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Review Paper

A Review Human Movement Through Different Altitude Layers of a Dwelling in Hot and Semi-humid Climates

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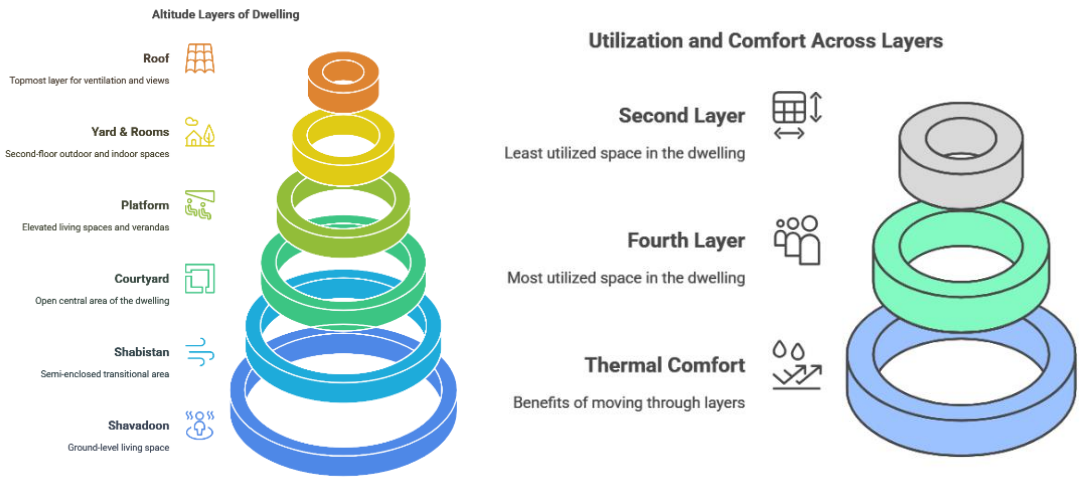
Abstract
This study explored one of the unique solutions to create climatic comfort in high-temperature and semi-humid dwellings. It also aimed to explain the role of different altitude layers of dwellings in Dezful throughout the year. It is an applied study with a descriptive-analytical method. This study was carried out on 23 local houses in Dezful, and revealed six altitude layers, including the first layer (Shavadoon), second layer (Shabistan), third layer (courtyard), fourth layer (the platform, first-floor room, and veranda), fifth layer (the yard on the second-floor, second-floor room, and veranda), and sixth layer (the roof). The data were collected through interviews, available documents, and field observations. The results revealed that moving vertically through layers can yield thermal comfort. The fourth layer has the most use of space, and the second layer has the most minor use of space during the year.

Keywords: *Hot and semi-humid climates, Dezful, Historic dwellings, Living layers, Vertical movement.*

GRAPHICAL ABSTRACT



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Glossary	
Shavadoon	*Shavadoons* are architectural elements invented based on the land's characteristics. A *shavadoon* is an underground space dug beneath the local dwellings in Dezful as deep as 5-12 meters.
Shabistan	*Shabistan* is a space in Dezful's traditional homes, located 1.5 meters above the courtyard level and functioning similarly to a basement. Accessible by a few steps, it features windows for light and ventilation, and it generally serves as a kitchen and storage area, often including a vertical canal (Darizeh).
Mahtabi	The Mahtabi is a roofless space higher than the courtyard level.
Pishboom	The yard on the second floor.
Sabat	covered passage.
Wind catchers *(Badgir)*	Wind catchers are towers built on rooftops for ventilation and cooling.

INTRODUCTION

Iran is located in a hot region and vernacular architectural strategies are among the most crucial aspects that shape Iranian dwellings. Dezful is a city located in the north of Khuzestan Province, southwestern Iran, 200 kilometres from the sea. The climate of Dezful City is hot and semi-humid. One of the characteristics of this city is the presence of the Dez River, which despite the intense heat, creates favorable winds in this city. The extreme heat, the existence of the river, the coolness of the water, and the resulting humidity in the air have created a unique architecture.

Instead of the common phenomenon of horizontal movement around the central courtyard (summer residence in the southern part and winter residence in the northern part of the courtyard) in traditional dwellings in a dry climate, this movement in Dezful takes place vertically from the roof at a height of 10 meters to a depth of 12 meters in *Shavadoon*. For comfortable residences during summer, underground spaces named *Shavadoon* were built. Underground spaces had apparent advantages in terms of thermal comfort and energy efficiency. Residents of hot and humid cities would use consistent temperature in the ground depth and its thermal capacitance to provide climatic comfort.

As a result, locals of southern Iran above the Persian Gulf, with a hot and semi-humid climate, utilize the potential benefits of Earth's thermal capacitance and vertical movement through the different altitude layers of buildings to achieve thermal comfort. Local dwellings in the southern region of Iran have several floors, built at different altitude layers, and each floor is used during a different time. These layers usually consist of one, two, or even three underground layers and the same number of floors above ground. This study mainly focuses on these architectural altitude layers.

Several studies have been conducted worldwide on traditional architecture with different altitude layers. Some studies have addressed the potential of the earth and the use of underground spaces (Foruzanmehr, 2015; Hassan et al., 2014; Hazbei et al., 2015). Other studies have also described the altitude layers above the ground and the orientation of the rooms in the dwelling (Chandel et al., 2016; Dili et al., 2011; Mohammadi et al., 2017; Motealleh et al., 2018; Rezazadeh Ardebili & Shafiei, 2016; Shanthi Priya et al., 2012). However, all different altitude layers have not been analyzed simultaneously to determine which spaces people used most and which they used least. The research problem addresses the lack of simultaneous analysis of different altitude layers in traditional dwellings in the southern region of Iran. While previous studies have explored individual layers, they have not analyzed how people utilize these spaces at different times of the year. Based on this information, future designers can design dwellings that are compatible with the climate and determine the size of each space based on how frequently people use it on different days of the year.

This study aims to explore vernacular architectural arrangements in hot and semi-humid climates. Findings can serve as a guide for improving the quality of energy consumption in sustainable communities by providing empirical evidence of living in local dwellings in Dezful. This study also seeks to analyze human movements on different altitude layers of various dwellings in Dezful. Finally, the study seeks to explore how vernacular architecture is adapted to the climate and how it is used.

Evaporative cooling is one of the most useful ways to cool buildings in hot and dry climates (Montazeri et al., 2010; Zaki et al., 2019). People use evaporative cooling in humidity under 70% (hot and dry climates) (Vakilinezhad et al., 2013). However, in some regions, the relative humidity is too high on hot days of the year, and evaporative cooling does not work. Therefore, this strategy is ineffective in hot and semi-humid climates.

Thus, due to the presence of high humidity in the air during the hot days of the year, it is not possible to use wind catchers (*Badgir*) and ponds in the central

yard. One of the contributions of this study is that residents in warm and dry climates move horizontally in local houses. Thus, the houses are wide and the city has low density. Residents use ponds, wind catchers (*Badgir*), and plants to create climate comfort. Residents in hot and dry cities build rooms only 5 meters underground to keep food cool and also benefit from the soil's thermal capacitor potential. Meanwhile, the movement of residents in Dezful takes place vertically. The depth of the land that can be used by the residents of this city reaches 10 meters due to the construction of the *shavadoons*. The houses do not have a large yard, wind catchers (*Badgir*), or pond, but the number of floor layers in these houses is more than the local houses constructed in the hot and dry climate.

To this end, the following two research questions are addressed in this study:

1) What is the role of different altitude layers of dwellings in thermal and climatic comfort conditions?

2) What percentage of space is used in different altitude layers in the local dwellings of Dezful?

Following the objectives of this study, we used a qualitative research design (case study approach with a qualitative and descriptive-analytical method) to explore the climate of Dezful. To this end, a total of 23 local houses were identified. Then, we interviewed some of the residents of the houses. The interviewed residents were 62 years old on average. The rationale for selecting these residents was that they had the experience of living in local houses. Thus, surveying their lived experience could reveal the frequency and time of using each part of the house. The interviews were conducted with six main questions. Besides, probing questions were asked to discover the local architecture of this city. In the next step, after discovering and identifying the frequency of use of spaces throughout the year, we compared the results with houses located in hot and dry climates.

LITERATURE REVIEW

Climate Strategies in Hot and Dry Climate

Essential architectural components in hot and dry climates used for evaporative cooling are wind catchers (*Badgir*), water basins, and gardens. With the flowing of hot and dry air over the water surface, water droplets are evaporated using the hot air, and as a consequence, the air is humidified and cooled. Thus, to maximize climatic comfort, residents of a dwelling move on the ground surface from the rooms on the north side of the dwelling (in winter) to the rooms on the south side of the dwelling (in summer). This means that the surface area of the dwellings is wide given the expansion of the house components, with several rooms surrounding a courtyard with a pond and a garden (Figure 1).

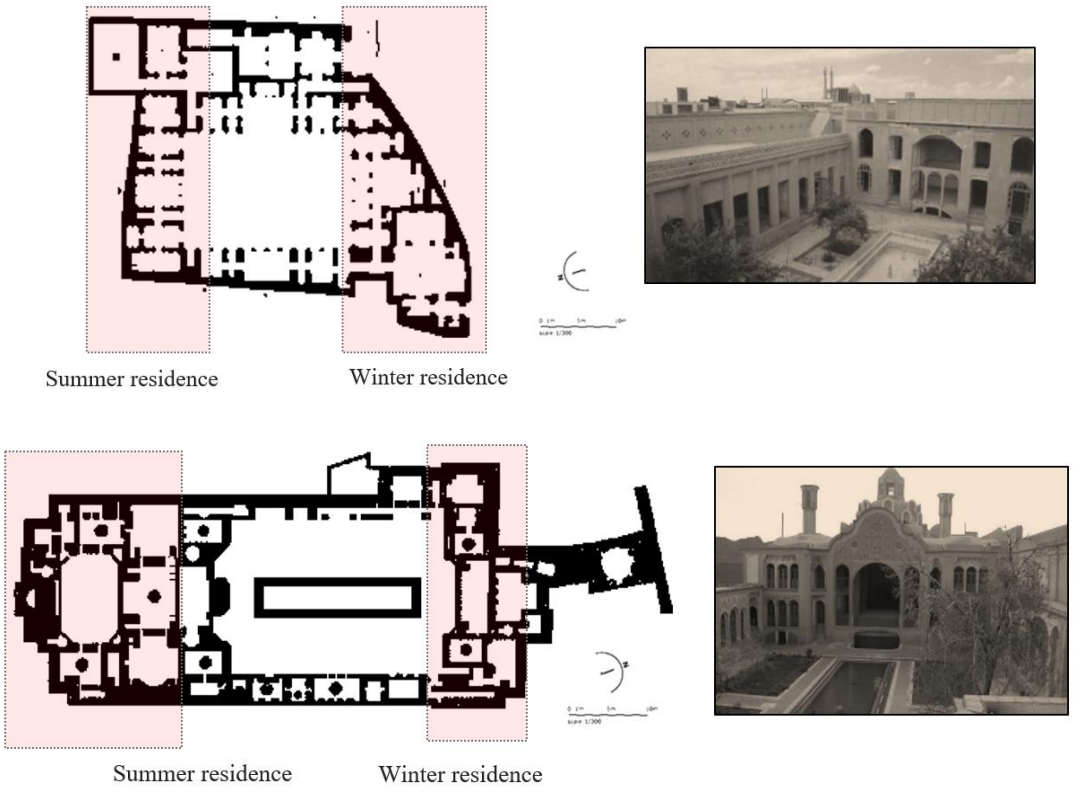

Fig 1. Samples of Local Dwellings' Plans in Hot and Dry Climates (Source: Ali et al., 2020)

Recognizing Climate Strategies in Hot and Semi-Humid Climate

Introduction to Dezful City

Located in Khuzestan Province, Dezful is situated in the southwest of Iran (Figure 2). Dezful has a hot and semi-humid climate. Summers in the city are scorching hot and humid, while winters are mild. Extreme heat, favourable wind directions, and natural factors, such as the river crossing, topography, and the difference between the river level and the city, all play essential roles in shaping and maintaining the complex architectural life of old Dezful. The dispersion of volumes, an architectural characteristic of humid regions, does not prevail in Dezful. Moreover, planting trees, using evaporative cooling through a pond in the courtyard, and using wind catchers (*Badgir*), which are common in hot and dry areas, cannot be seen in Dezful either.

In this study, for climatic analysis, 23 dwellings within the Dezful historical fabric were selected (Table 1 and Figure 3).

The studied residential houses had been all constructed during the Qajar era (1789-1925). The oldest of them was Tizno House, with some parts added to it in different historical periods. Based on the architecture of these houses, different altitude layers and their roles and functions will be described. Most of the houses in Dezful have been built on the ground on one to two floors. However, due to the special architecture and the use of underground layers, they have six layers of floors. Thus, the first and second layers are constructed underground, the third layer is on the ground floor, the fourth layer is on the first floor, the fifth layer is on the second floor, and the sixth layer is constructed on the roof of the houses.

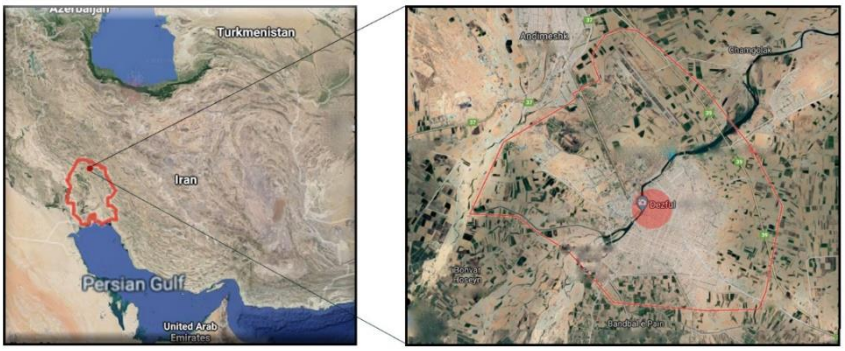

Fig 2. Location of Dezful (Source: Google Earth, 2023, adapted by the author)

Table 1. The Introduction of Selected Dwellings (Source: Authors)

Row	Name	Orientation	No. of floors
1	Tizno	Eastern-western	2
2	Rashidian	Eastern-western	2
3	Siah Pooshan	Eastern-western	2
4	Nilsaz	Eastern-western	2
5	Zargar	Eastern-western	1
6	Suzangar	Northern-southern	2
7	Darikvandi	Northwest- southeast	2
8	Delvar	Northern-southern	2
9	Bahramvand	Northern-southern	2
10	Ghalambar	Eastern-western	2
11	Lami	Eastern-western	2
12	Nafisi	Eastern-western	2
13	Shaygan	Northwest- southeast	2
14	Tehrani	Eastern-western	2
15	Tooni	Eastern-western	2
16	Khalilo	Northern-southern	2
17	Ziyai	Northwest- southeast	2
18	Ashiri	Northern-southern	2
19	Baghban	Northern-southern	2
20	Azarabad	Eastern-western	2
21	Bibaz	Eastern-western	2
22	Diyanati	Eastern-western	1
23	Filbanzade	Eastern-western	1

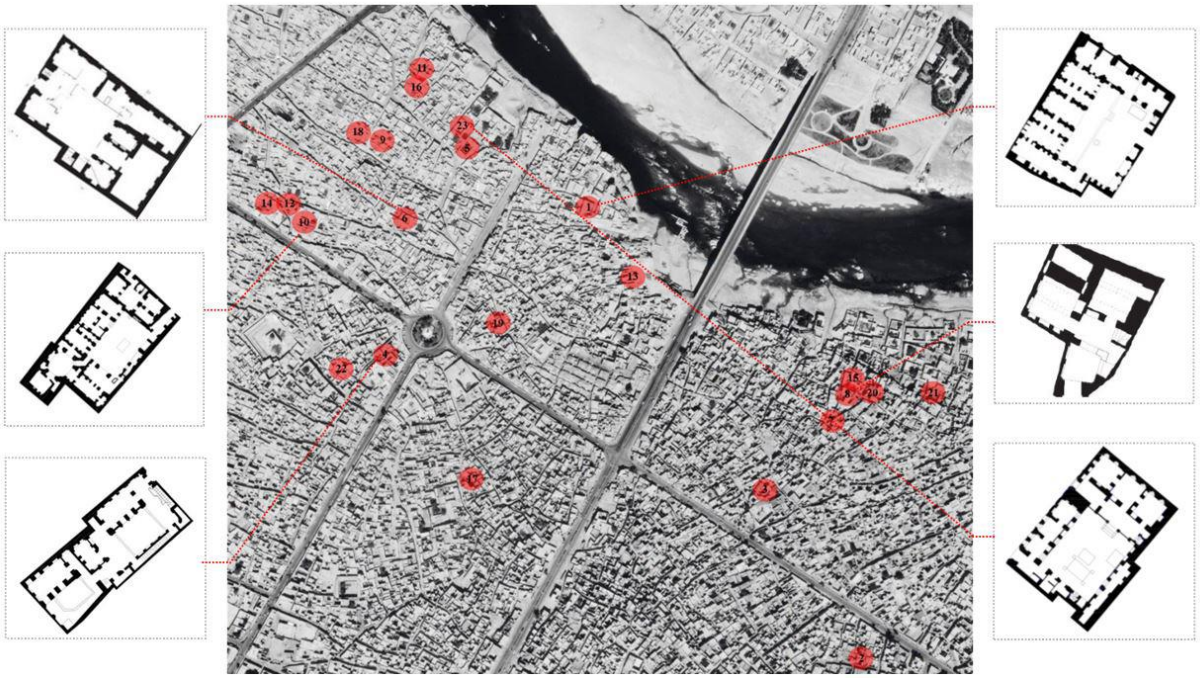

Fig 3. Aerial Photographs of Dezful in 1966 (Source: Cultural Heritage Organization of Dezful, Historical Sites Map of Dezful, 1996; adapted by the author)

MATERIALS AND METHODS

In this study, we used a qualitative and descriptive-analytical method, with a single-case study. Moreover, we used field observations and questionnaires to collect the data. In this research project, we first explore the climatic comfort of people in Dezful, followed by a discussion of how architectural strategies have helped create comfort in this climate. In the second step, we identify the different altitude layers of 23 local dwellings. Given the similarity of dwellings in the study, we have only illustrated the graphical analyses of three dwellings. In the next step, 50 people aged 50 to 70 years old, who experienced living in historical dwellings with different altitude layers, were interviewed. The interviewees were 23 females and 27 males with an average age of 62 years. Since the dwellings had mainly six layers, the interview consisted of six main questions, each with a set of sub-questions. Six mutual questions were asked on all six layers, such as 1) What was the name of the space? 2) Where is the location of the space? 3) How would you have entered the space? 4) In which months did you use this space most? 5) How much would you use it throughout the year? 6) How many hours and at what specific times would you use that space throughout the day?

While surveying people who recalled living in the historical dwellings of Dezful, we had an in-person conversation, recorded the replies, and used a semi-open questionnaire; we considered the layer, type of utilization, and time of utilization during each question. We have developed this questionnaire based on the data from three months of field observations, behaviour observations of spaces, attitude assessments, and exploring library materials and documents. A total of 50 questionnaires were distributed among residents with a 100% response rate. The interview and observation data were analyzed using qualitative methods. We have divided the research results into four categories: morning, noon, evening, and night according to the descriptions of the residents of the space, as well as the length of time they spent in the space.

FINDINGS

Vernacular Architecture in Dezful

Overall, the data from field observations indicated the buildings in Dezful are densely placed next to each other due to the intense heat, with low occupancy and high-density rates. Thus, a house typically includes the first floor, second floor, ground floor, basement, and *Shavadoon*. This type of design creates a shadow. The streets are narrow and often have roofed passages. The materials used in the local buildings of this city differ in different layers. For instance, bricks are used in the layers on the ground, and the underground layers are constructed manually and their body is made of natural rubble. Cedar wood - which is not suitable for

carpentry and has many twists - has been used as a filature and force regulator in the brick structures of walls and arches. The traditional decoration of houses is brickwork, and various geometric patterns have been created by placing bricks in front and back, as well as using bricks with different designs and dimensions.

The spaces of houses are divided into three types: open, semi-open, and covered spaces. The open space includes the courtyard, the semi-open space contains the porches, and the covered space consists of the bedroom, living room, bathroom, toilet (located in the courtyard in most of the local houses), basement (warehouse), and *shavadoon*.

The interviews conducted with the residents of local houses that are explained in the section Materials and Methods (The interviews were conducted with 50 individuals aged 50 to 70 years old who had lived in historical dwellings in Dezful with multiple altitude layers) revealed that the living spaces (as covered spaces) and the porch (as a semi-open space) on the first and second floors are used for gatherings, a pantry for cooking, a basement for storing food, a *Shavadoon* for gatherings and sleeping during the hot season. The roof eave and roof are also used for sleeping at night when the weather is favorable. In this climate, the yard is used as a dividing space.

The Position and Role of Different Altitude Layers in the Local Dwellings of Dezful

Dezful is a unique city in terms of climatic architecture and the innovative design of buildings and urban spaces to combat heat. Six different altitude layers define the architecture of dwellings in the city and their spatial order (Figure 4)

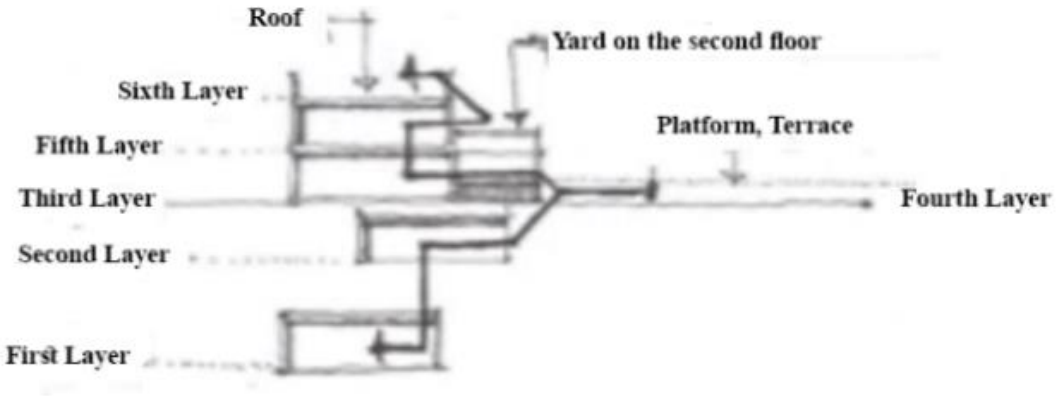

Fig 4. Living Layers and the Displacement of Altitude Levels in a Dezful Dwelling (Source: Authors)

First layer: *Shavadoon*. This basement is located 10-12m under the ground.
Second layer: *Shabistan*. It is as deep as half a floor and is accessible from the courtyard.
Third layer: The courtyard
Fourth layer: Platform (*Mahtabi*) or **terrace**, 1-2m above the courtyard level and as high as the rooms' level and **First-floor**
Rooms .
Fifth layer: Veranda, second-floor rooms and yard on the second floor **(*Pishboom*),** first-floor roof, which people use as a second-floor yard. It is a yard for the rooms located on the second floor of the house and sometimes it is extended to the alley due to the presence of a covered passage (*Sabat*).
Sixth layer: The roof.
Figure 5 shows all the introduced layers:

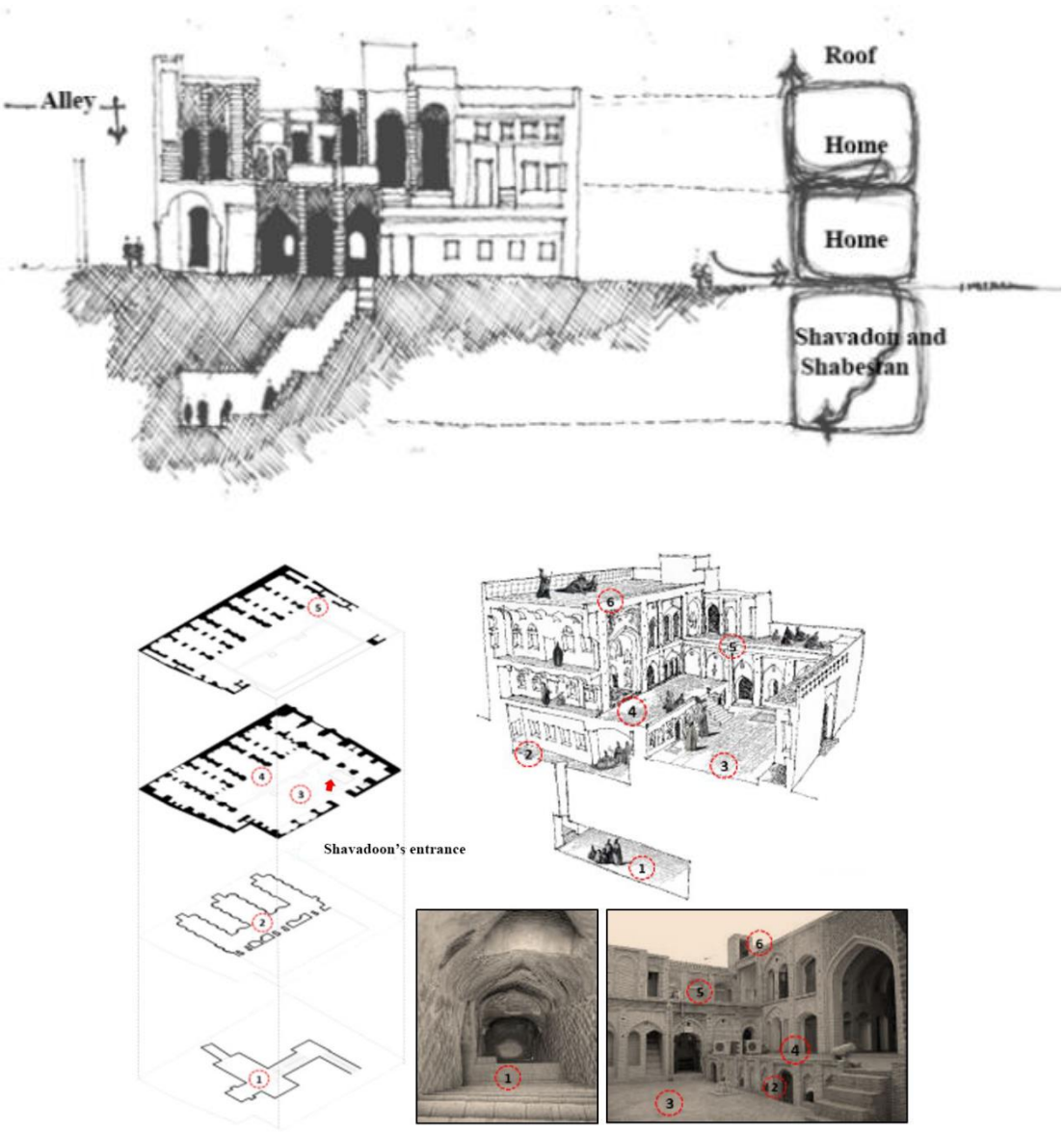

Fig 5. The Introduction of the Layers of the Tizno House, Dezful (Source: Cultural Heritage Organization of Dezful, adapted by the author)

It is important to note that the six layers listed above are four-layered or five-layered in some dwellings. The destruction caused by War[1] and subsequent renovation ruined many fully patterned dwellings (houses with six layers). Tizno House contains the complete pattern of the altitude layers of the Dezfuli dwelling, and we have studied it as a basis for further research.

The First Layer: *Shavadoon*

The ground is a natural thermal capacitor under buildings, courtyards, alleyways, and throughout the city. During summer, the soil is cool enough to act as a heat absorber throughout the hot days (Lechner, 2014), and the earth's temperature (as a thermal capacitor) in winter is higher than the air temperature. Thus, people can use this heat to control the indoor temperature and save energy. The deeper we penetrate the earth, the earth's temperature is less affected by changes in surface temperatures, so much so that at a depth of 8 meters below the surface, all year round and all over the world, the average temperature is almost 11 degrees Celsius (Emadian Razavi & Ayatollahi, 2014) (Figure 6). *Shavadoons* are architectural elements invented based on the land's characteristics. A *shavadoon* is an underground space dug beneath the local dwellings in Dezful as deep as 5-12 meters and is used to escape from the heat from May to October at noon (Hazbei et al., 2015) (Figure 7).

[1] The 8-year war between Iraq and Iran, 1981-1989.

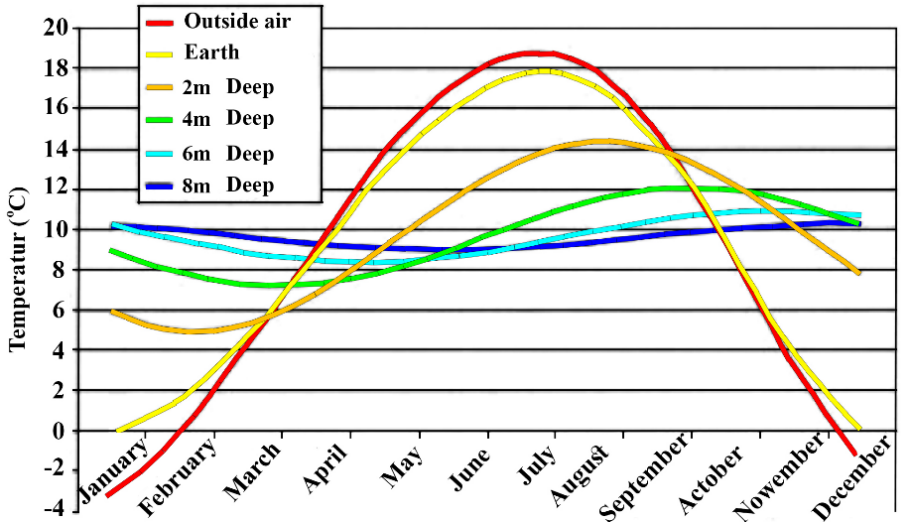

Fig 6. The Underground and Surface Temperature Differences Throughout Different Months of the Year (Source: Hazbei et al., 2015)

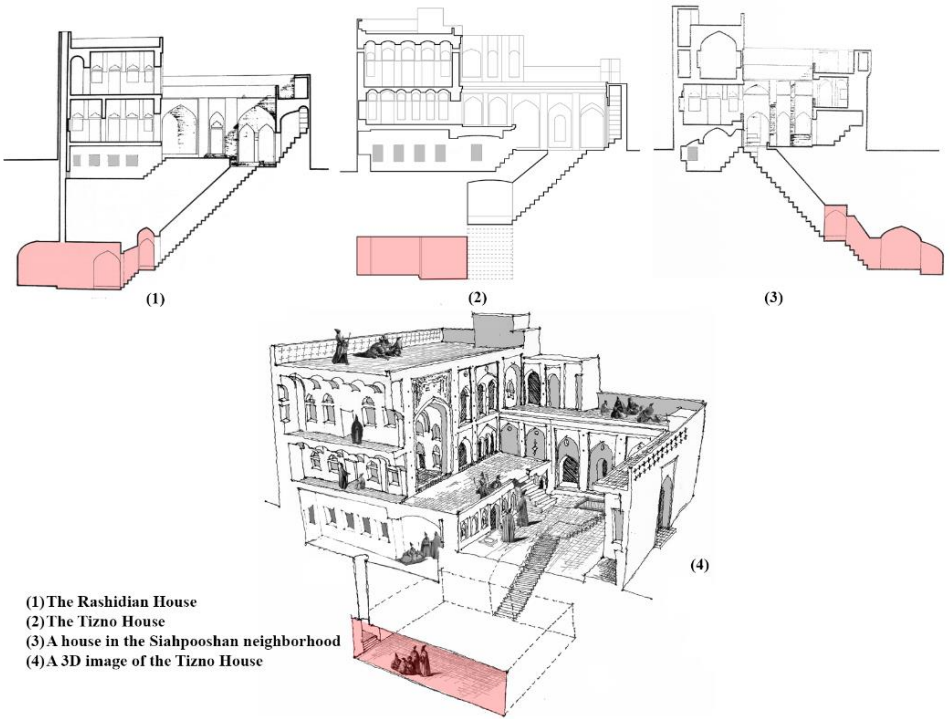

Fig 7. The First Layer (*Shavadoon*) (Source: Authors)

One of the remarkable features of *Shavadoons* is that many of them have underground connections to each other. As a result, a neighborhood connection forms underground. In some cases, the boundary of the *Shavadoons* does not just extend to its dwelling itself but also extends under the public areas and adjacent dwellings. A large portion of the old town dwellings is connected by this complex underground architecture, which eventually leads to the river through the *Shavadoons* in neighboring buildings (Figure 8)

The Second Layer: Shabistan

There is a space called Shabistan in the local dwellings of Dezful. Shabistan is located 1.5 meters above the courtyard level, and it is similar to a basement in many climates. It is approached from the courtyard through a few steps. It also has windows that provide light and ventilation. In general, Shabistan serves as a kitchen and storage area. Often, there was a vertical canal (Darizeh[1]) in Shabistan (Figure 9).

[1] A one meter-diameter cylindrical vertical canal was used for lighting and ventilation.

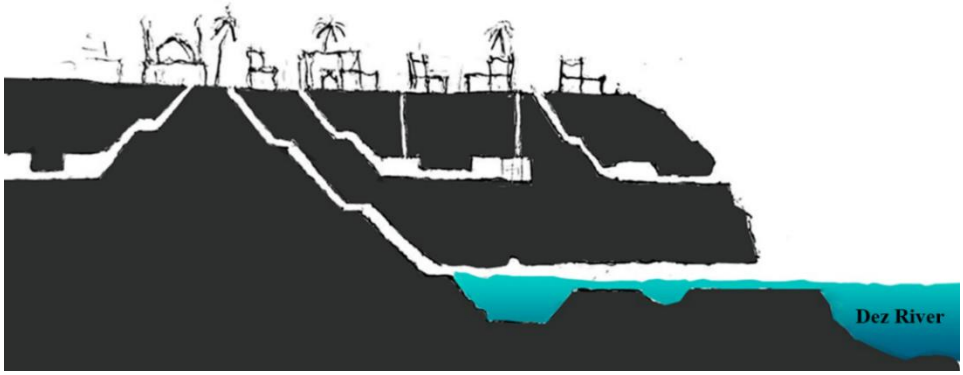

Fig 8. The *Shavadoons'* Interconnection (Source: Authors)

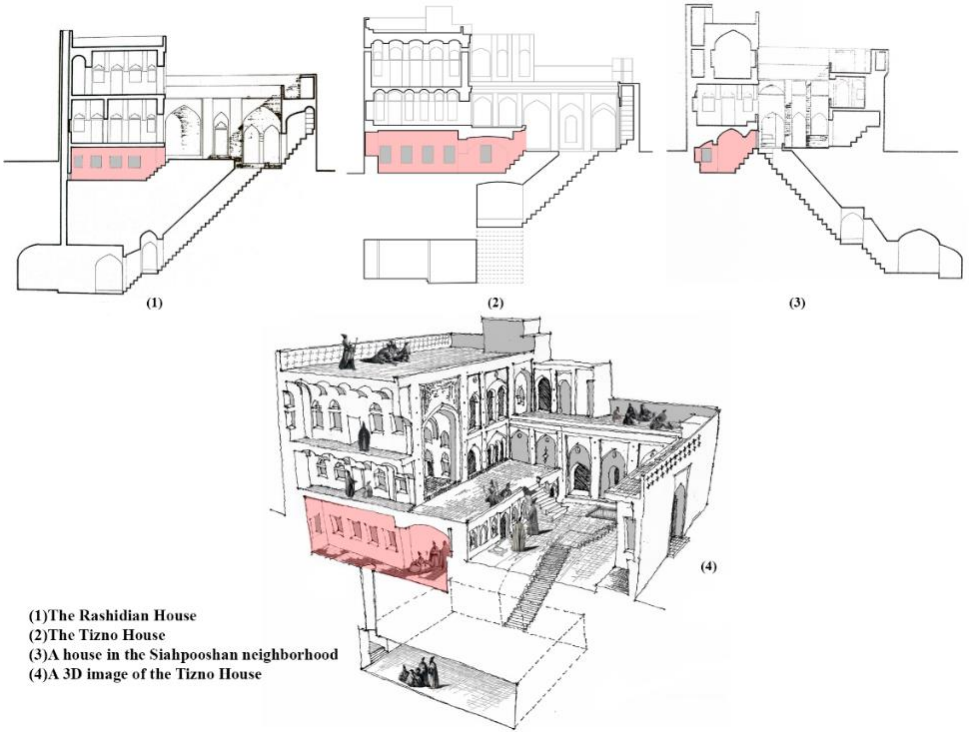

Fig 9. The Second Layer (Shabistan) (Source: Authors)

The Third Layer: the Courtyard

In hot and semi-humid, dry, and hot climates, courtyards with enclosed, semi-enclosed, and even open spaces have always been standard features. It serves as a space for the family's movement between other spaces and was also used by them as a garden and they do some of their daily activities in most seasons. To minimize the heat inside the building, courtyards have been designed to maximize natural ventilation. In summer, the courtyard acts as the vertical vent, with a 20°C difference between the ground floor and the roof. Thus, when a temperature of 48°C makes the roof-top unbearable, it can be comfortable to sleep in the underground spaces. Rooms opening north and east are preferred to those opening south and west as there is a 2 to 3 C temperature difference even between basements on opposite sides of a courtyard (Figure 10)

The climate of Baghdad and Dezful is similar in terms of heat and humidity (Warren & Fethi, 1985)

The Dezful climate does not permit evaporative cooling, so the courtyards have no large ponds. Additionally, courtyards in hot and dry climates have been extended upwards to increase shade (the height of a yard is much higher than its width or length). The length-to-width ratio of courtyards in the buildings in the city is 1:1.4, with a square plan in most cases. The prevailing wind in Dezful is a mild breeze, with short winding hours in the summer. The summer temperature in Dezful is very high, which is why the courtyards in Dezful dwellings are designed in a way to allow for less airflow and more heat and radiation protection (Figure 11).

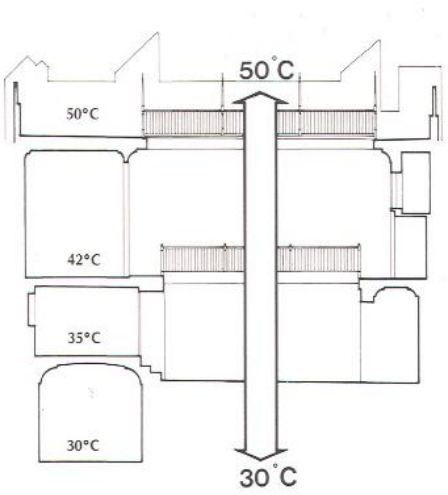

Fig 10. Temperature Differences from the Lowest to the Highest Floor in a House in Baghdad

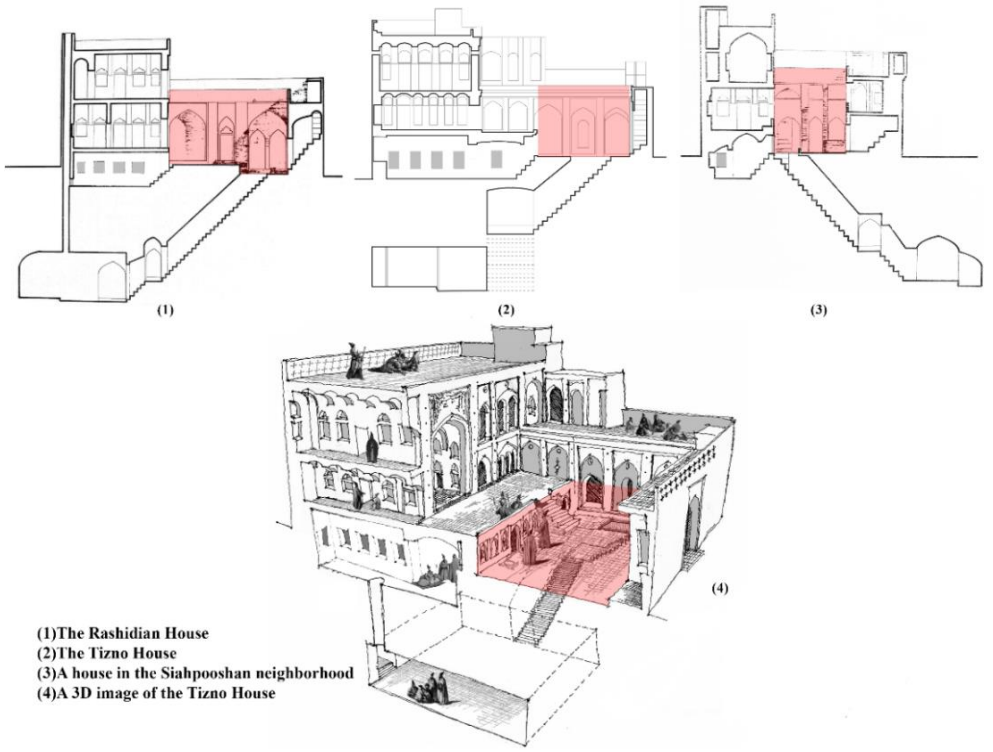

Fig 11. The Third Layer (Courtyard) (Source: Authors)

Fourth Layer: The Platform (*Mahtabi*) or Terrace and the First-floor rooms

Platform (*Mahtabi*) or terrace: The terrace is a roofless space higher than the courtyard level. People mostly use the terrace in the early nights and during the spring and autumn when it is not yet chilly. It is also used during summer when it is not too hot (Figure 12).

First-floor Rooms: A room in traditional Iranian houses is a multi-purpose closed space for various activities, such as eating, sleeping, getting together, and entertainment. To allow simultaneous use of these spaces during day and night, and summer and winter, depending on climate and other factors, most rooms are carpeted and almost devoid of heavy furniture (Foruzanmehr, 2016) (Figure 12).

The Fifth Layer: Veranda, the Yard on the Second Floor (*Pishboom*), and Second-Floor Rooms

A veranda is a semi-open space between the open (courtyard) and closed spaces (rooms). This space reduces heat, lets light in, and controls the temperature. A veranda is a summer space in Iranian dwellings, in which occupants sometimes sleep in the afternoon or at night.

The yard on the second floor often serves as a place to sleep at night during the summer (Figures 13 and 14).

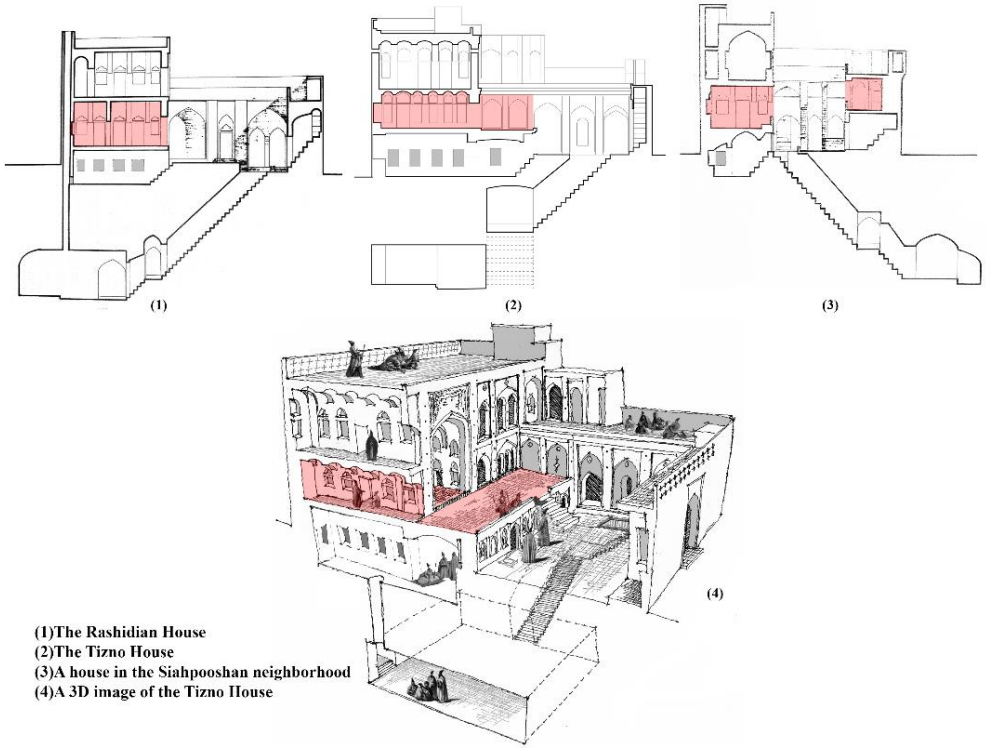

Fig 12. The Fourth Layer: Platform (*Mahtabi*) or Terrace and the First-floor rooms (Source: Authors)

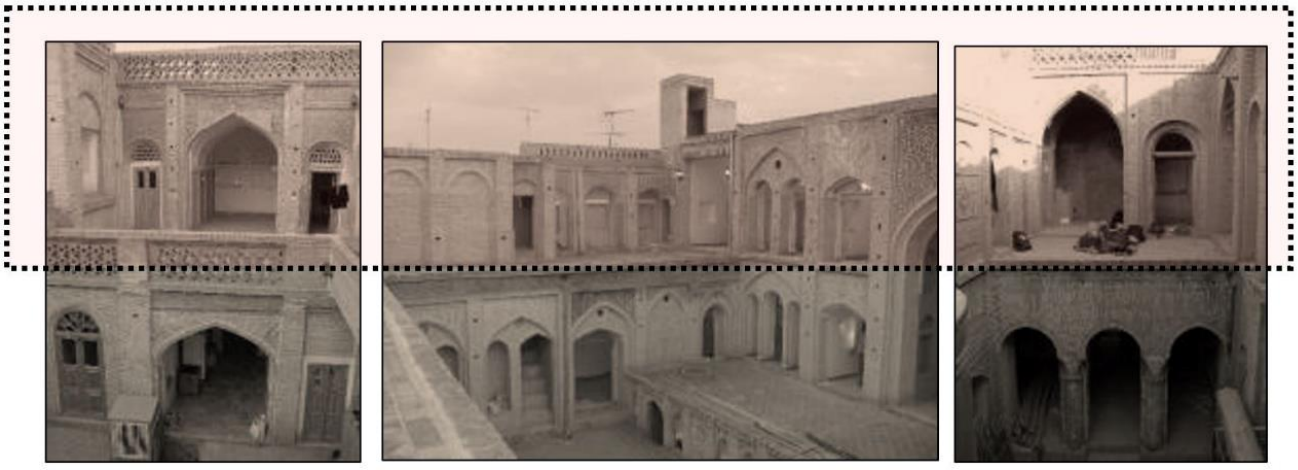

Fig 13. The Fifth Layer (Yard on the Second Floor and Second-floor rooms) (Sources: Authors)

Architects have designed two living spaces on the fourth layer (the platform and first-floor rooms) and the fifth layer (the yard on the second floor and the second-land rooms). On the fourth layer, besides the platform, which is part of the open space, the veranda and room are on the same level as the semi-open and enclosed spaces. On the fifth layer, besides yards on the second floor that serve as open space, people use rooms as enclosed spaces, and sometimes a tiny veranda as a semi-open space.

Vernacular architecture in Dezful also includes yards on the second floor (*Pishboom*), which in some dwellings extend to the passage of neighbouring homes, creating a covered passage. In cities with hot and semi-humid climates, covered passages are an essential architectural element of passageways. The semi-enclosed structure of covered passages contributes to the climatic adjustment of the environment beneath them. Moreover, the difference between the sunlight and the shade creates wind and coolness throughout the passageway (Figure 15)

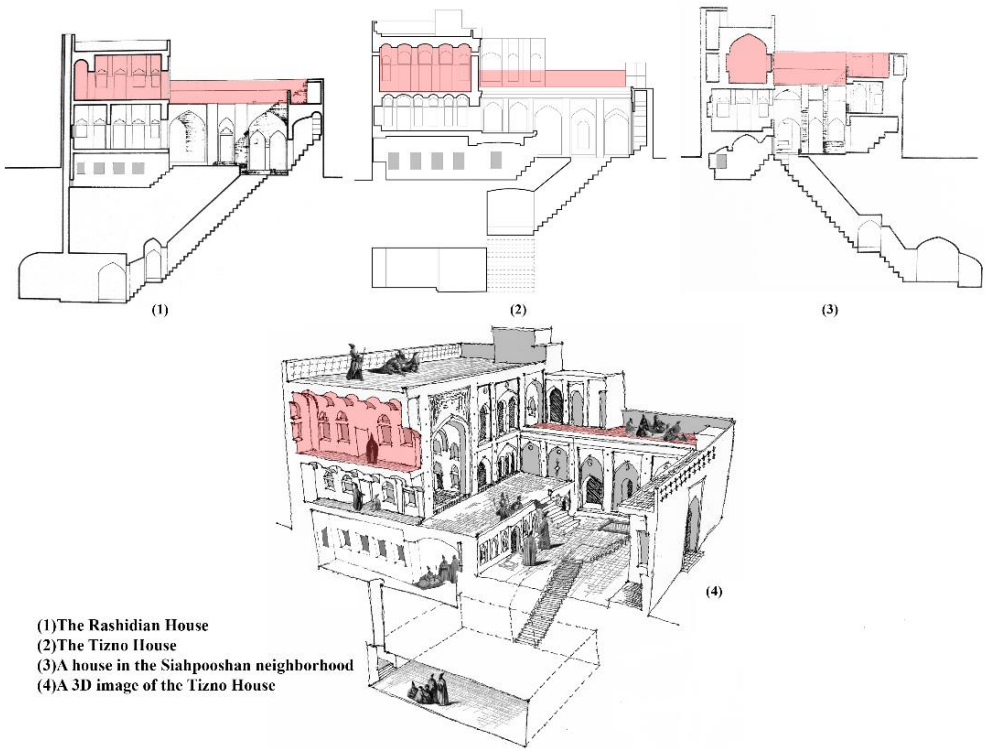

Fig 14. The Fifth Layer (Veranda, Yard on the Second Floor (*Pishboom*) and Second-floor rooms) (Source: Authors)

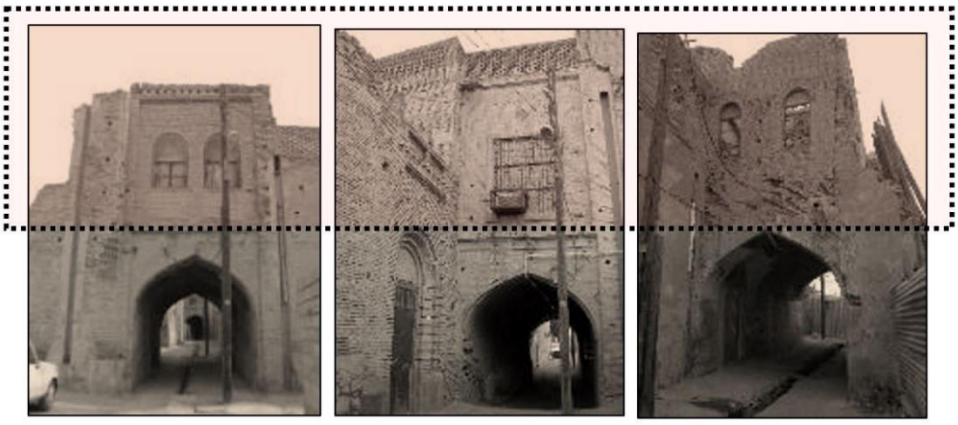

Fig 15. Images of a Covered Passage in the Local Dwellings of Dezful (*Sabat*) (Source: Authors)

The Sixth Layer: Roof

In the past, the roof was used as an open space in hot and semi-humid climates and had a flat shape to maximize usage for night-related activities and sleeping at night. In some months of the year, the roof served as a space for sleep. As a result of its importance during the hot seasons, a lattice brick wall is built to enclose the roof, transforming it into a private and veiled courtyard. Architects make the lattice brick wall around the roof with various patterns. These walls do not prevent the airflow on the roof (Figures 16 and 17).

Fig 16. The Reverse Application of Lattice in the Roofs of the Buildings (Source: Authors)

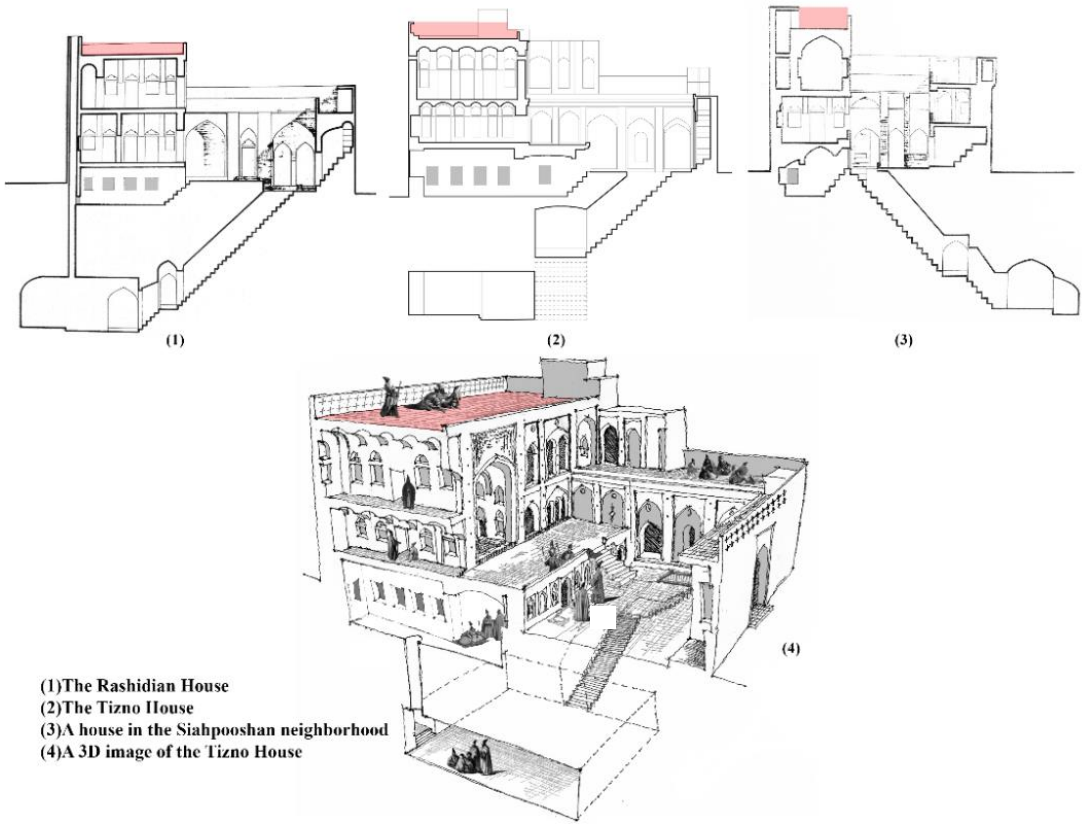

Fig 17. The Sixth Layer (Roof) (Source: Authors)

DISCUSSION AND CONCLUSION

The results showed that the residents do not use different parts of the dwelling simultaneously. When environmental conditions and seasons change, they pick the desired living space in a specific altitude layer of the dwelling. It is common for residents to move about constantly, and most of this movement is vertical. In the summer, for example, they spend the morning in rooms, the noon in *Shavadoon*, the afternoon on the veranda, and the night on the roof. Constant movement in the dwelling reveals the dynamism, and interconnectedness of the residential spaces. Hence, it is necessary to engage with people who have lived in Dezful dwellings to determine the usage patterns of each layer of the house.

Table 2 shows the duration of stay in the houses. There are two spaces in this table: the main space and the subspace. Generally, the residents' priority is to use the main space, but they use the subspace in extreme weather conditions, such as rain or wind, or sudden temperature changes. The grey color represents the main space and the orange color represents the subspace. By the end of every season, green marks the highest usage, and red marks the lowest.

Table 2. The Usage Duration of Each Layer, Based on the Season and the Year (Source: Authors)

Season	Month	Time	First layer (*Shavadoon*)	Second layer (*Shabistan*)	Third layer (courtyard)	Fourth layer		Fifth layer		Sixth layer (roof)
						Platform	Room & iwan (veranda)	Yard on the second floor	Room & iwan (veranda)	
Spring	March	Morning								
		Noon								
		Evening								
		Night								
	April	Morning								
		Noon								
		Evening								
		Night								
	May	Morning								
		Noon								
		Evening								
		Night								
Total use of the layer during the season/ percentage			2.08	2.08	4.16	8.33		6.25		2.08
Summer	June	Morning								
		Noon								
		Evening								
		Night								
	July	Morning								
		Noon								
		Evening								
		Night								
	August	Morning								
		Noon								
		Evening								
		Night								
Total use of the layer during the season/ percentage			6.25	4.16	0	4.16		4.16		6.25
Autumn	September	Morning								
		Noon								

		Evening						
		Night						
	October	Morning						
		Noon						
		Evening						
		Night						
	November	Morning						
		Noon						
		Evening						
		Night						
Total use of the layer during the season/ percentage			2.08	2.08	2.08	6.25	8.33	4.16
	December	Morning						
		Noon						
		Evening						
		Night						
Winter	January	Morning						
		Noon						
		Evening						
		Night						
	February	Morning						
		Noon						
		Evening						
		Night						
Total use of the layer during the season/ percentage			0	2.08	4.16	10.41	6.25	2.08
Use of space/ percentage			**10.41**	**10.41**	**10.41**	**29.15**	**25**	**14.58**

Guide: Gray color represents the main space and the orange colour represents the subspace. By the end of every season, green marks the highest usage, and red marks the lowest.

* First, the percentage of usage for each layer was calculated based on the number of occurrences during different times of the day, namely morning, noon, evening, and night, across three months of each season. Then, this percentage was divided by the number of seasons (i.e., 4) to determine the share of each layer for the entire year.

Table 2 shows the frequency of spaces occupied in different seasons. As can be seen, the fourth layer accounts for 29.15%, the fifth layer 25%, the sixth layer 14.58%, and the first, second, and third layers each 10.41% of the usage. It is noteworthy that layers are often used based on weather conditions and circumstances.

Accordingly, we can conclude that the city's residents make good use of the earth's thermal capacitor. During summer, they most frequently used the first layer with a depth of 10 meters. This layer is also used to store food during other seasons.

Local dwellings of hot and dry regions consist of summer residences in the south and winter residences in the north part of the house. The dwellings in Dezful generally have one primary part on the south side. A basement with a depth of fewer than 5 meters is typically used in hot and dry climates (Foruzanmehr, 2016). However, basements in local dwellings in Dezful have a depth of 8 to 12 meters. Table 3 depicts other differences between the two climates.

Table 3. The Architectural Differences and Similarities of Hot and Dry Climate Dwellings with Hot and Semi-humid Climate Dwellings (Source: Authors)

Hot & dry climate dwellings	Hot & semi-humid climate dwellings
Horizontal movement throughout the spaces surrounding the courtyard (Fathy, 1986)	Vertical movement between the different altitude layers on one side of the courtyard
Vaster area with less density (Fathy, 1986)	A smaller area with more density
5 meter deep basement (Fathy, 1986)	8 to 12-meter-deep basement
No Shabistan (Fathy, 1986)	Shabistan
Use of the pond and the wind catcher (Fathy, 1986)	No use of the pond and the wind catcher
Use of plants in the courtyard wind catcher (Fathy, 1986)	No use of plants in the courtyard
Four Altitude layers(Fathy, 1986)	Six Altitude layers

Architecture in Iran is typically characterized by elements of a hot and dry climate. However, by examining other microclimates, different and unique aspects of Iranian climatic architecture are identified. This study analyzed the vernacular architecture of Dezful with a hot and semi-humid climate. Thus, the six-layer structure, which played a crucial role in the Dezfuli dwelling in different altitude layers, was studied. The introduced layers (*Shavadoon*, *Shabistan*, courtyard, platform and room, Yard on the second floor and room, roof) are interconnected and a fundamental part of the Dezfuli dwellings. Field observation, theoretical studies, and interviews with the locals regarding the living layers of Dezfuli dwellings reveal the following results:

- ***New architectural solutions instead of standard solutions of the Iranian architecture***

Dezful's complex architectural arrangements compared to hot and dry climate architecture is one reason for introducing and analyzing its vernacular architecture. Evaporative cooling is used in hot and dry climates to provide thermal comfort, but the high humidity in Dezful makes this impractical during the summer months. As the temperature difference between the ground and the underground varies between 10 and 19 degrees, the residents of Dezful have used vertical movement between the different altitude layers ers to have climatic comfort. Thus, various levels form, from 12 meters underground to 8 meters high above the ground.

- ***The extent of using the different altitude layers throughout different seasons***

In the spring, the platform was mainly used as an open space in front of the rooms, as well as the first-floor rooms and veranda. Over the summer, they used the *Shavadoons* and roof. During the autumn, they used the Yard on the second-floor and the second-floor rooms and veranda. During the winter, they used the first-floor rooms and veranda, as well as the platform in front of the rooms.

- **A city with intertwined components**, and the houses' expansion in the lower and upper layers beyond the dwellings' area.

The layers are not limited to the floor area as the upper parts and the basement of the dwellings often exceed the surface ground. The construction of covered passages and the expansion of a house above the passage as the stories increase, and the link between *Shavadoons* underground has resulted in the entanglement of the city's dwellings. The particular morphology of Dezful is the product of these structural forms, architectural elements, and aesthetic proportions, which develop into a city with an intricate mechanism and intertwined parts.

- ***An underground city with its unique definition of an underground neighborhood***

Shavadoons are one of the unique characteristics of the architecture of Dezful. The study of the 23 dwellings' *Shavadoons* revealed that these spaces are interconnected underground and eventually reach the vertical wall of the river through horizontal canals.

- ***Movement in various vertical levels rather than energy consumption***

The diverse climate has resulted in the construction of different spaces for people to move through in pursuit of climatic comfort. Therefore, there is no need to consume energy and residents use passive energy. The difference between this style and today's architecture

is that we create a space and try to provide climatic comfort conditions by consuming energy.

This paper presents analyzed vernacular architecture and its arrangement in hot and semi-humid climates and thus it has some implications for architects and urban planners. The study demonstrated the importance of using a variety of spaces in different altitude layers. Identifying various passive energy consumption systems such as vertical migration in different altitude layers can be effective in two respects: Conducting some interventions to restore existing historic buildings as well as building new constructions compatible with the climate with minimal energy consumption. As passive vernacular systems are essential, we suggest that future studies explore data quantification and how much energy is saved in each layer. So suggest that future studies could build upon our findings by incorporating quantitative environmental data and simulations to provide a more comprehensive understanding of the role of altitude layers in climatic comfort.

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