reveals the negative effects of modernization on residential transformation, particularly in historical urban areas, where cultural heritage is often neglected during rapid construction.
- The study highlights the importance of compatibility between house form and lifestyle, emphasizing the need for new residential units to align with the cultural and social needs of the inhabitants.

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- Traditional houses provide essential welfare, privacy, stability, and vitality, which are often lacking in modern homes, leading to a diminished sense of belonging, physical discontinuity, and socio-economic inequality.
- The transition from traditional to modern housing has led to changes in design and functionality, influenced by global architectural trends, modern lifestyles, and the interplay of modernity and housing.
- The study recommends incorporating traditional architectural elements into new developments while adapting to current situations to achieve culturally sensitive and sustainable housing solutions.

Keywords Modernity, Housing transformation, Residential units, Traditional homes, Architectural evolution, Cultural heritage, Socio-cultural transformations, Household pattern, Yazd

Introduction

The rapid urbanization and modernization processes have led to significant changes in residential patterns and housing structures. The restructuring process of residential units from houses to homes has been influenced by modernity, which has resulted in new housing models that prioritize energy efficiency, comfort, micro-climate, economy, innovation, and location over social, cultural, ethnic, psychological, emotional, and religious aspects (Ronald et al. 2016; Murie 2009; Tong & Hays 1996). The historical evolution of Iranian society, characterized by political, economic, and social changes, has led to the emergence of modernization and urbanization trends in Iran (Pilehvar 2021; Ehlers and Floor 1993). The process of modernization and urbanization has brought about significant changes in the physical and social structure of Iranian cities, including the transformation of residential units (Habibi 2017). The emergence of a middle-class and the production of middle-class neighborhoods became part of a nation-building strategy in shaping the physical and social structure of Iranian cities (Rahbarian-yazd 2022; Pilehvar 2021; Schnaiberg 1971). The impact of local traditions on housing in Yazd is extensive and multifaceted. Local customs such as guest hospitality, privacy, and the relationship between building and user have influenced the architectural design of traditional courtyard houses in the region. The unique climatic conditions of Yazd have also played a significant role in shaping housing structures, with specific features being developed to maximize passive cooling potential. Additionally, the interplay between modernization and tradition is evident in the transformation of Iranian housing during the modernization period, where efforts were made to accommodate growth while preserving local customs. The vernacular architecture of Yazd reflects this interplay, with the use of local materials and construction techniques to respond to the local climate and cultural traditions (Baboli et al. 2015; Jafarbegloo 2018; Maragheh 2022).

Yazd's architectural heritage, characterized by traditional earthen construction and a unique urban fabric, is

undergoing a transformation. Existing research provides valuable insights into Yazd's traditional housing, highlighting characteristic features like central courtyards, local materials, and climate-responsive design. These elements embody the city's cultural identity (Beladi 2022; Afshari 2017; Maleki 2011). Modernization's impact is a well-studied theme, with research addressing architectural style evolution, the balance between heritage and progress, and environmental considerations in contemporary housing (Coşkun and Karakök 2023; Ali and Yildirim 2022; Mishra 2024; Gur et al. 2012). However, a gap exists regarding the influence of religious and cultural factors beyond the dominant focus. While studies like "Impact of Religious Commandments on Residential Architecture of Zoroastrians in Yazd City" (Karimian et al. 2020) and "Aspects of the Traditional Courtyard House in Iran" (Brown and GhH 2003) explore religious ideology's influence, a more comprehensive analysis is needed. Specifically, the impact of Zoroastrian principles and local knowledge on housing transformations requires further investigation. Additionally, research on the socio-economic implications of these transformations is crucial. This study aims to address this gap by focusing on the previously unexplored area of local traditions. Extensive literature exists on the interplay between modernity and housing in Yazd, but how local traditions have influenced residential unit transformations remains understudied.

Through a qualitative approach using semi-structured interviews with families in both traditional and modern housing developments, this research explores the impact of local traditions on Yazd's housing. By evaluating the social and physical effects of housing transformations while emphasizing cultural preservation and exploring the challenges of modernization, this study informs a more sustainable and culturally sensitive approach to Yazd's ongoing housing development. Thus, the research aims to provide socio-cultural transformations insights into how local traditions have affected modernity and household patterns in Yazd City to offer valuable perceptions for urban planners, architects, and policymakers to

Table 1 Core architectural features of traditional houses with central yards

Feature	Description
Central Yard	A core element, often designed with a focus on symmetry and featuring green areas, pools, or landscaped gardens
Plan Form	Mainly single-story, but some variations might exist
Building Materials	Often constructed with adobe and mud techniques
Front Façade Decorative Elements (Overlooking Central Yard)	Limited ornamentation on external walls, but decorative elements like sash windows, doors, arches, and arch-like features are found in internal facades facing the central courtyard

Source: Elaborated by authors

develop more culturally sensitive and sustainable housing solutions that resonate with the local community's needs and practices.

Urbanization and housing challenges and the quest for home in developing countries

Rapid population growth, accelerated urbanization, and a pressing need for housing pose significant challenges for cities worldwide, particularly in developing countries like Iran. Social and economic changes in recent decades have significantly transformed housing developments in the country (Gottschalch 2015; Wynn et al. 2023; Ziari 2006). The first housing crisis in Iran occurred during the third national development plan due to land reforms and the dependent growth of capitalism (Ziari 2006). The second crisis emerged due to oil price shocks and increased centralism policy enforcement (Hanzaei and Tafti 2016; Pour et al. 2013). Building native-style as well as modern houses has become a need of life due to inappropriate policies (Fanni 2006).

In Yazd city specifically, social and economic transformation has led to accommodating immigrants who migrated to the city to find a job. Depending on their cultural and economic statuses, population increase has resulted in inharmonious development, spatial mismatch, environmental degradation, reduced security, and loss of identity (Ghabari 2015; Mehrpoya et al. 2015; Komisar 2008). Paying no attention to the proper use of traditional and modern styles has caused physical discontinuity and changes in the pattern of household and cultural as well as socio-economic inequality. To cope with the shortage of housing due to these issues, local authorities have been forced to make clusters of apartment buildings in front of historically introverted houses. This has caused some changes in the interior space of houses and the social relationships of families. Modern houses are nonfunctional and lack the sense of belonging found in old local houses (Habitat 1996; Keivani and Werna 2001). While 'neighborhood unit' designs have addressed housing needs in some contexts, they often lack elements that foster social connections (Cohen 2006; Montgomery

2008). New residential complexes in developing countries require a fresh approach that aligns with local conditions, community requirements, and cultural considerations (Cutrona et al. 2006; Habibi and De Meulder 2015; Putrik et al. 2014). Habitat II (1996) defined adequate housing as encompassing not just physical structure, but also factors that promote well-being, such as security, appropriate space, and access to essential services (Keivani and Werna 2001). The terms 'house' and 'home' are often used interchangeably. However, a key distinction exists. A house is the physical structure, providing shelter and basic necessities (Merz and Huxhold 2010). A home, on the other hand, goes beyond the physical and encompasses the emotional and social aspects of a place. It is a place where one feels a sense of belonging, security, and comfort. A home is where people live, but it is also where they build relationships, create memories, and develop a sense of identity. While a house can be a home, not all houses are necessarily homes. The difference lies in the intangible qualities that make a place feel like home (Bassuk and Geller 2006; Coleman et al. 2016; Wan and Su 2016).

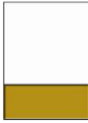
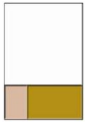
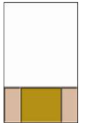
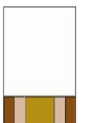
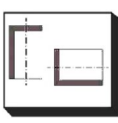
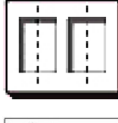
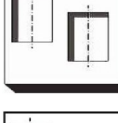

Architectural features and yard configurations defining traditional house design

Traditional houses often feature a tripartite structure with the central yard as the core element. This primary space is distinguished by its size, abundant natural light, and open sky exposure (Amiriparyan and Kiani 2016). Secondary spaces surround the central yard, while tertiary spaces act as intermediary zones between the secondary spaces and the house's perimeter. Tables 1 and 2 illustrate this layout and compare houses based on the number of central yards they possess.

Table 1 provides a snapshot of the architectural characteristics that define traditional houses with central yards, emphasizing the features that contribute to the overall design and interaction with this central space.

Given the central yard's significance in traditional houses and its positive influence across various disciplines, this section explores its function in both historical and

Table 2 Characteristics of house designs by yard configuration

Numbers	Description of layout	Diagram
One yard	Only a hall exists in a corner of the house	
One yard (plus space)	A spacious area exists in addition to a hall, creating a more functional layout	
One yard (emphasizing spaciousness and functionality)	Generous adjoining space beside the hall fosters a welcoming and functional layout	
Multiple yards	Four separate spaces are situated adjacent to the hall	
Multiple yards (vertical axes)	The layout features multiple yards with vertical axes	
Multiple yards (parallel axes)	The layout features multiple yards with parallel axes	
Multiple yards (non-adjacent parallel axes)	The layout features multiple yards with parallel yet non-adjacent axes	
Hybrid or composite courtyard organization	This layout combines elements from spatial organization modes (parallel axes, vertical axis, and Non-Adjacent Parallel Axes) within a single dwelling	

Source: Elaborated by authors

contemporary dwellings in Yazd, Iran. Focusing on Yazdi housing, the research investigates how local traditions, particularly Zoroastrian principles and local knowledge, influence housing transformations. While prior studies have examined traditional features and the interplay of tradition and modernity, the impact of Zoroastrian principles has received limited scholarly attention. This research aims to bridge this knowledge gap by investigating how local traditions shape housing design, use, and social aspects in both traditional and modern contexts. Ultimately, the goal is to inform a more sustainable and culturally sensitive approach to Yazd's ongoing housing developments.

Materials and methods

Data collection and analysis

This qualitative study investigates the influence of local traditions on housing transformations in Yazd, Iran. To achieve this goal, the research employs a multi-pronged approach that gathers data through various methods. In-depth discussions conducted with 50 housing experts directly related to the research focus: local traditions, housing, and the impact/evolution of vernacular architecture in Yazd. Alongside these interviews, a literature review and historical analysis conducted using library resources to provide historical context. Data from Iran's central statistical office also incorporated to enrich the understanding of Yazd's

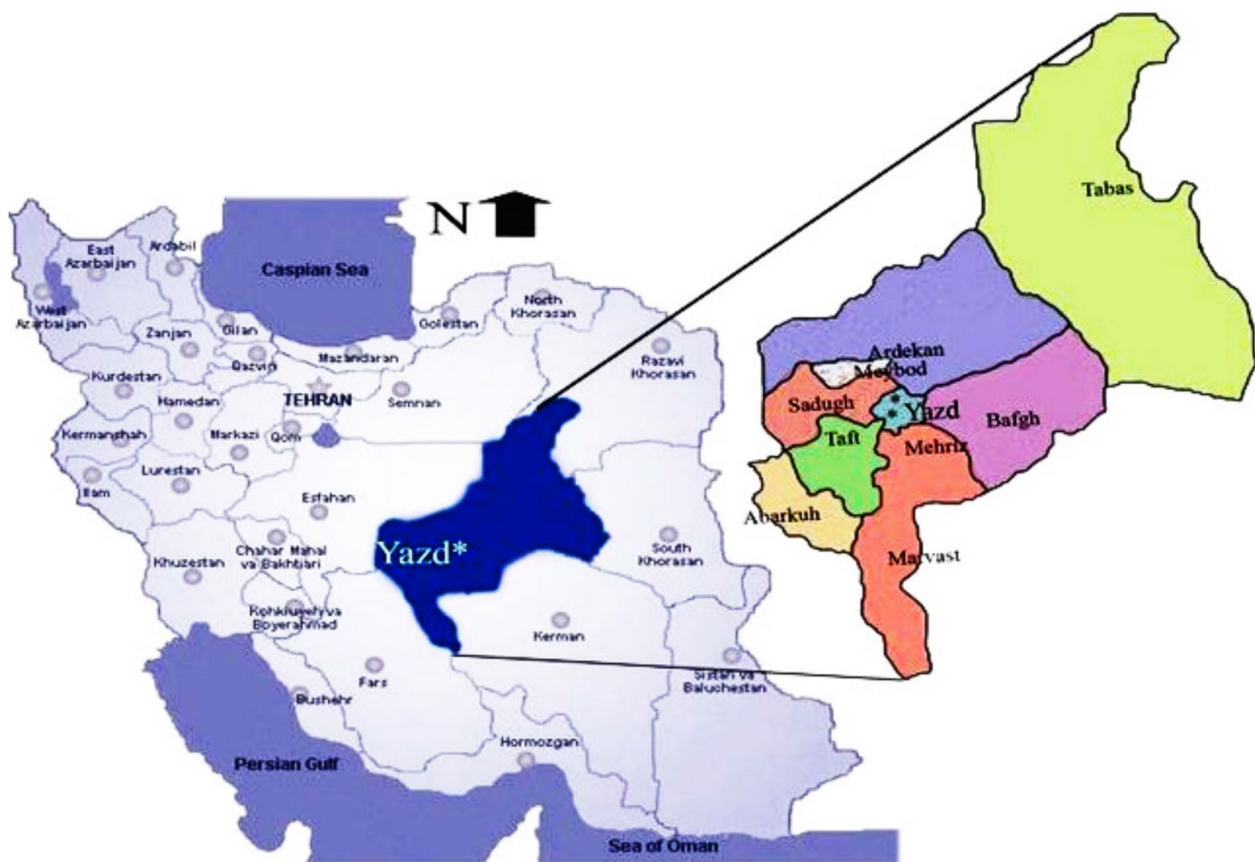


Fig. 1 Map of Iran indicating Yazd County's location in central Yazd Province. Source: Eslami et al. (2020)

housing development. Fieldwork involved case studies chosen based on specific criteria: preservation of traditional architectural elements, seamless integration of contemporary Iranian architecture with cultural traditions, and evidence of the influence of modernization and Western trends on housing evolution.

The collected data was analyzed using a combination of methods. Thematic content analysis, a qualitative approach, was used to identify recurring themes and patterns within the interview data, providing insights into the impact of local traditions. Additionally, historical data and literature were subjected to in-depth analysis to understand the historical context of Yazd's housing development. To explore the interplay between tradition and modern influences, a two-fold data analysis approach was employed. Qualitative analysis of architectural elements and spatial design focused on traditional materials, spatial organization, and decorative elements in contemporary housing, revealing how local customs are reflected in modern design. Additionally, a Geographic Information System

(GIS) analysis mapped the distribution of modern and traditional housing types across Yazd, allowing visualization of how the balance between tradition and modernity varied within different areas.

Case background

Yazd, also known as "Yard City," is a historic Iranian city situated in central Iran, southeast of Isfahan. Nestled between the Dasht-e Kavir and Dasht-e Lut deserts, it thrives as a vital oasis along ancient trade routes. The city's location at an elevation of around 1216 m (3990 feet) above sea level contributes to its hot and dry climate, a factor that heavily shaped the unique features of traditional Yazdi housing, such as courtyards designed for passive cooling (Fig. 1).

Notably, the distinct geographical distribution of traditional and modern housing in Yazd reflects the interplay of local traditions, climatic conditions, and contemporary trends in the city's ongoing housing development. Traditional dwellings are concentrated in the historical district, while modern houses are found in new residential

Table 3 Number of residential units and buildings in Yazd City

Area	1			2			3			
	1	2	3	1	2	3	1	2	3	
Districts	1	2	3	1	2	3	4	1	2	3
Total buildings	11,400	11,700	35,100	13,800	8200	17,500	16,000	9500	3500	
Number of residential buildings	8700	10,300	26,300	11,300	6800	13,900	13,500	8600	2700	
Percentage of residential BUILDINGS	76.32%									

Source: Elaborated by authors

neighborhoods. Both categories possess unique architectural features that embody this interplay. Traditional houses in Yazd's historic district are characterized by unique architecture and introverted layouts. These courtyard houses utilize local materials like adobe and clay, and their orientation is based on solar radiation and wind flow for passive cooling. This design reflects a strong connection between humans and nature. In contrast, modern houses prioritize functionality, comfort, and modern amenities. Situated in new residential neighborhoods, they offer comfortable living spaces with a focus on indoor and outdoor integration. Contemporary materials and designs are utilized to promote a sense of modernity, comfort, and aesthetics.

Results

The research investigates the impact of vernacular architecture in Yazd, Iran, on achieving sustainable and culturally sensitive housing development. Preserving cultural heritage is crucial, but so is promoting modern housing that aligns with environmental sustainability and social well-being. Incorporating traditional elements fosters compatibility between house form and contemporary lifestyles. A qualitative approach (Table 4), comparing four historical and four modern houses, revealed key differences. Traditional Yazdi houses are characterized by central courtyards, local materials (like adobe and clay), and climate-responsive design. These elements embody Yazd's cultural identity and contribute to a harmonious relationship with the central space. Quantitative analysis using GIS showed a higher concentration of traditional housing in the historic core and modern housing in the outskirts. Historic texture analysis (traditional districts, qanat system, adobe houses, bazaars, hammams, and mosques) further enriched the understanding of Yazd's architectural heritage. Examining these elements together highlights the enduring influence of past traditions on contemporary housing practices.

In Yazd, Iran (2023 data), an analysis of building distribution across districts reveals variations in residential building concentrations. The Table 3 details district information, total buildings, number of residential buildings,

and the percentage of residential buildings within each district.

Figure 2 offers valuable insights into Yazd's urban fabric. A higher density of residential zones in the city center suggests a potential concentration of traditional housing, particularly if this area aligns with the historic core. The presence of diverse zones throughout the city indicates a vibrant mix of residential areas alongside cultural zones, schools, and treatment facilities, hinting at a potential interplay between housing and other urban functions. The distribution of public services and amenities suggests an effort to distribute resources across different areas. Finally, the placement of industrial zones on the outskirts and scattered empty land offer clues about urban planning strategies to minimize industrial impact on residential areas and plan for future development.

Evolution of traditional housing

Yazd's traditional houses are not only characterized by their unique architectural features (Fig. 3) such as central courtyards and local materials like adobe and clay, but also by a thoughtful integration of environmental factors into their design. These elements, shaped by centuries of local traditions, climatic conditions, and cultural practices, reflect a deep connection between humans and nature.

Courtyard layouts, for instance (Fig. 4), not only provided a central social space but also facilitated natural ventilation and passive cooling, particularly crucial in Yazd's hot and dry climate. The use of local, earth-based materials like adobe further enhanced thermal comfort by absorbing and releasing heat effectively. This focus on environmental responsiveness stands in stark contrast to modern housing, which often prioritizes aesthetics or functionality over a holistic approach.

Yazd's historical district and modernization

Yazd's climate is hot and dry, and the city's historical district features old houses with traditional architecture and introverted layouts. These houses occupy 1500 ha of continuous and discrete land within the old texture. Some old buildings in Yazd have been combined for family reasons, resulting in valuable collections such as Oвлиya,

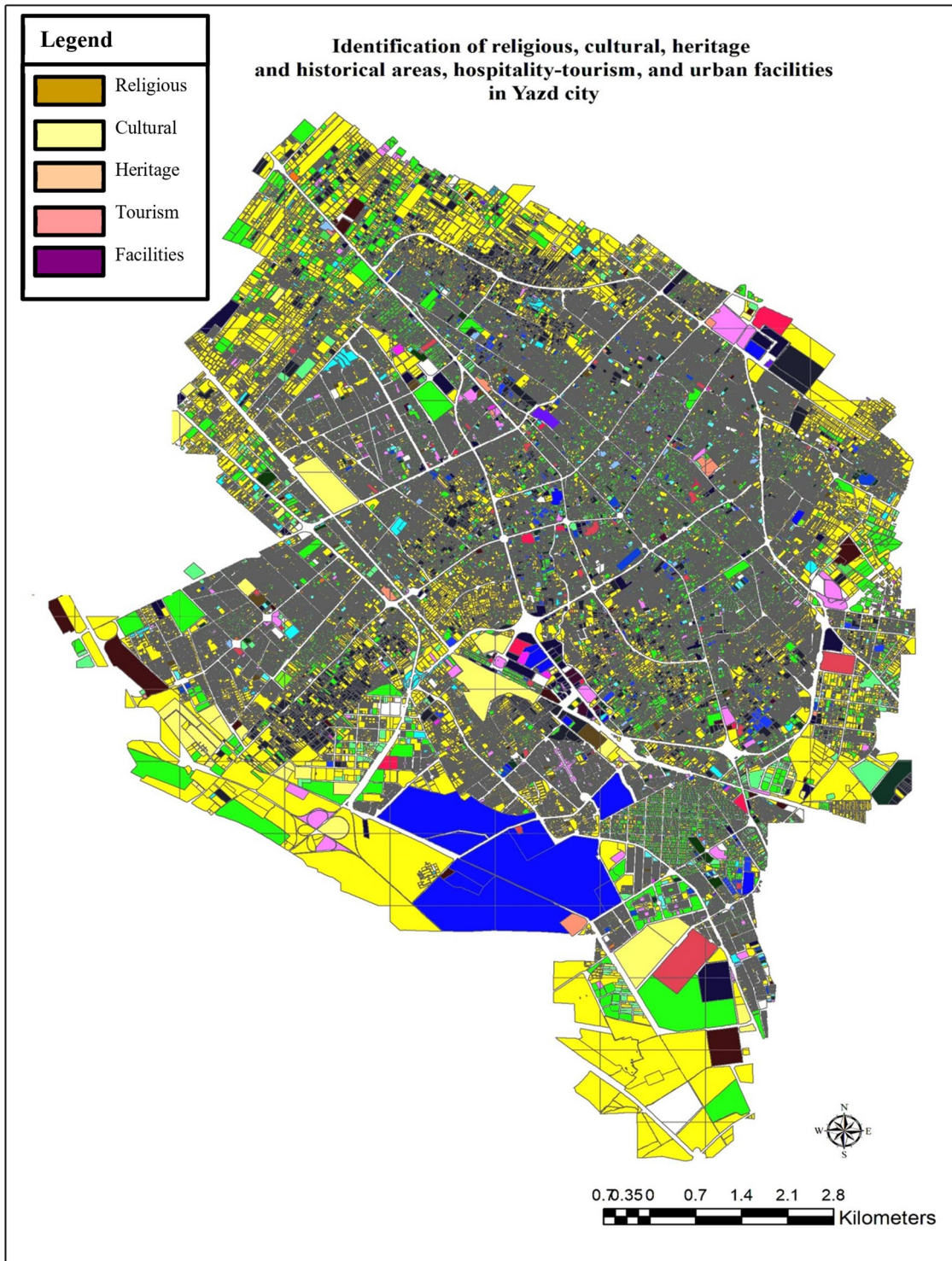


Fig. 2 Identification of religious, cultural, heritage and historical areas, hospitality-tourism, and urban facilities in Yazd city. Source: Geographic and Spatial Data Base. (2023, December 3). پایگاه داده های جغرافیایی و مکانی. Retrieved February 01, 2024, from <https://rsgisc.com/>

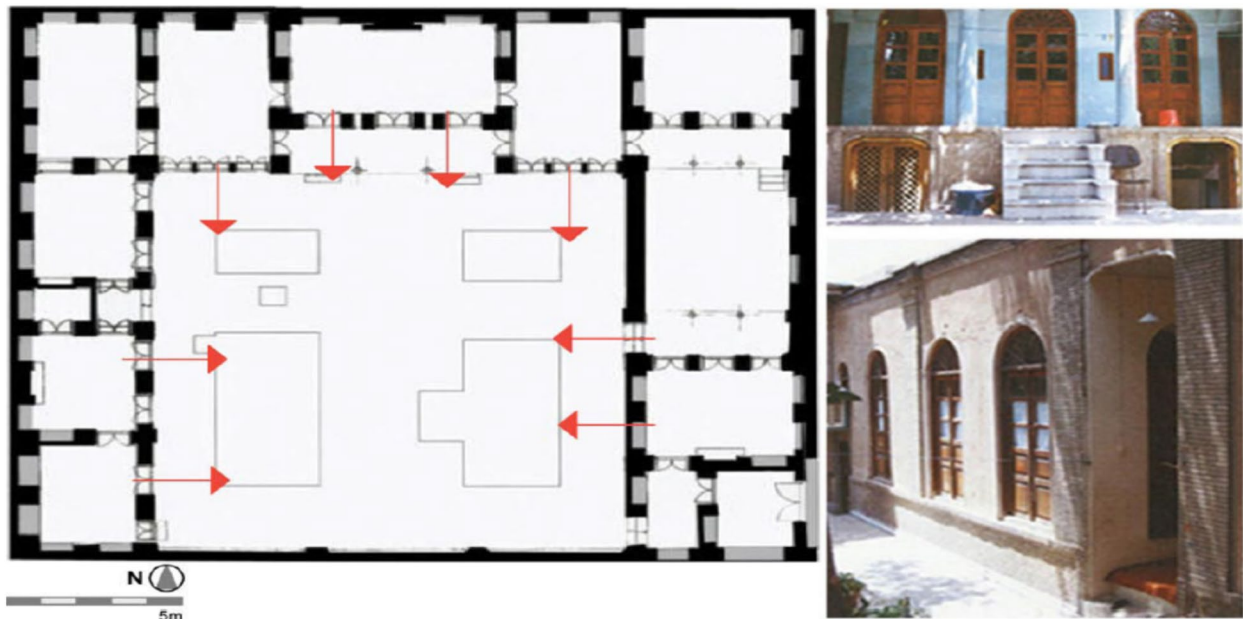


Fig. 3 Traditional houses pattern. Source: Maryam Jafarbegloo (2018)



Fig. 4 Traditional Iranian housing Plan Organization. Source: Shabani et al. (2010)

Arabha, Shirazi, Lariha, Hajj Aliakbar Ghanad, Sheykh Harati, Moshir, Hoseynian, Mirza Mohamad Khan Ghazvini, and Poostforushha houses. The analysis of housing units in Yazd reveals three key points. First, the growth of housing units in the old city center is much lower than that of the new residential neighborhoods (Table 3). Second, the ratio of infrastructure areas to the total number

of buildings in the old city is 44.9%. Third, most one-story units belong to old houses.

The modernization of housing in Yazd, Iran, has led to the creation of contemporary houses reflecting global architectural trends and modern lifestyles. Architectural characteristics have become more varied, flexible, and dynamic. Iran's 20th-century modernization significantly

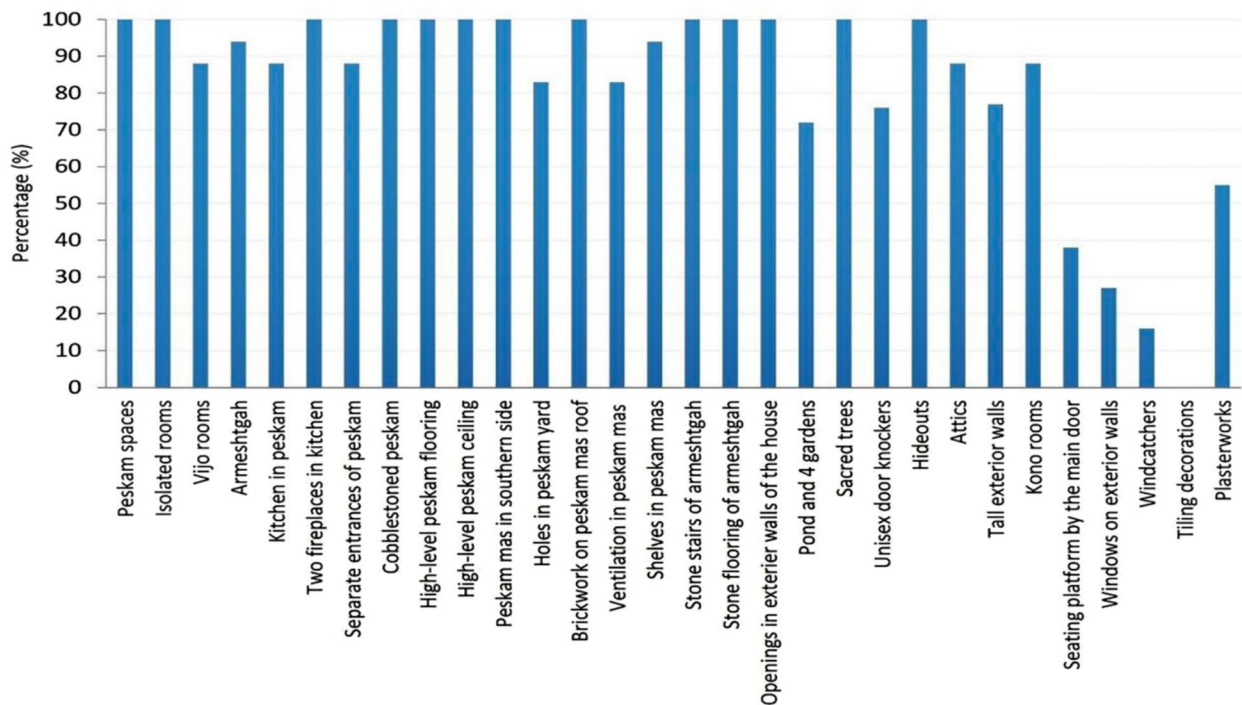


Fig. 5 Influence of Zoroastrian instructions on the architecture of residential buildings in Dasturān district, Yazd. Source: Karimian et al. (2020)

impacted residential unit design, leading to a shift from traditional to modern and Western-influenced forms (Mollayousef 2015; Sani and Mahasti 2013). The interplay of modernity and housing has influenced the architectural characteristics of contemporary Iranian houses, resulting in changes in design and functionality. Following the emergence of modernity and industrialization, traditional societal structures underwent significant economic and social transformations. The primary drivers of architectural changes have been the advent of motor vehicles, population growth, and increasing speed. These factors led to two interrelated processes: demolition of old houses and construction of larger units around existing urban fabrics. Regrettably, Yazd has primarily experienced the former.

The city of Yazd has undergone significant urbanization and socio-cultural transformations, influenced by historical, geographical, and modern factors. The interplay of modernity and housing has driven the evolution of residential units from simple houses to culturally significant homes. This transformation is evident in the city's architecture, urban planning, and social dynamics. Yazd's unique architecture, characterized by elegant earthen structures and innovative urban planning, reflects its symbiotic relationship with the desert. The socio-cultural transformation is evident in the evolution of residential units from traditional houses to modern homes. The

city's architecture and urban development have been influenced by the international modernist movement. Yazd's culture is deeply rooted in Persian traditions, with a majority Shia's Muslim population and a significant Zoroastrian minority. This cultural diversity contributes to the unique blend of influences in the city's way of life and architecture. The interplay of modernity and housing has also influenced privacy culture in Iranian residential units. The transition from traditional houses to high-density vertical development has led to a reevaluation of spatial organization, considering the cultural value of privacy.

Influence of zoroastrianism on architecture

The study found that the "edicts of worshipping the sun" had the most significant impact, implemented in 100% of the studied buildings. This influenced the formation of Peskam areas (wind catchers) and the arrangement of components within this architectural feature. Other features influenced by Zoroastrian commandments include the presence of a central fountain surrounded by four small gardens, cobblestone flooring of Peskams, stone-covered floors and stairs within the Armēšt-gāh (ritual washing area), and the existence of Viju and Kūno rooms (specific functional spaces).

The study also found a correlation between these commandments and specific architectural features, as

detailed in Fig. 5. Notably, Zoroastrian houses had doors with a single unisex doorknob, few seating platforms on the sides of the main entrance, high surrounding walls, and minimal decorations. The study concludes that Zoroastrian commandments significantly influenced the formation of spaces in historical Yazdi houses, particularly the practices of "respect of sanctity of the four elements (Chahar- water, air, fire)" and "faith in cosmos order (Aša/Rta)". This influence on residential architecture reflects the deep roots of Zoroastrianism in Yazd, a city that has also fostered a long tradition of religious tolerance for other faiths. The Jewish community in Yazd boasts a history of ~ 1700 years. They reside in a designated quarter known as "Mahalleh-ye Seh-o Judehian," where historical synagogues such as the Synagogue of Ezra and the Molla Zadok Synagogue are located. The continued presence of these Jewish institutions further underscores Yazd's remarkable tradition of peaceful coexistence among different faiths. A defining characteristic of Yazd is the remarkable harmony that has existed between its diverse religious communities. This peaceful coexistence has been remarkably well-preserved throughout Yazd's history, despite occasional religious tensions in certain periods. Cultural and social interactions amongst adherents of different faiths have transformed Yazd into a unique example of respect and acceptance in Iran. With its distinct religious demographics (Muslims: 99%, Zoroastrians: 0.6%, Jews: 0.4%), Yazd serves as a powerful testament to the enduring strength of interfaith dialogue and understanding in Iran.

Discussion

The research investigates the interplay between local traditions and modern influences on housing patterns in Yazd, Iran, focusing on their socio-cultural impacts on residential spaces. Employing a qualitative approach, the study utilizes thematic content analysis, in-depth historical literature analysis, and semi-structured interviews with 50 housing experts relevant to the research focus. Data collection involves secondary data from library research, fieldwork, and statistics obtained from Iran's central statistical office. Case selection prioritizes sites that exemplify the seamless integration of contemporary Iranian architecture with cultural traditions, while considering the influence of modernization and Western trends on housing evolution.

The study's findings highlight the significance of local traditions in shaping the socio-physical aspects of residential spaces in Yazd. Incorporating traditional architectural elements into new developments while adapting to contemporary needs is crucial for sustainable urban living. Analysis of modern Yazd homes emphasizes the need for compatibility between house form and lifestyle,

spaces for communication and social interaction, cultural continuity and change, architectural elements, and environmental conditions during design and planning. These findings align with prior research highlighting the loss of traditional elements in modern houses, leading to deficiencies in essential aspects like privacy, stability, and fostering a sense of community. The identification of missing elements like five-door rooms, halls, windhole rooms, sash-window rooms, Balakhane (upstairs), Gooshvare (corridors), and Takhtgahi (house beds) demonstrates the disparity in social and familial relations between new urban areas and traditional districts. Furthermore, the findings resonate with the concept of "home" extending beyond the physical structure to encompass the emotional and social aspects of a place. A home is where one feels a sense of belonging, security, and comfort; it's not just a place to live, but also where relationships are built, memories are created, and identity develops. This concept is well-supported by various studies, including those by Bassuk and Geller (2006), Leith (2006), and Wan and Su (2016), which all emphasize the importance of emotional and social aspects in defining a "home."

The research stands out from existing work in two key ways. First, its focus on the specific context of Yazd, Iran, offers a unique perspective on the interplay between tradition and modernity in housing patterns. By delving deeper into the socio-physical aspects of Yazdi homes, the study provides a more comprehensive understanding of how these features contribute to a sense of home and community. This includes exploring how the physical design interacts with social practices, examining specific design elements like room dimensions and spatial organization, and analyzing how traditional materials and construction techniques contribute to aesthetics and environmental comfort. The study also investigates how the design of exteriors and entryways shapes the relationship between the home and the public realm. Second, the employed methodology, which combines qualitative data collection and analysis with case studies, allows for a deeper understanding of the challenges and opportunities associated with preserving Yazd's architectural heritage in new developments. This focus on both traditional design elements and their integration into contemporary housing paves the way for future research opportunities. One potential area of exploration is discussing strategies for incorporating traditional elements into contemporary design while meeting modern needs and sustainability considerations. The findings of this research can inform further investigations into optimizing the balance between cultural preservation and sustainable urban development in Yazd. This knowledge could then be applied as a model for similar endeavors in other historical cities around the world.

Socio-physical aspects of home and housing in Yazd

The socio-physical aspects of housing in Yazd, Iran, are significantly influenced by religion, cultural practices, and the environment. Religious and relational hierarchies shape the spatial configuration of both traditional and modern houses, reflecting the interplay of local traditions and social dynamics. The architectural elements in Yazd's traditional houses effectively addressed the cultural, social, and economic needs of the community, embodying specific cultural values and identity (Darvish et al. 2019; Irani and Armstrong 2016). Examining human behavior, we see how it shapes modifications of living spaces in traditional Persian homes to suit specific needs and preferences. The layout of houses in Yazd's historic district prioritizes access to natural resources and fosters social interactions aligned with cultural practices. This layout exemplifies the influence of social and cultural values on the physical structures of a region, particularly in terms of family units, reflecting privacy, security, and the social relationships among residents. The central courtyard, revered as the heart of the home, serves both physical and spiritual needs while ensuring the safety and promoting the integrity of families. The architectural designs of dwellings in Yazd are shaped by the city's location, extreme climate, and the needs of its inhabitants. The houses are designed to be comfortable in both scorching summers and frigid winters, with walls serving functional, security, and even spiritual purposes, reminiscent of the city walls surrounding Yazd. The study also comprehensively examines architectural elements, floor plans, and the qualitative structures of historical houses in Yazd, offering valuable insights into the unique design features that define the city's architectural legacy.

Both traditional and modern Yazd houses showcase a thoughtful integration of environmental factors with architectural design to create comfortable living spaces while maintaining a connection to nature. Traditional Yazd houses are designed with courtyards, local materials like adobe and clay, and an orientation based on solar radiation and wind flow. They aim to provide passive cooling in summer and comfort throughout the year. Modern houses in Yazd prioritize similar goals, featuring central living spaces and employing design elements such as shade and wind for climatic comfort. However, significant differences exist between traditional and modern Yazd houses. Traditional houses often lack the modern amenities found in their contemporary counterparts. The analysis of modern homes in Yazd, based on a comparative study of four examples, reveals the negative effects of neglecting cultural heritage during rapid construction in historical areas. The study suggests incorporating traditional architectural elements into new developments

while adapting to current situations to achieve sustainable urban living.

The transformation of residential units from houses to homes in Yazd has several implications for the socio-physical aspects of housing:

- **Compatibility between House Form and Lifestyle:** The new residential units should align with the cultural and social needs of the inhabitants.
- **Spaces of Communication and Social Contact:** These spaces are essential for social interactions and community engagement.
- **Cultural Continuity and Change:** The transformation should consider how it affects cultural identity and social behaviors.
- **Architectural Elements and Environmental Conditions:** The design and planning of residential spaces should consider environmental factors for energy consumption and interior comfort.

These implications highlight the importance of integrating socio-physical aspects into the design of residential units to ensure cultural preservation, community well-being, and environmental sustainability.

Modern houses in Yazd often lack the internal spatial coherence of traditional houses. In traditional houses, the entrance leads to distinct spaces for receiving guests and private family gatherings, located near a yard. Modern houses, often smaller, lack this clear separation. Additionally, modern apartment complexes lack the privacy found in traditional houses, where an entrance space existed before accessing the living areas. While modern buildings may have better facilities and materials, some argue they lack intimacy due to technological advancements and cultural changes (Alitajer and Nojumi 2016; Isenstadt and Rizvi 2011; Mirmoghtadae 2009; Tavasoli 1997).

Elements of traditional Yazdi house design

The dimensions of the rooms

The dimensions of rooms in traditional Iranian architecture, particularly in the city of Yazd, have attracted significant interest and research. The concept of the 'Iranian Golden Rectangle', or the Golden Ratio in Iranian art and architecture (approximately equal to 1.618), has been widely employed in the design of rooms, courtyards,¹ and other spaces. Research suggests that room dimensions in traditional Iranian architecture, including

¹ This ratio extends beyond room dimensions, influencing the shape of the courtyard, five-door and three-door elements, and potentially other architectural features. For instance, the Iranian Golden Rectangle is likely applied in five-door rooms that receive light from their longer side.

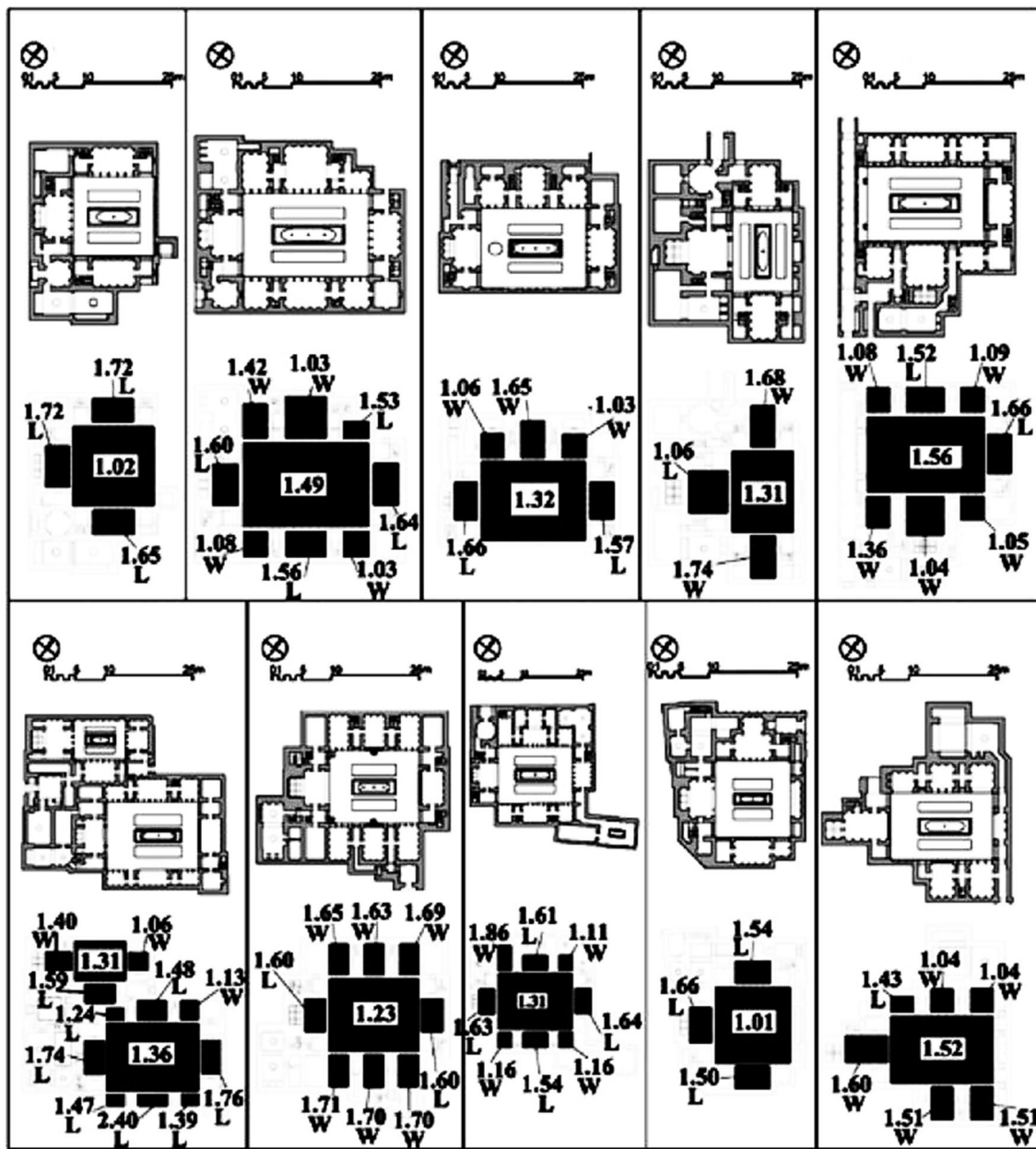


Fig. 6 Aspect ratios of main courtyards and surrounding rooms in seventeen traditional Yazdi houses. Source: Mojtaba Pourahmadi et al. (2011)

those in Yazd, follow the principles of the Iranian Golden Rectangle. These rooms are typically rectangular, with a length approximately 1.618 times the width. This ratio is believed to have been used to create a sense of harmony and balance within the space. For instance, a typical room in a traditional Yazdi house might measure around 4 m long and 2.5 m wide, a ratio close to 1.618. The use of the Iranian Golden Rectangle in traditional Iranian room design is likely influenced by the principles of Islamic architecture, which emphasizes geometric shapes and

proportions to achieve harmony and balance (Sharami 2023) (Fig. 6).

Planimetric organization of spaces

Traditional houses in Yazd are characterized by a distinct spatial organization centered around a prominent central courtyard. This courtyard serves as the heart of the home, offering a tranquil oasis for relaxation and social interaction. Secondary spaces, such as halls, rooms, and corridors, surround the central courtyard, organized in a

Table 4 Plans and Qualitative Structures of Four Historical Houses in Yazd

Title	Description	Architectural plan
Akhavan sigari house	The analyzed building features a prominent central courtyard, along with three smaller backyards. It has two primary entrances: one ornate and the other more understated. The main entrance includes a vestibule that connects to both the eastern backyard and the main courtyard via a corridor. The north and south facades differ in design, with the east and west facades being symmetrical. Notably, the north facade features a three-door room in the center, while the south facade boasts a portico-like space in the middle. The north facade is particularly diverse and significant, while the south facade includes an upper air hole	
Rasolyan house	The proposed house design features a significant division into two sections. The primary area centers around a spacious courtyard, while the secondary portion revolves around a smaller yard situated to the west. Additionally, a backyard is located north of the house, adjacent to the kitchen area, known as the kitchen yard. The house features a comprehensive entrance system consisting of a specific entrance, an expansive vestibule, and passageways that extend into both sections of the house. One of these corridors connects to the corner of the main courtyard, while the other runs parallel to both yards between the two sections and extends up to the kitchen yard	
Golshan house	The described dwelling features three outdoor areas, including two enclosed spaces and several open ones. Both the eastern and western yards are significant focal points of the house, with the western yard being larger than the eastern one. The two rectangular yards are positioned in the northeastern and southwestern corners of the property. The secondary entrance, situated on the southwestern side of the house, connects to the primary yard via corridors. The third yard, smaller in size, is located in the northeastern part of the larger yard and is accessible through a small entryway	
Mortaz house	The described dwelling is comprised of two distinct sections, each with a unique courtyard and independent entrance that are precisely connected. Upon entering through the entrance, a refined foyer, and a hallway, one arrives at the corner of the primary courtyard. In front of the smaller courtyard entrance, there is simply a doorway and a brief passageway that leads to a modest porch situated on the southern corner. Within the house, there are regular octagonal spaces positioned at the four corners of the courtyard	
Legend		

Source: Elaborated by authors

hierarchical manner. Additionally, tertiary spaces function as intermediaries between the secondary spaces and the house’s outer edges. Table 4 provides detailed plans for each of the four historical houses (Akhavan Sigari House, Rasolyan House, Golshan House, and Mortaz House), showcasing the intricate spatial organization and

the relationships between the different dwelling components. For example, the Akhavan Sigari House features a prominent central courtyard alongside three smaller backyards. Distinct entrances and corridors connect the various spaces. In contrast, the Rasolyan House demonstrates the flexibility and adaptability of traditional

housing design. It is divided into two main sections, each with its own courtyard and independent entrance.

Architectural consistency

Traditional houses in Yazd exhibit a remarkable architectural consistency. Local materials like adobe and clay contribute to the city's unique character and environmental sustainability. Passive cooling strategies such as wind towers and courtyards minimize reliance on mechanical cooling, while decorative elements like sash windows, doors, and arches enhance the visual appeal and cultural identity. For instance, the Akhavan Sigari House exemplifies the use of thatched roofs and incorporates decorative elements overlooking its central courtyard. In contrast, the Golshan House showcases geometric principles and spatial organization through regular octagonal spaces positioned at the courtyard's corners.

These traditional elements offer a valuable model for sustainable design in new developments. Incorporating them can contribute to cultural preservation, fostering a sense of identity and connection to the past. Furthermore, traditional design promotes community well-being by encouraging social interaction and a sense of belonging. Environmentally, local materials and passive cooling strategies reduce the environmental impact of new constructions. Specific elements for consideration in new developments include central courtyards for natural ventilation and social interaction, continued use of local materials to maintain Yazd's architectural identity, and the incorporation of traditional wind towers and strategic building orientation for a climate-responsive approach. By integrating these elements from Yazd's architectural heritage, new developments can achieve a balance between cultural preservation, modern needs, and the creation of socially and environmentally sustainable living environments.

Facade design and entry systems

Analyzing the architectural details of four historical houses in Yazd reveals variations in both facade design and entry systems. The Akhavan Sigari House showcases a distinct contrast between its north and south facades, while maintaining a symmetrical design on the east and west sides. The Rasolyan House demonstrates a comprehensive entry system, featuring a dedicated entrance, a spacious vestibule, and passageways that connect both sections of the dwelling. The Golshan House incorporates a secondary entrance on the southwest side, linked to the main courtyard by corridors. Finally, the Mortaz House stands out for its unique bipartite plan, with two distinct sections, each possessing a dedicated entrance and a unique courtyard. Furthermore, the architectural characteristics of

these houses highlight the presence of decorative elements, such as sash windows, doors, arches, and arch-like features adorning the internal facades overlooking the central courtyards. This focus on ornamentation, alongside descriptions of central courtyards designed with a focus on symmetry and proportionality, featuring lush green areas, stunning pools, and intricately landscaped gardens, demonstrates the cultural significance and aesthetic value placed upon these dwellings.

Preserving Yazd's architectural heritage in new developments

To preserve Yazd's architectural heritage in new housing developments, key traditional elements need to be integrated. These elements not only maintain cultural identity but also promote environmental sustainability and social well-being.

- Courtyard layouts: The central courtyard, a defining feature of Yazdi houses, fosters relaxation, social interaction, and a connection to nature. New developments should prioritize courtyard-based designs. This can be achieved by:
 - Designing residential units around central courtyards, ensuring their prominence and functionality within the home.
 - Integrating the courtyard layout as a key principle in master planning for new neighborhoods.
 - Implementing incentives or regulations encouraging developers to incorporate courtyards.
- Use of local materials: Traditional Yazdi houses extensively utilize local materials like adobe and clay. Their continued use in new developments can maintain the region's architectural identity and reduce environmental impact. This can be achieved through:
 - Providing training and support for local artisans and craftspeople to ensure the continued use of traditional techniques and materials.
 - Establishing building codes or guidelines mandating the use of locally sourced, sustainable materials.
 - Offering incentives or subsidies to developers who incorporate these materials and construction methods.
- Passive cooling strategies: Traditional Yazdi houses employ wind towers and strategic orientation for passive cooling. Integrating these strategies into new

designs can enhance environmental sustainability and occupant comfort. This can be achieved by:

- Conducting studies on traditional passive cooling methods and developing design guidelines for modern applications.
 - Providing training and education for architects, engineers, and developers on the benefits and implementation of passive cooling strategies.
 - Incentivizing the use of passive cooling techniques through building codes, energy efficiency programs, or other policy measures.
- **Spatial Organization and Hierarchy:** Traditional Yazdi houses exhibit a distinct spatial organization with a clear hierarchy of spaces for guests and family. Maintaining this separation fosters privacy, security, and social relationships. This can be achieved by:
- Designing new residential units with a clear delineation of public and private areas, such as separate entrances, reception areas, and living quarters.
 - Incorporating transitional spaces like vestibules or corridors to maintain the spatial hierarchy and privacy.
 - Educating architects and developers on the importance of spatial organization and hierarchy in traditional Yazdi houses and their integration into modern designs.

By carefully considering these key traditional elements, Yazd's new housing developments can achieve a balance between cultural heritage, modern needs, and the creation of socially and environmentally sustainable living environments.

Future research opportunities

This study offers valuable insights into traditional Yazdi housing, but it also opens doors for exciting future research avenues. One key area for exploration is adapting traditional elements for sustainable modern housing. Building on the understanding of the unique inside-outside relationship and inherent sustainability features of Yazdi houses, future studies can explore how these principles can be adapted to contemporary design while preserving cultural identity. This could involve investigating innovative ways to integrate courtyards, maximize natural light and ventilation, and foster a connection to the natural world. Furthermore, this research highlights the potential of these traditional elements to inform the development of eco-friendly and culturally sensitive housing models. Further studies can delve deeper into how specific features like spatial organization,

local materials, and climate-responsive design can be incorporated into contemporary housing to meet the needs of current residents and promote environmental sustainability.

Another area for exploration is learning from tradition for culturally-sensitive design. This study emphasizes the importance of understanding the rich socio-cultural aspects of traditional Yazdi housing. This knowledge can be utilized to develop new housing models that effectively balance modern living with the preservation of local heritage and community practices. Further research could involve engaging with stakeholders like architects, planners, and residents to explore how traditional elements can be seamlessly integrated into contemporary designs, fostering a sense of place and belonging. Additionally, this research provides a foundation for a more comprehensive comparison of traditional and modern Yazdi houses. Future studies can delve deeper into specific architectural features, spatial layouts, and construction techniques employed in both styles. This comparative analysis could inform the development of culturally-sensitive contemporary design principles, ensuring that new housing developments respect and build upon the region's architectural heritage. Finally, recognizing the social impacts and changing household dynamics resulting from the transition to modern housing opens a door for further investigation. Future studies can explore how these changes impact residents' needs and living patterns. This knowledge can be used to develop housing solutions that better align with the evolving lifestyle of the local community.

By pursuing these areas of exploration, future research can build upon the foundation established by this study and contribute significantly to the development of culturally-sensitive, sustainable, and community-oriented housing solutions for Yazd.

Conclusion

The study underscores the importance of integrating traditional design elements into contemporary Yazdi housing for sustainable urban development. Modern housing often neglects features that foster social interaction, privacy, and community aspects effectively addressed by traditional Yazd architecture. These elements, coupled with their cultural significance and environmentally sustainable design principles, offer valuable models for future development. This research not only deepens our understanding of Yazd's specific context but also paves the way for broader application in historical cities facing similar challenges. By advocating for culturally sensitive design and sustainable living practices, this study provides crucial guidance for urban planners and policymakers,

ultimately contributing to the creation of more livable and enduring urban environments.

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Author contributions

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Availability of data and materials

The data and materials generated during this study are available upon reasonable request to the corresponding author. The raw data are stored securely in a password-protected database and will be provided in a deidentified format to ensure confidentiality. The materials used in this study, including experimental protocols and reagents, are available upon request with appropriate material transfer agreements in place. All requests will be reviewed by the corresponding author on a case-by-case basis to ensure compliance with relevant policies and guidelines regarding data and material sharing. The data can be accessed by contacting the corresponding author at msaraei@yazd.ac.ir, e-mail address.

Declarations

Competing interests

The authors declare that they have no competing interests. The research presented in this manuscript was conducted independently and without any financial support.

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