

HIDDEN CULTURAL ECOSYSTEM SERVICES IN PRIVATE GREEN SPACES: A CASE OF UNESCO WORLD HERITAGE SITE

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Abstract

Urban green spaces serve as a cultural ecosystem service that contributes to human well-being and quality of life, as well as mitigating stress and anxiety. However, the climatic and cultural conditions in the Middle East, particularly in desert cities, present varied opportunities for the development of green spaces on a smaller scale and in private or semi-private settings. Hence, the aim of this paper is to investigate how private urban green spaces contribute to the production of cultural ecosystem services in Yazd, a UNESCO World Heritage site in Iran. Additionally, it seeks to identify the primary activities and interactions that arise from these cultural ecosystem services within the context of private urban green spaces. To achieve these objectives, we employed qualitative methods, including the analysis of pre-existing data, participant observation, and semi-structured interviews with experts and professionals. The findings indicate that these private green spaces are integral components of larger integrated socio-ecological systems within the courtyards. Furthermore, the specific architectural design of these courtyards, in conjunction with the green spaces, promotes social cohesion and interaction, provides recreational benefits, and contributes to the development of place identities. Understanding the mechanisms underlying this cultural ecosystem service can inform sustainability strategies aimed at addressing climate change challenges.

Keywords: Ecosystem service; Quality of life; Sustainability; Heritage preservation; Courtyard; Desert city; Iran; Yazd

Introduction

From the past to the present, in Middle Eastern urban areas, the limited presence of people in public urban spaces has made private open spaces, such as residential yards, important locations for social and cultural activities for families and communities [1-3]. These spaces have predominantly included a mixture of urban green areas [4]. The need to continue this sustainable approach in current residential areas is underscored by the rising average temperatures in these urban regions due to climate change impacts [5] and, consequently, the increasing importance of having convenient spatial environments. Therefore, to preserve and redevelop this historical approach to urban green spaces, it is worth studying the mechanisms that support their functionality for cultural activities, leading us to the concept of cultural ecosystem services provided by green spaces.

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Cultural Ecosystem Services refer to the intangible benefits people gain from ecosystems, including spiritual growth, learning, contemplation, recreation, and aesthetic enjoyment [6, 7]. One of the natural elements that could produce these cultural ecosystem services in cities is urban green spaces, which are characterized as a thoughtfully organized network of natural, semi-natural, and artificial spaces, along with other elements intended and managed to offer a range of benefits [8]. *Cheng et al.* [9] observed that the cultural ecosystem services emerging from urban green spaces encompass cultural diversity, spiritual and religious values, knowledge systems, educational benefits, aesthetic inspiration, social cohesion, sense of place, recreational and ecotourism opportunities, and cultural heritage preservation.

However, an extensive review of the literature on cultural ecosystem services of urban green spaces highlights two significant gaps within this field of study. The first gap relates to the limited distinction made between public and private urban spaces in the literature. Researchers have predominantly examined aspects such as recreation and ecotourism [10, 11], aesthetic values [12, 13], cultural heritage [14, 15], spiritual and religious values [16], sense of place [17], and social interactions and relations [18] within public urban green spaces, including areas like parks, gardens, meadows, and forests [9]. Notably, none of these studies address private green spaces, which may hold unique cultural and ecological significance yet remain underexplored in the context of urban environments.

The second gap includes geographical gaps. As *Cheng et al.* [9] reviewed, most studies about cultural ecosystems of urban green spaces are allocated to developed Western countries, including the USA, Germany, Spain, the UK, Italy, Poland, Australia, and Canada, and only China and Africa are the countries from the East or not completely developed. This is despite the fact that many historical documents show that ancient civilizations, such as those in Iran and Egypt in the Middle East, have predominantly considered green spaces a foundational element in designing and planning urban infrastructures throughout history [19-21]. They valued green spaces for their aesthetic, social, and psychological benefits, even without directly referencing the concept of cultural ecosystem services.

Based on what has been discussed above, this research has two main objectives. First, we aim to study how private urban green spaces produce cultural ecosystem services in the arid city of Yazd, Iran, representing an urban area in the Middle East. This is important because, due to cultural, social, and religious limitations, public urban areas in this region have not been central locations for significant social and cultural activities [1, 3, 22]. Consequently, private urban green spaces have been prioritized over public ones. Second, this study seeks to identify the main activities and interactions resulting from cultural ecosystem services within these private urban green spaces.

We use qualitative analysis, including document review, observation, and semi-structured interviews with experts, to study selected private and semi-private urban green spaces in the historic city of Yazd, Iran. This research contributes to the study of cultural ecosystem services derived from urban green spaces in two ways. First, by exploring private urban green spaces, it proposes a new definition for cultural ecosystem services, as opposed to those provided by public urban green spaces. This definition could serve as a guideline for enhancing cultural ecosystem services in private or semi-private residential areas within urban environments. Second, by examining the types of cultural ecosystem services provided by green spaces in Middle Eastern urban areas, this research may propose new dimensions of cultural ecosystem services relevant to this context.

The study's outline is as follows. The Data and Methods section provides a brief description of our case study city, methods, and datasets. The Results section presents the qualitative analysis of documents, observations, and interviews about the mechanisms forming cultural ecosystem services of greenery in the case studies. In the Discussion section, we examine the codes and categories extracted from the qualitative results from the perspective of ecosystem services and sustainable urban development.

Data and Method

Case study

Yazd Province (Fig. 1) is one of the 31 provinces of Iran, situated in the central region of the country, with geographical coordinates ranging from latitudes 29°48' to 33°30' N and longitudes 52°45' to 56°30' E. The province is delineated to the east by the Lut Desert and to the north by the Great Salt Desert. The climatic conditions of the region are characterized by hot and arid summers, while winters are marked by cold and dry weather [23]. The capital of Yazd province, the historic city of Yazd showcases an impressively sophisticated earthen construction system and the adaptation of living standards to its harsh environment over several millennia. The city reflects a blend of diverse cultures connected to various religions, including Islam, Judaism, and Zoroastrianism, all of which coexist peacefully. This coexistence is evident in the combination of structures such as houses, mosques, fire temples, synagogues, mausoleums, hammams, water cisterns, madrasas, and bazaars. Additionally, Yazd exemplifies a traditional human settlement that highlights the interaction between humans and nature in a desert environment. Its success stems from the optimal use and careful management of limited resources through the qanat system and the construction of buildings featuring sunken courtyards and underground spaces [24].

The historic city of Yazd (Fig. 2), encompassing an area of 195 hectares, was inscribed as a World Heritage Site during the 41st session of the UNESCO World Heritage Committee, held from July 2 to 12, 2017, in Kraków, Poland. Prior to this designation, Dolat Abad Garden and Zarch Qanat, both situated within this region, were inscribed as World Heritage Sites in 2011 and 2016, respectively [25].



Fig. 1. Area of the historic city of Yazd. Source: (UNESCO 2023)

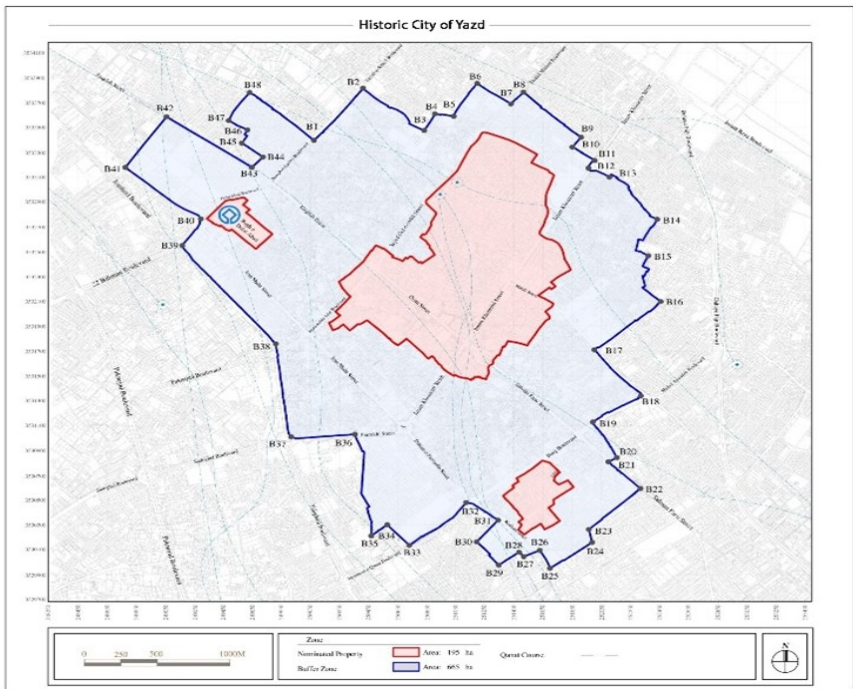


Fig. 2. Area of the historic city of Yazd. Source: (UNESCO 2023)

Data

The data was collected through qualitative methods, including three phases. In the first phase, pre-existing data were used to conduct a comprehensive review. Pre-existing data, such as textual sources from academic literature, scholarly papers, and relevant materials, can be juxtaposed with firsthand data obtained through systematic observations and comprehensive interviews. This comparison enables a comprehensive analysis of beliefs and perspectives held by individuals [26]. In the context of the mechanism of residential green spaces in Iran, the documents in the field of Persian architecture and urbanism provided the initial step for understanding this mechanism. In the second phase the participant observation was conducted by the authors. In this phase, three courtyard houses were observed based on some observation guidelines (Table 1). These houses were located in the historic center of Yazd with Iranian architecture. These houses were revitalized, with one remaining dedicated to residential use, another converted into a hotel, and a third adapted for use as an architectural firm. Also, some informal conversations were carried out with the residents of these three houses.

Table 1. Courtyard observation guidelines

Category	Includes	Researchers should note
Appearance of the courtyard	wind-catchers, sunken courtyards, cellars and greenery	Which of the four items under consideration is present within the premises of the house? Do these elements continue to function effectively, or do they exist solely as symbols?
Residents' connection to the courtyard	Residents who enter, exit, and engage in activities at the observation house	Do individuals appear in the courtyard alone or in groups? What activities are conducted in the courtyard?
Feelings and emotions	Gatherings and meetings conducted for recreational and leisure purposes	During which hours is the courtyard utilized most frequently? How individuals perceive their presence in this environment through informal discussions with participants in these meetings? What are the feelings of individuals before and after their presence in the courtyard?

In the third phase, the semi-structured interviews were conducted for obtaining several perspectives about the mechanism of residential green spaces in Yazd. The participants were familiar with courtyard houses in Yazd. An interview guideline was prepared based on the literature review and in line with the study's objectives (Table 2). A period of time between 20 and 35 minutes was allotted for each interview, which took place at the respondents' offices at a time of mutual convenience. Of these 15 interviewees, 8 were female and the rest were male (Table 3).

Table 2. Interview guidelines

1. What is the logical reasoning for establishing such structures?
2. What is the symbiotic relationship between these structures and the climate of Yazd?
3. What intangible roles have these structures played throughout history?
4. What impact do these structures have on the lifestyle of residents?

Table 3. Profile of experts

Respondents	Gender	Age	Educational level	Occupation
R01	Male	40	Master	Consulting firm
R02	Male	33	Ph.D.	Conservation architect
R03	Female	34	Master	Conservation architect
R04	Female	37	Master	Conservation architect
R05	Female	36	Master	Conservation architect
R06	Female	27	Master	Conservation architect
R07	Male	36	Ph.D.	University lecturer
R08	Male	30	Master	Urban planner
R09	Female	29	Master	Urban planner
R10	Female	45	Ph.D.	University lecturer
R11	Male	38	Master	Urban planner
R12	Male	59	Master	Architect
R13	Female	35	Master	Archaeologist
R14	Male	45	Ph.D.	University lecturer
R15	Female	37	Master	Architect

Method

The collected data were transcribed carefully and then transferred to Atlas.ti software. The thematic analysis technique was employed to analyze the data. Through this technique, textual data is analyzed in order to elucidate themes [27]. Their key characteristic is the systematic process of coding, examining meanings, and providing descriptions and interpretations [28]. The primary research themes were identified during the open coding phase of the three-step data coding process in this analysis. The open coding procedure commenced, and data were coded in accordance with the research inquiries to identify interesting elements of the data. The codes were subsequently classified based on their semantic and conceptual relationships, and each category was designated a name. Subsequent to this phase, a network of coding groups was established, with a principal theme designated for each network and additional sub-codes/sub-themes associated with the primary themes to elucidate the interconnections among the concepts [29].

Findings

Based on three phases of data collection and subsequent analysis, six primary themes were uncovered. Within these themes, we identified numerous codes that offer insights into the processes associated with private urban green spaces and their contribution to cultural ecosystem services. Furthermore, we explored the activities and interactions arising from this type of cultural ecosystem service in the arid city of Yazd. Three homes were observed as case studies, two of which were converted into a boutique hotel and an architecture office, while one has remained

residential. The initial three themes are aligned with the first research objective, while the subsequent three themes correspond to the second research objective.

Climate adaptation and environmental integration

Iranian architecture utilizes the resources provided by the surrounding environment and climate. In this approach, it not only avoids the degradation and destruction of the natural landscape but also aims to enhance and strengthen the surrounding ecosystem [30]. Yazd is renowned for its distinctive skyline characterized by windcatchers, which are tall and elegant. Windcatchers are designed to capture the slightest movement of air and direct it downward into subterranean chambers for cooling. The residential architecture of the region features expansive vaulted Talars that open onto spacious courtyards, which are adorned with aesthetically pleasing water features and gardens [31]. This theme encompasses a range of factors influencing the formation of cultural ecosystem services, including elements such as climate-driven architecture, seasonal awareness, the symbiosis of built and natural elements, and strategic shading. The courtyards in the houses of Yazd serve as a comprehensive manifestation of introversion. Within the Yazd courtyard, the environment markedly contrasts with the external surroundings. In this compact garden, residents cultivate trees and flowers that are native to the region, accompanied by a long pond, thereby establishing a conducive environment for leisure during the hot summer days characteristic of Yazd [32].

Most of the respondents cited climate and environmental considerations as the rationale for establishing this type of ecosystem service. The experience of residing in the climatic conditions of Yazd over time has resulted in the development of a distinctive ecosystem. This climatic classification encompasses various resources, including fuel, wind, soil moisture, and access to water. The interplay of these elements contributes to the establishment of specific structures, such as windcatchers, sunken courtyards, cellars, and greenery, as well as the incorporation of moisture within residential spaces, which serve as private green areas within the urban landscape of Yazd (Fig. 3).

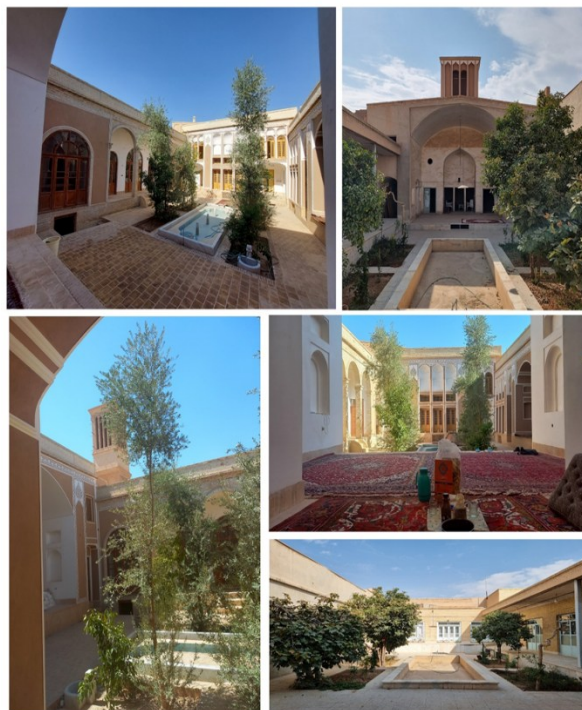


Fig. 3. Diverse perspectives on the courtyards

One participant (R01) said, *"In essence, the entirety of this structure reflects how they have leveraged the natural environment for architectural purposes and adapted to living in this climate by incorporating private green spaces within their residences."* Another respondent (R03) explained, *"The architect has positioned the courtyard at the center of the residence, taking into account the absence of external views or terraces in the surrounding village. He has designed a spacious hall that opens onto this courtyard. The central courtyard's climatic considerations have led to a sunlit or shaded facade, enabling the house's spaces to fulfill their intended functions in both summer and winter."* Due to the nearly equal distribution between mass and space, the courtyard functions as a sub-climate that effectively contributes to the cooling and heating of the house. It plays a significant role in regulating air quality, thereby providing a relative level of climatic comfort for the residents [33]. One respondent (R14) proclaimed that *"This indicates that the lifestyle of a Yazdi individual developed in an outdoor environment, as air circulation was essential due to the high temperatures prevalent in the region. To facilitate this necessary airflow, the implementation of windcatchers was required. The structure known as the windcatcher has existed for approximately 400 years. Prior to this time, windcatchers were absent, and elongated porches were constructed to provide prevailing winds by utilizing non-bearing walls."* Typically, the central area of the courtyard comprises extensive gardens, characterized by trees that attain a height sufficient to reach the roof, thereby contributing to the verdant ambiance of the space. These gardens are generally situated on either side of a lengthy pond within the yard, featuring a diverse array of trees, including pomegranates and grapes [32]. The majority of respondents asserted that the presence of courtyards and gardens has significantly mitigated the effects of the hot and arid climate of Yazd, addressing the deficiencies in both vegetation and water resources. Furthermore, the trees within these spaces contribute to the production of crops and provide essential shade. In the absence of public green spaces in Yazd, these private areas serve as vital sources of greenery within residential environments.

Architectural design features as ecosystem service enablers

The most salient and significant characteristic of the architecture of residential spaces in Yazd city is the arrangement of rooms around a central courtyard. This configuration reflects a longstanding principle in Iranian architecture. Regardless of the nature of the activities conducted within this space, the central courtyard has retained its original significance to the present day. Indeed, the interplay between climate and architecture has facilitated the development of this architectural ecosystem [34]. This theme underscores the ways in which various architectural features enhance ecosystem services. It elucidates adaptive design practices, basement cooling, self-sustaining courtyard ecosystems, and micro-ecosystems within residential design. Furthermore, this theme elucidates how residential design contributes to the creation of micro-ecosystems. The courtyard in Yazd houses serves as the focal point and essence of the architectural design (Fig. 4).

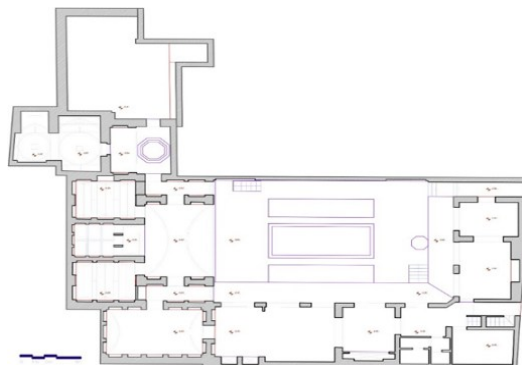


Fig. 4. The courtyard as a central element in architectural design

Characteristically, the traditional houses of Yazd feature a central courtyard flanked by verandas on each side. While it is conceivable that the courtyard may not occupy the geometric center of the house, it is regarded as the nucleus of domestic life and activities [35]. A group of respondents asserted that the design of residential spaces serves as a facilitator for ecosystem services. One notable aspect of the discourse surrounding green space design in residential environments is the incorporation of a sunken courtyard. This sunken courtyard is situated at the center of the courtyard and is constructed approximately one story below ground level, facilitating easier access to water sourced from the aqueduct and providing soil for the bricks utilized in the construction of the building. Additionally, trees such as pomegranates and figs were cultivated within the sunken courtyard. Notably, in arid desert regions, residences were excavated to enhance insulation against sound and heat, to facilitate access to water from the aqueduct, and to augment the structural resilience of the buildings [36]. An experienced architect (R05) said, *"It is evident that climate significantly influences various architectural elements, including the dimensions of the central courtyard, which typically exhibits a ratio of one to three. Furthermore, the orientation of the courtyard is generally aligned in a north-south direction. The aspect of shading in the courtyard is also noteworthy, as one half remains shaded for half of the day, while the other half is shaded during the remaining portion of the day."* This indicates that there has historically existed a significant relationship between humans and their surrounding environment, characterized by a desire to maximize the utility of limited resources. For instance, one respondent (R06) said, *"The quality that can be added to the courtyard extends beyond mere vegetation. For instance, the incorporation of a pond at the center may enhance the landscape, provided it is managed to prevent excess water accumulation near the house. Additionally, the construction of a Payab or the excavation of a sunken courtyard is feasible, particularly where a shallow aqueduct is present, allowing for access to this water source. The rationale behind the establishment of the sunken courtyard was not solely related to the climatic comfort of the architectural design. Initially, upon observing that the water table was situated four meters lower than the surrounding area, it was determined that the courtyard would be repositioned four meters downward, necessitating the relocation of the garden and the excavation of a sunken courtyard."*

Sustainability and resource management

The indigenous architecture of Yazd has successfully integrated sustainability into the design of buildings within a desert climate, responding to environmental needs through innovative elements specific to the region. The architects of historic houses have addressed the challenging climatic conditions characteristic of desert cities including significant temperature fluctuations, low humidity, pronounced thermal expansion and contraction due to direct sunlight, minimal rainfall, and strong winds by implementing effective solutions. These efforts have enhanced the comfort and sustainability of the living conditions for residents in this arid region [37]. This theme encompasses recycling and resource management, self-sufficiency, practices of environmental sustainability, and water management. Additionally, this theme may elucidate how the private green spaces in Yazd serve as a representation of sustainability. Interviewees indicated that the principles of sustainability were adhered to in the creation of these spaces and that they were constructed using locally available materials. They also sought to optimize the utilization of limited resources, employing native plants and trees found within the desert climate for fuel. In the context of Iranian architectural terminology, these resources are referred to as 'Indigenous Materials' [35]. One respondent (R15) pointed to resource management as the main characteristic of courtyards and stated, *"In historical residential courtyards, the visibility of production processes and growth cycles was notable. Residents maintained poultry, including chickens and roosters, which provided eggs. They cultivated vegetables, harvested crops, and engaged in further processing of these resources, thereby contributing significantly to various facets of daily life. Additionally, these materials were often repurposed into fertilizers, illustrating their involvement in sustainable recycling practices within the domestic environment"*.

Due to the substantial size of these houses, it is estimated by one expert that they typically accommodated approximately 30 to 40 individuals. In this regard, one participant (R04) said, *"Another pertinent topic is the structure of the extended family in traditional Iranian households, which often consisted of twenty to thirty individuals residing under one roof, accompanied by a staff of approximately forty to fifty members. In such circumstances, it becomes essential for the household to address many of its needs internally, as transporting this large group to a resort may not be feasible. Consequently, various needs are met within the household, akin to a large family that shares a common green space."* Another participant (R02) declared, *"One reason for this phenomenon is that, during periods of extreme heat in Yazd, individuals likely preferred to construct their shelters in proximity to their immediate environment rather than endure the inconvenience of traveling to a distant urban area. Furthermore, they may have prioritized considerations of enclosure and proportionality, allowing them to effectively manage sunlight exposure an undertaking that would be more challenging in a larger urban context and more feasible on a smaller scale"*.

Social cohesion and family dynamics

The courtyard serves as a multifaceted space for rest, social gathering, conversation, and celebration, as well as the hosting of both wedding and mourning ceremonies. Furthermore, the courtyard functions as the central organizing element of the dwelling, around which various other spaces are arranged. This theme encompasses the intangible dimensions of private green spaces, including family-oriented environments, community and familial cohesion, architectural elements that facilitate community building, and the connections within neighborhoods. Spaces such as the courtyard, which facilitate significant movement and interaction, enhance the liveliness and utility of social engagements [38]. Houses with expansive courtyards would serve as venues for children engaging in soccer, while neighbors would convene in these communal spaces. The interviewees posited that this architectural style is shaped by the climatic conditions of Yazd, which, in turn, has led to a tendency among the residents to adopt introverted behaviors and to favor formal conduct in their interactions and ceremonies. For instance, one respondent (R07) explained that *"One significant factor was the climate issue, which undoubtedly played a crucial role. Beyond the climate and specifically regarding Yazd, this structural characteristic can also be observed in other desert cities of Iran. The inhabitants of Yazd have historically exhibited a tendency towards introversion, maintaining predominantly inward-looking and familial relationships. It appears that there is a need for social spaces that facilitate broader interactions"*. Another respondent (R08) counted attributes of private green spaces as *"For instance, multiple families resided within a single dwelling, and as their children entered into matrimony, the courtyards of these houses expanded. Consequently, they began to conduct certain religious ceremonies in these courtyards, a practice which correlated with the growing population. These ritual ceremonies became more prominent in this context"*.

In addition to serving as a transitional space that connects various areas and provides a landscape for individual spaces, the courtyard can assume multiple functional roles. Activities such as outdoor sleeping, family gatherings, and children's play can all occur within this space, thereby enhancing the utility of the courtyard as an integral component of the household. The courtyard in Yazd serves as an additional living space for families during periods of the year when the climate is neither excessively cold nor excessively hot. Considering these points, the dimensions of the courtyard are influenced by the overall size of the house and the requisite spaces. In accordance with the architectural design of the residence, courtyards are categorized into inner and outer types. One-yard houses are prevalent in Yazd, while two-yard houses (comprising both inner and outer spaces) are also relatively common. Typically, two-yard houses are associated with affluent members of society, serving as venues for business meetings or accommodating guests from other cities [36]. The majority of interview participants posited that central courtyards, beyond their primary climatic and architectural functions, have developed significant cultural and social roles over time.

Multi-functional social and recreational spaces

The central courtyard, as an ecosystem, serves as a fundamental site for the formation of the behavior, culture, and society of Yazd. This private green space emerges as a result of the interactions among the behavioral patterns of residents and various social spaces. This theme presents the courtyard as a socio-cultural space encompassing various functions, including its role as an event venue, a private recreational area, a site for economic activities, and a context for gardening experiences. The delineation of public and private territories and boundaries, the quantity and intensity of mental security and physical comfort activities, the capacity to ensure privacy and isolation, interpersonal communication, and similar factors are contingent upon the conceptualization of individual architectural spaces within traditional houses [30, 39]. One respondent (R11) said *"Approximately 200 years ago, during ceremonies conducted in the courtyards of residential buildings, women typically occupied the rooms surrounding the courtyard, while men congregated within the courtyard itself. This arrangement indicates that the courtyard served a civic and social function that extended beyond its familial role. Wedding ceremonies, for instance, were commonly held in these spaces. In the historical neighborhoods of Yazd, many residents celebrated weddings in houses featuring large courtyards, often measuring around 500 to 600 square meters. As the size of these courtyards increased, they began to offer services to the neighborhood, reflecting the use of the house and the socioeconomic status of its affluent owner. Additionally, weekly gatherings of local residents were frequently conducted in these courtyards"*.

While the expansive central courtyard catered to the services required by individuals at a neighborhood level, smaller courtyards also addressed the needs within the domestic setting. For instance, respondent R12 observed that *"On one hand, the individuals' commuting and interactions with the external environment were likely diminished. Their needs were largely fulfilled within the confines of their home and courtyard, with many engaging in work-related activities indoors. For instance, in a sample of ten residences, approximately six or seven contained a weaving machine in the basement. Additionally, families transformed their courtyards into play areas for children, potentially reducing the necessity for outdoor play in the alley. This phenomenon likely contributed to the observed effect"*. The interaction between humans and animals, such as birds, cats, and fish, can be exemplified by activities such as observing birds in the garden and engaging in playful actions, such as throwing objects toward them. Additionally, the process of cultivating a garden—planting seeds, harvesting produce, and witnessing the transformation of a sapling into a mature tree—provides insight into the effort and care involved in nurturing living organisms. Furthermore, it is noteworthy that children's interactions with animals have evolved significantly over time, reflecting changes in societal norms and values.

Emotional and symbolic connections to space

This theme pertains to the relationship between individuals and private green spaces, which often evoke a form of symbolic emotion among the inhabitants of these residences. The codes most frequently assigned to this theme included the symbolic representation of dwelling, the emotional impact of heritage spaces, the courtyard as a symbol of cultural identity, and the psychological effects of courtyard design. Individuals develop an interest in and establish connections with a location due to behaviors that emerge from cultural imperatives. This phenomenon elicits a sense of social, cultural, and historical vitality that accompanies the experience of being in a familiar environment. An appropriate recognition and comprehension of cultural and societal contexts facilitate a dialogue between the place and its inhabitants, thereby fostering a profound emotional bond between them and their environment [40]. Respondents felt that an image is constructed for the inhabitants through the components of the ecosystem. One respondent (R09) declared, *"I contend that the most significant role this image has played throughout history is its association with the concept of a living space—a habitat that fosters maximum comfort and tranquility. This association reflects the embodiment of comfort and peace within the human experience"*. Occupying these environments represents a novel experience for individuals accustomed to contemporary settings, subsequently providing them with psychological comfort. One interviewee (R01) highlighted, *"Indeed, there exists a parallel in*

psychological comfort. For instance, we previously worked in a modern office environment, but we now find ourselves in a traditional space, which presents a stark contrast. This shift has a significant psychological impact on us".

Architecture and urban planning serve the critical function of preserving ancient cultural values and are thereby recognized as foundational elements of cultural identity. Traditional Iranian architecture, characterized by its distinctive identity, exemplifies this principle. In particular, the elements of traditional Yazd architecture, from the moment one enters a building to the experience of the courtyard, foster a profound connection with the identity of the community [41]. One informant (R10) explained, *"A significant aspect of their discourse is influenced by the notion that life transpires within the courtyard. The courtyard, therefore, emerges as a dynamic element that evolves in tandem with the progression of societies, aesthetic considerations, decorative elements, and proportional relationships."* The design of the courtyard, particularly at the moment of entry, exerts a significant psychological influence on the audience. One participant (R13) confirmed this statement that *"Upon traversing the hierarchical structure, one arrives at the threshold of a space characterized by a transition from a confined corridor with limited illumination and considerable height to an expansive area that is well-lit, cooler in temperature, and possesses a more agreeable atmosphere. This abrupt expansion of spatial dimensions engenders a sense of well-being in individuals following their passage through the hierarchy"*.

Discussion

The cultural role of private urban green spaces as a component of larger integrated socio-ecological systems

The first objective of this study is to explore how private urban green spaces contribute to cultural ecosystem services in Yazd, an arid city in the Middle East. After coding and categorizing the data derived from pre-existing texts, participant observation, and interview manuscripts, three themes were identified as the primary categories of our research findings. What stands out about the extracted categories is that the green spaces in the private residential areas of our case studies provide various dimensions of cultural ecosystem services for families and communities. These include fostering social cohesion and interaction, offering recreational benefits, and contributing to the formation of place identities. Additionally, the integration of these green spaces with the specific architectural design of these homes creates an aesthetically pleasant experience for their residents. These findings align with previous studies, indicating that, due to climatic conditions, the limited presence of individuals in public urban spaces has rendered residential yards critical areas for families and communities [1, 42, 43].

However, it seems that these private green spaces are part of larger, integrated socio-ecological systems in these places. Socio-ecological systems refer to the interconnected and interdependent relationships between social and ecological systems, where changes in one system can impact the other. These systems are complex and dynamic, with interactions that can either promote or hinder sustainability [44-46]. Therefore, the various components of these private spaces, including architectural elements, windcatchers, courtyards, sunken gardens, and green spaces, as well as the links between them and the social groups that use them, could be defined as specific socio-ecological systems within urban green spaces.

In fact, the mentioned cultural ecosystem services are shaped by a combination of environmental and architectural factors, leading to the development of specific socio-ecological systems in private areas where green spaces are just one component. Understanding this mechanism and how these cultural ecosystem services are created within the broader socio-ecological system is crucial, as it can help sustain approaches to address current crises such as the impacts of climate change. These climate change adaptation strategies have the potential to foster more resilient urban environments, thereby preserving social and economic stability and facilitating growth in an evolving climate [5].

Specific cultural ecosystems services of private urban green spaces

The second objective of this study is to investigate the primary activities and interactions driven by cultural ecosystem services within private urban green spaces of the case studies. Private urban green spaces in the arid city of Yazd play a pivotal role in fostering unique cultural ecosystem services. These services are deeply rooted in the cultural, social, and environmental characteristics of the region, shaped by centuries of adaptation to its harsh climate. Furthermore, these cultural ecosystem services encompass a sense of place and opportunities for the preservation of cultural heritage [9], which are crucial elements in the conservation plan for a UNESCO World Heritage site. Through this study, three primary themes were identified that encapsulate the activities and interactions arising from these spaces.

Firstly, private green spaces serve as hubs for social cohesion and family dynamics. The central courtyards in Yazd's traditional homes function as versatile spaces for family gatherings, religious ceremonies, and celebrations, fostering strong interpersonal bonds. This design promotes a sense of belonging and unity, which is particularly significant in a society where public spaces have limited accessibility due to cultural and environmental constraints [42]. Although there are some Persian gardens on an urban scale, the design of each Persian garden is influenced by climate, art, beliefs, poetry, literature, and the cultural romance of the country and region in which the garden is situated [4].

Secondly, recreational and aesthetic experiences are prominent cultural ecosystem services provided by these spaces. The presence of greenery, water features, and shaded areas creates a tranquil environment for relaxation and leisure. These spaces often act as extensions of indoor living areas, offering comfort and psychological benefits during milder seasons. The visual and sensory appeal of these gardens enhances the quality of life for residents, providing an escape from the arid external environment.

Thirdly, these spaces contribute to the preservation of cultural identity and heritage. The architectural design of courtyards and the integration of natural elements reflect traditional values and practices, linking contemporary inhabitants to their historical roots. This symbolic connection fosters a sense of pride and continuity, reinforcing the cultural significance of private green spaces.

Fourthly, private green spaces support multi-functional uses. Beyond serving as family-oriented environments, they host small-scale agricultural practices, such as the cultivation of fruits and vegetables and even small livestock. This self-sufficiency aligns with sustainable practices and enhances the utility of these spaces, addressing practical needs alongside cultural functions [5].

Lastly, the symbolic and emotional connections to these spaces cannot be overlooked. For many residents, private green spaces represent more than mere physical environments; they evoke a deep emotional attachment. This bond is often tied to memories, cultural narratives, and the sense of tranquility that these spaces offer, serving as anchors for individual and collective well-being.

In summary, the cultural ecosystem services provided by private urban green spaces in Yazd are multi-dimensional, encompassing social, aesthetic, recreational, and symbolic aspects. These services are integral to the socio-ecological systems of the region, reflecting a harmonious balance between cultural practices and environmental adaptation. Understanding and preserving these spaces is essential for sustaining their unique contributions to urban life in Yazd and similar arid regions.

Conclusion

This study highlights the significant role of private urban green spaces in the arid city of Yazd, Iran, as contributors to cultural ecosystem services, emphasizing their unique socio-ecological systems. Unlike public green spaces commonly addressed in existing literature, private spaces in Yazd demonstrate distinct functionalities, shaped by centuries of architectural adaptation to a harsh desert climate and cultural preferences for introversion. Through six

identified themes, this research underscores how these spaces foster social cohesion, preserve cultural identity, and provide aesthetic and recreational benefits. The integration of architectural elements such as windcatchers, courtyards, and sunken gardens into residential designs illustrates how these green spaces serve as sustainable solutions for climate adaptation, self-sufficiency, and community well-being. These findings redefine the scope of cultural ecosystem services, emphasizing their multidimensional contributions to urban life.

Moreover, private green spaces in Yazd transcend their physical utility by fostering symbolic and emotional connections among residents. They function as hubs of cultural heritage, bridging the past with the present while supporting activities like family gatherings, ceremonies, and small-scale agriculture. The socio-ecological systems formed by these spaces reflect a harmonious interplay between human needs and environmental adaptation, promoting sustainability and resilience in urban settings. This study not only broadens the understanding of cultural ecosystem services in private spaces but also offers a definition for integrating traditional design principles into contemporary urban planning, particularly in arid regions where resource efficiency and cultural identity are paramount. These insights provide valuable guidance for policymakers and urban designers aiming to enhance the quality of life in rapidly urbanizing areas while respecting their unique historical and environmental contexts.

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