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Analysis of the Architectural Style of Historical and Traditional Housing in the Sistan Region with a Climatic Approach and Proposing Criteria and Models for Contemporary Architecture

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Abstract

Considering the severe climatic conditions in the Sistan Region of Iran and due to 120-day winds and burning sun, it is imperative to adapt the traditional housing in this region to the climate. Unfortunately, the use of patterns disproportionate to the climate in recent decades has become a common problem considering the changes in people's lifestyles and livelihoods and technological changes. The question is "How can the historical and traditional architectural style in the Sistan region be used for developing contemporary housing?"

Using a case study and a descriptive-analytical approach, the adaptation of rural houses to environmental conditions was investigated in five prominent historical villages of Sistan. Subsequently, solutions were proposed to adapt to the climatic conditions of the region. In addition, models for rural housing were proposed. Based on the findings of the field study, it seems that using the old models of traditional Sistani architecture is an effective strategy for designing housing suitable for the special climate of this region in the present era. Moreover, the findings highlighted the necessity to pay attention to the orientation of the building for better use of wind and natural ventilation, create natural and artificial windbreaks, use water and green space, shade the walls, and use introverted architectural models and central yards.

Keywords: Climatic Architecture, Historical and Traditional Architecture, Contemporization, Sistan.

Article Type: Research Article

Introduction

Sistan is a wide area of land in the southeastern part of the Iranian plateau, a large part of which is presently located in Afghanistan (Dowlatyari, 2013). According to the latest provincial division in Iran, Sistan consists of five cities including Zabol, Hirmand, Hamoon, Nimrooz, and Zahak (Sistan and Baluchestan Province Administration, 2017). The special geographical conditions in the north of Sistan and Baluchestan Province, the 120-day winds, sweltering weather, low altitudes, dust in most parts of the year, and dry Hamoon Lake all make the climate in this region a unique and special one. The most important wind flow of the region is the 120-day wind (Lavar) from the northwest to the southeast, which moves quicksand and causes sandstorms (Molanaei & Soleimani, 2016: 60). The period of these winds ranges from June 15 to October 15 (Saligeh, 2003). McMahan called it "the land of the winds" after visiting Sistan in 1906 (Hamidianpour, Mofidi, & Saligeh, 2016). The average rainfall in Sistan is very low (about 65.9 mm per year) (Tavakoli & Hedayati, 2008).

Rural life and the rural dwellers' perspectives on the world and nature, their capabilities and knowledge for construction and production, and their methods of efficiency, contribute to shaping the environmental components most desirably while maintaining simplicity and establishing a logical and complementary relationship among them, with maximum effectiveness. In recent decades, due to the urgent need for new housing in both rural and urban areas, governments have shown an increased inclination toward rural housing production.

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However, most of these inclinations have had a somewhat limited scope, often focusing primarily on structural aspects of housing (Mahdian & Sartipipour, 2012: 45). All around the world, many studies have considered the virtues and values of employing past architecture in modern housing design practices. Iran is not an exception in this regard. Currently, the face and physical structure of villages in Iran are increasingly manipulated by the influences and influx of technology, and urban culture, along with the degradation of the cultural and native values of villagers (Zandieh & Hessari, 2012). To provide decent rural housing, it is inevitable to take into account the sustainable values of the traditional dwellings in the villages (Mahdian & Sartipipour, 2012: 4).

Rural housing is a social, cultural, economic, and physical phenomenon created to provide the right conditions for living. Margins of the central desert of Iran are regions characterized by violent nature and low average rainfall. Clay and mud are the basic architectural materials in Iranian deserts. The texture of densely populated villages and the use of clay, which is a material with good thermal resistance, provided isolation against the summer heat. In addition, introverted dwellings provided an open space while protecting residents from violent nature and 120-day winds (Mahdian & Sartipipour, 2012: 4).

The use of traditional patterns and advantages of past architecture can be a guideline for contemporary architects. The way the architecture of each region has adapted to environmental conditions over the years guarantees the continuity of people's relative comfort. There is a paucity of studies on the traditional architecture of some regions in Iran including Sistan. Accordingly, case studies selected in this research are superior in terms of age and architectural qualities to the other patterns. After collecting and sorting the different examples, the patterns and characteristics of the architecture of the selected buildings were analyzed. The principles of adaptation of these buildings to the climate of this region – which according to experts is one of the most difficult climatic conditions in Iran – were extracted as well. Based on data and findings from the field study, the principles, rules, and approaches that have been used in the past, guaranteeing the relative comfort and survival of the people of this region in difficult climatic conditions, were collected, analyzed, and updated from various aspects. In fact, through field study and visiting the rural regions, the rural housing patterns of Sistan were categorized. To categorize the dominant patterns and describe the observations and findings, a holistic approach was adopted. The final section discusses the principles and solutions for designing contemporary buildings and proposes rural housing patterns for Sistan.

Research Data and Methods

The research, based on the purpose, is an applied work and in its nature, it is a descriptive-analytic study. Research direction and Research Methods were selected proportionate to each stage. Firstly, based on library studies and analytical approaches, the specific geographic and climatic characteristics of the Sistan region and the architectural characteristics of the housing were studied. Then, through a case study and based on library studies and field studies, the number of traditional houses were determined in the Villages near Zabol and Zahak cities. After finding the prevailing patterns in the area, the architectural characteristics of the selected residential buildings were analyzed focusing on how they had been adapted to the climatic conditions. After deducing the rules, guidelines, and principles for adapting the traditional Sistani housing patterns to the environment, definitive criteria were proposed for designing contemporary housing patterns as the basis for designing contemporary rural housing patterns in Sistan.

Research Objectives

1- Determining typology of and analyzing local historical and traditional housing patterns in the Sistan region, focusing on the role of climatic conditions.

2- Extracting and inferring solutions and criteria for contemporary architecture.

3- Presenting proposed models for contemporary housing.

Reliability and Validity of Research

Cultural heritage records were used to select case examples. Architecturally and historically valuable houses in the Sistan region were selected in the studied villages and the maps of the houses were prepared. Then field data analysis was done using scientific methods. To ensure the persuasiveness and believability of the findings, the Delphi method and the opinions of cultural heritage experts and prominent architecture professors of the province were used.

Scope and Limitations of the Research

Considering the diverse climatic and geographical conditions of the vast province of Sistan and Baluchistan, and considering the unique climate of the Sistan region, which has a direct impact on the regional housing architecture, only historical and traditional housing with an age of more than 100 years in Sistan region in the north of the province were considered.

Literature Review

Sistan is an ancient land with a history of five thousand years of civilization. This region is located in southeastern Iran and north of Sistan and Baluchestan Province in a plain near Hamoon Lake. It is surrounded by Khorasan Province in the north, Zahedan and Baluchistan in the south, Afghanistan (a neighboring country) in the east, and Kerman Desert in the west. The plain depends on the famous Hirmand River, which originates from the mountains of Baba Yaghma in the south of the Jalil Hendokosh mountain range. The river enters Iran after traveling for hundreds of kilometers in the Jarbekeh area, and after watering Sistan, the rest of the water is flooded into Hamoon. Through the Shileh River, water reaches Goodzereh on the border between Pakistan and Afghanistan (Aria, 2014). The direction of the dominant wind is from the northwest of Sistan to the southeast, known as the 120-day winds. The weather vane of the annual heat of the Sistan is presented in the charts in Figures 1 & 2.

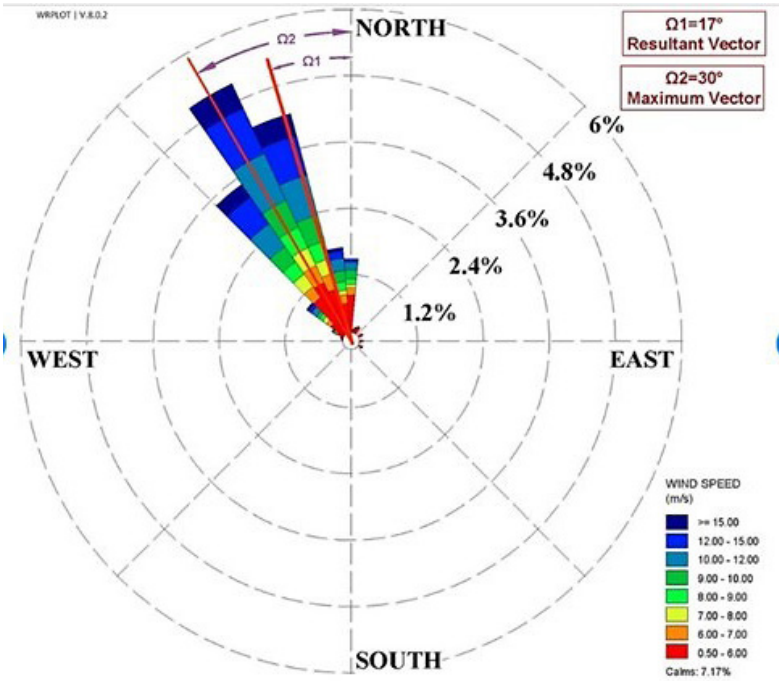


Figure. 1: *weather vane of the Sistan region (After: Mohammadi et al, 2022)*

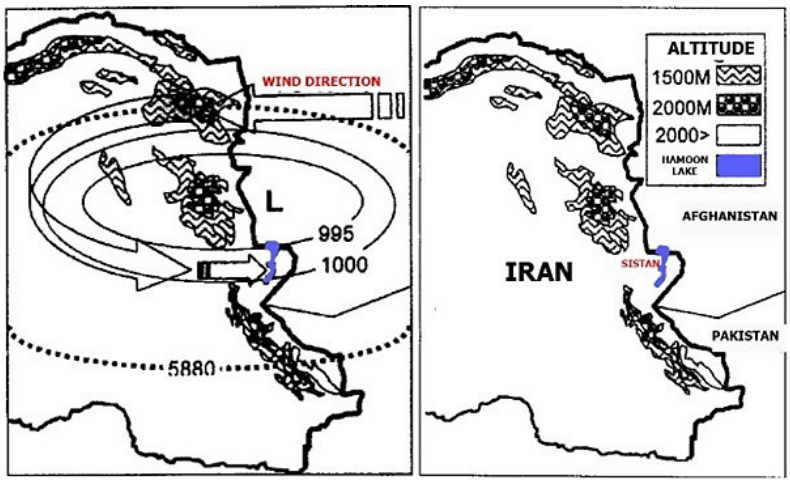


Figure. 2: *wind direction in Sistan (After: Saligeh, 2003: 113).*

Sistani people are highly skilled in adapting to their environment. Their residential buildings are admirably adapted to the climate of the region and the dominant winds. Buildings have ventilation holes, with a shaft or perpendicular duct passing through two walls and opening to the rooms. The ceilings are highly dome-shaped. The entrance doors are toward the southeast so that the building entrance is safe from wind blow (Afshar Sistani, 1983) (Figure. 3).



Figure. 3: *a view of the combination of dome roofs and one-way windproof in Sistan (Kamali Village)*

"The Sistani people are highly skilled in adapting to their environment," wrote Mr. Tit, an archaeologist and English historian who settled in Sistan from 1903 to 1905. "Their houses are appreciably built according to the climate of the area. High domes and various vents are advantages of Sistani architecture." Although more than a century has passed since Mr. Tit visited the region, the features of traditional Sistani architecture have survived in rural areas (Heydari *et al*, 2012: 45). House ventilators are the fixed features of every village. A typical ventilator or ventiduct in Sistan includes an input span in the form of an aperture with a width much smaller than its length at the beginning of the shaft or its ventricular duct. This tall, narrow entrance is not completely perpendicular to the direction of wind and is slightly tilted to the north or northeast. This deviation breaks the wind force; otherwise, the wind may enter the shaft or the vertical ventiduct through the entrance and go down and disturb the residents during storms.

The Sistani people employ a slight deviation in the orientation of the entrance opening to always maintain a strong and downward airflow in the chimney without it becoming excessively intense. This simple measure is remarkably effective in achieving the desired outcome. A false window is usually constructed in the direction of prevailing winds, with its upper part arched and projecting outward. The interior space of the window is blocked by a network of heavy bricks, allowing light and air to pass through the openings in the network. Depending on the airflow requirements and conditions, some of the openings are blocked using a clay plug or a piece of brick, or they are opened if previously blocked, thus adjusting the airflow.

During the cold seasons, the openings can be blocked. Due to the hot weather for about six months, the traditional architecture of Sistan simultaneously utilizes the cooling effect of the wide while preventing dust particles from entering the inner spaces. To this end, various techniques have been utilized such as the windproof features (locally called *kolak*), hatches (*soorak*), and *kharkhaneh* and lattice valves (Molanaei & Soleimani, 2016: 62).

Hatch (*soorak*): holes embedded in a circle known as a hatch positioned on the northern dome roofs of the traditional Sistani houses. Hatches are usually in the shadows and function as a kind of ventilator embedded in the wall. The air inlet and outlet duct are embedded at a specific angle in the wall to break the wind force before letting it into the interior space so that less dust enters the building by decreasing the wind speed. This design is unique to the Sistan region. In this manner, as the wind speed decreases, cool and moist air enters the indoor space by passing through the dense thorny bushes in the outer area, which intermittently become moist. The purpose of the hatch is to remove the warm air accumulated under the ceiling and cool the air inside (Heydari *et al*, 2012: 45; Molanaei & Soleimani, 2016: 62) (Figure. 4).

Kharkhaneh: In Sistan, a room called "thorn room" cools the air and transforms hot and dry air into cool and moist air. It functions similarly to an evaporative cooler. Essentially, by moistening the thorns behind the wind-facing openings, humid and cool air enters the indoor space of the house (Molanaei *et al*, 2016: 63).

Kolak: One of the techniques for cooling down the air in Sistan and other hot areas is the use of windproof. During the hot seasons, this key element

directs the wind to the house and functions as a cooler. The middle of the dome ceiling features a hatch like a ventilator with a windproof hatch called kolak. In the roofs of many traditional houses in Sistan, a window-like opening called "koolak" (facing north) was typically installed and essentially served as a windcatcher. Due to the extreme wind in most of the warm years, it was not necessary to build long windproofs like other Iranian desert areas. The koolaks, in a simple way, direct the wind into the interior space and cool the air inside. The warm air of the room is also removed through the sooraks, which are the same as the holes above the door (Molanaei & Soleimani, 2016: 62) (Figure. 5).

Latticed Valves: Latticed valves on the northern front of the building direct the air directly into the interior and play a significant role in cooling the space during the hot seasons. Along with letting light and air in, the valves can be used to adjust the flow of air as needed by blocking or opening the apertures.

Field Studies

The distribution of visited villages in Sistan and Baluchistan Province is shown in Figure 6.

After field surveys and library studies, out of the 40 houses surveyed by the cultural heritage and tourism organization of the Sistan region, eight preeminent houses, with a long history were selected. Surveys and field observations of all selected houses are presented in the annex to the article.

In the images below, the maps, 3d model and field impressions of the analysis of two case samples are presented for Lotf Ali Khan village of Zabul City and Khamak Village of Zahak City (Figure. 7-10).

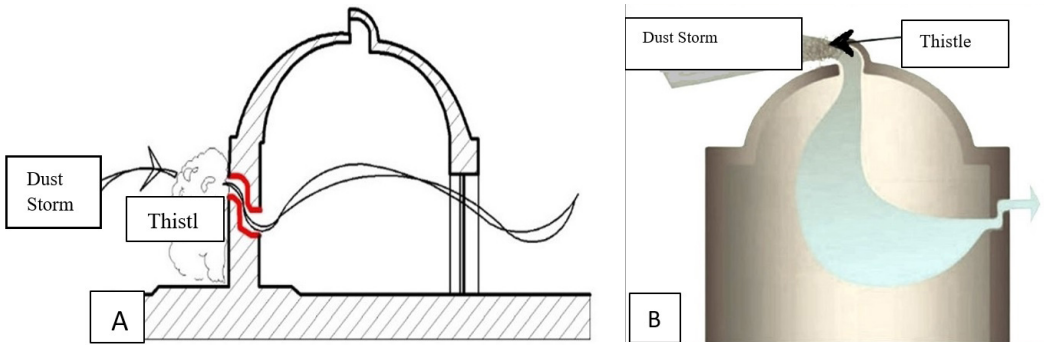
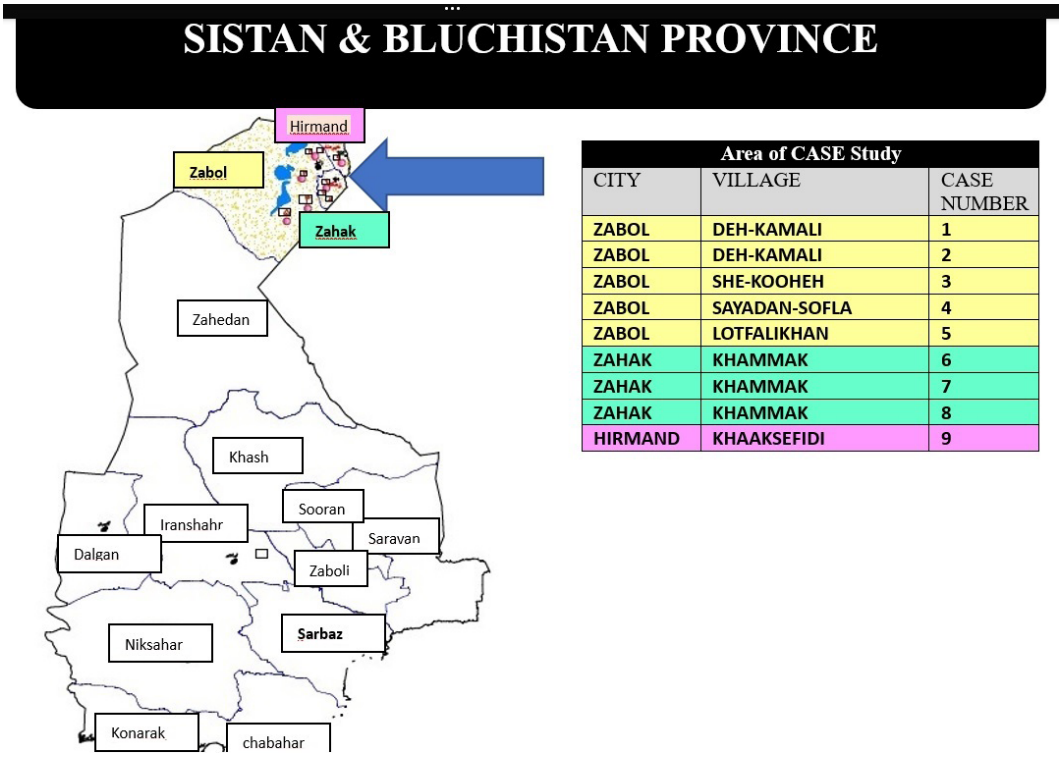


Figure. 4: *Window hatches in the wall for the wind entrance (A) (After: Ghasri et al, 2012). Kolak (windproof) in the Sistan region (B) (After: Molanaei & Soleimani, 2016).*



Figure. 5: *A : a small window (aperture) on the top of the door to let light and airflow in (Khamak Village), B : Doors with low height prevent the flow of storm into the inner space (Khamak Village).*



Area of CASE Study		
CITY	VILLAGE	CASE NUMBER
ZABOL	DEH-KAMALI	1
ZABOL	DEH-KAMALI	2
ZABOL	SHE-KOOHEH	3
ZABOL	SAYADAN-SOFLA	4
ZABOL	LOTFALIKHAN	5
ZAHAK	KHAMMAK	6
ZAHAK	KHAMMAK	7
ZAHAK	KHAMMAK	8
HIRMAND	KHAAKSEFIDI	9

Figure. 6: *Distribution of investigated villages in the region of Sistan*

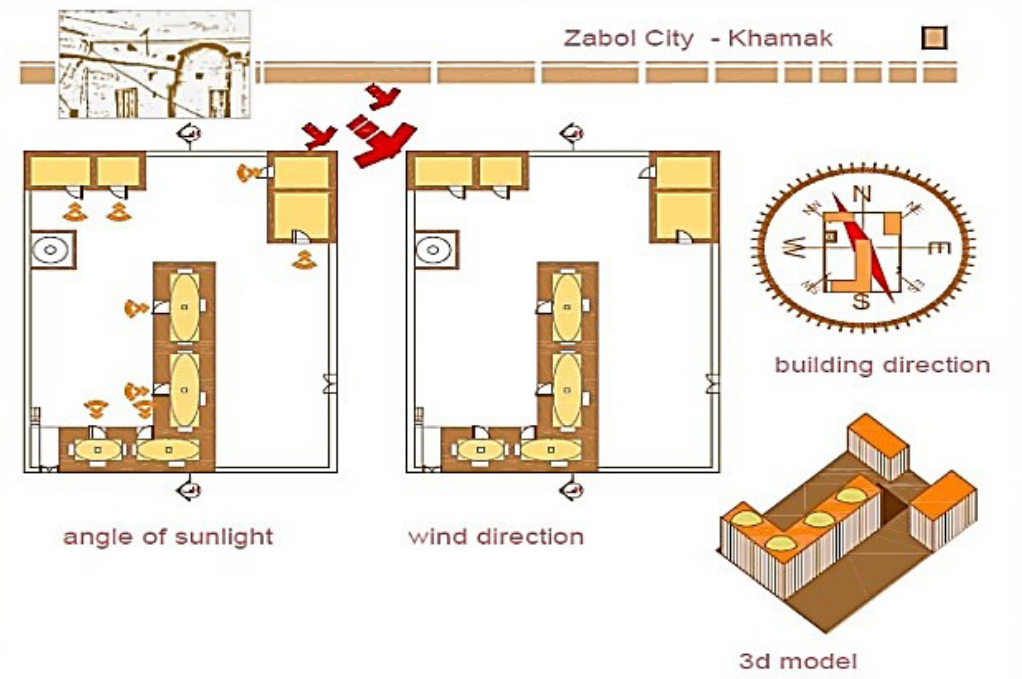


Figure. 7: *Climatic and architectural analysis of one of the historical types of housing in Lotf Ali Khan Village, Zabul City*

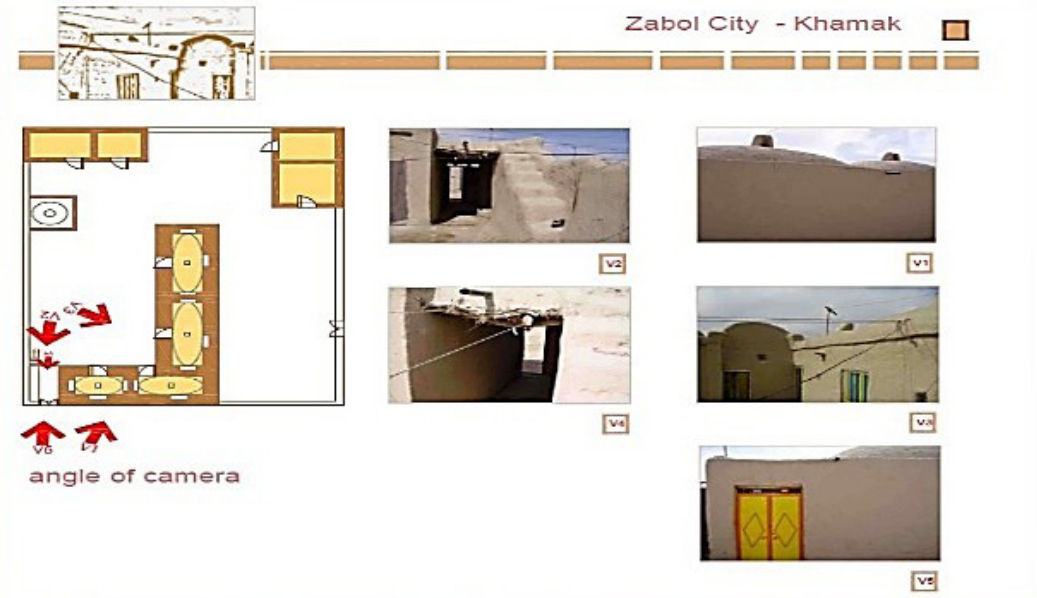


Figure. 8: *Picture of one of the historical types of housing in Lotf Ali Khan Village, Zabul City*

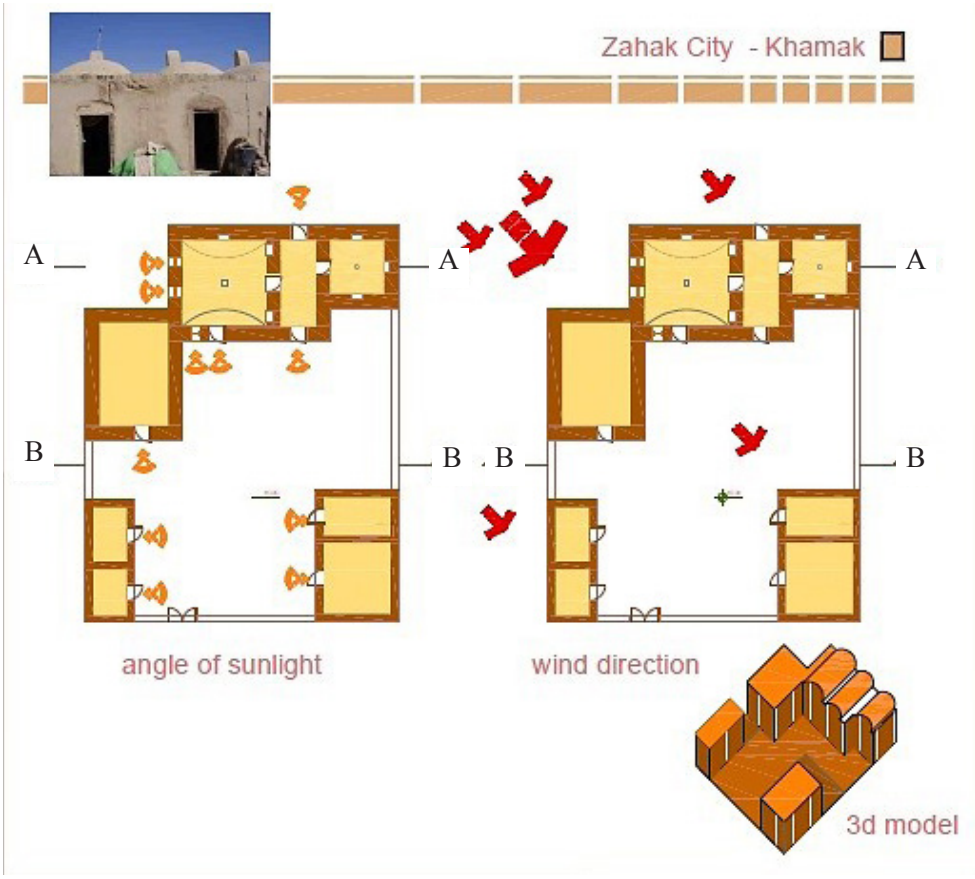


Figure. 9: *Climatic and architectural analysis of one of the historical types of housing in Khamak village, Zahak City*

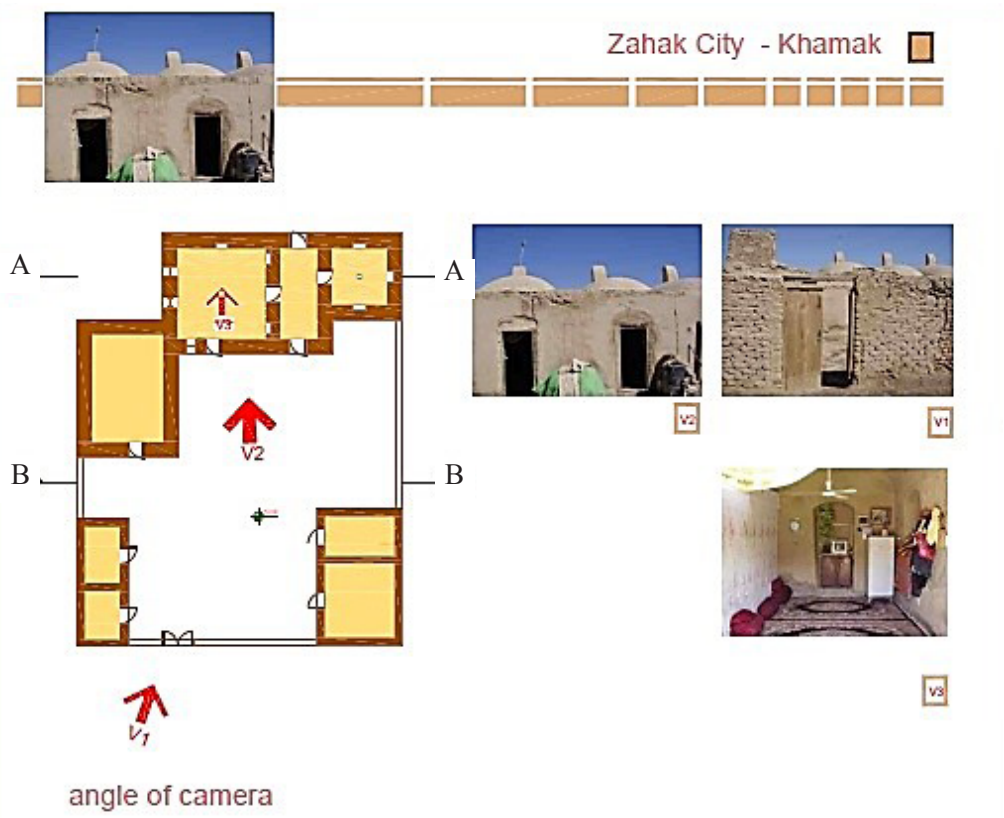


Figure. 10: *One of the historical housing types in Khamak Village, Zahak City*

The results obtained for all the examined species are presented in Figure 11. In this diagram, a comparative examination of the selected houses is presented in terms of using and dealing with climatic conditions (Figure. 11).

Results and Findings

In this section, some principles and rules are suggested for designing housing in semi-cold, very hot and dry climates. The data obtained from surveys and field studies and analyzing the traditional rural

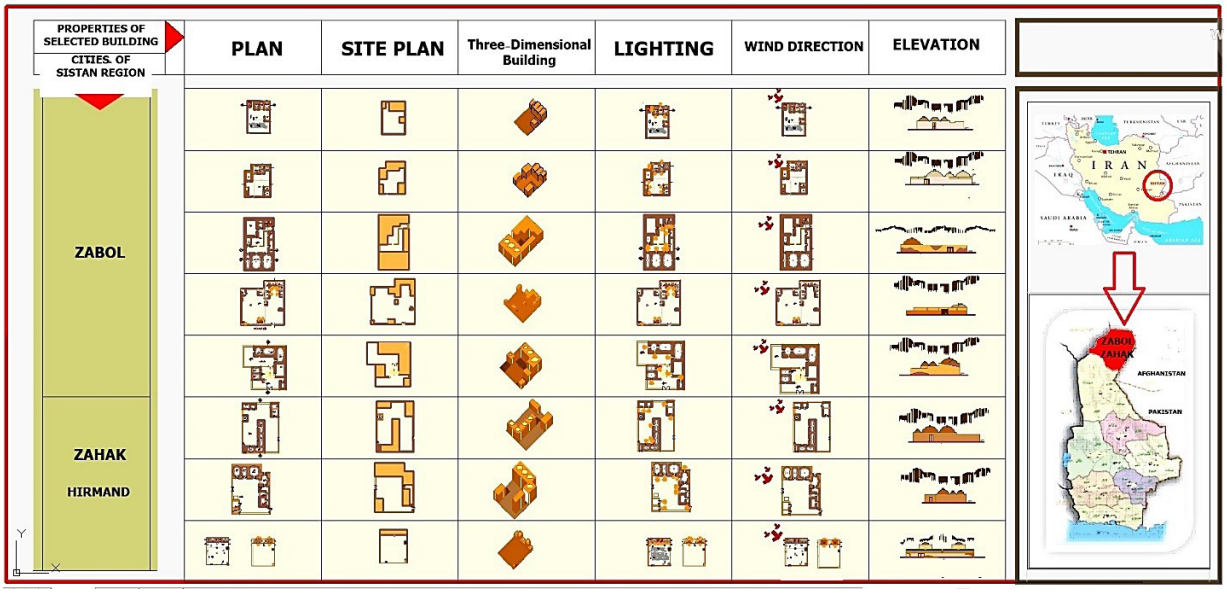


Figure. 11: *Comparison of different types of rural housing in the Sistan region (plan, brightness, openings, facade, wind direction)*

houses in the Sistan region are presented briefly in Figure 11. The techniques of adaptation to the climate can be used in designing contemporary housing patterns in this area:

Protection of the Building against External Heat

•Covering the exterior walls of the building with soil (traditional architecture).
Enclosing the areas used during hot periods with heavy and insulated materials, and using lightweight materials for areas used during appropriate times.
•Designing compact and dense buildings.
•Separating heat-producing areas, such as kitchens, from other spaces.
•Using thermal insulation with any type of material.
•Using small windows and minimizing their number.
•Using wooden shutters or movable thermal insulating screens.

Protection of the Building against Solar Radiation

•Avoiding east or west-facing slopes for building construction.
•Orienting the building to minimize solar energy absorption during hot periods.
•Choosing suitable materials for the surroundings to minimize heat gain.
•Using deciduous trees to create shade on the building.
•Expanding the building plan along the east-west axis.
•Maximizing the use of shared walls in building complexes and creating compact structures.
•Opening the main spaces to shaded internal courtyards with open spaces.
•Using light-colored and moderately textured exterior walls.
•Avoiding skylights.
•Avoiding windows on eastern and especially western facades.
•Using roof overhangs, covered porches, or balconies to create complete shade.
•Utilizing appropriate shading devices (ideally external shading devices).
•Using wooden shutters or movable thermal insulating screens behind windows.
•Predicting outdoor spaces for use when the weather is suitable.

Using Daily Fluctuations in Temperature

• Covering external walls with soil.
• Using heavy and dense building materials (with high thermal capacity).
• Using heavy materials and integrated thermal insulation on the surfaces.
• Predicting proper distance between external walls and bushes and foliage.

Utilizing Solar Energy for Building Heating

•Selecting south-facing slopes for building construction.
•Keeping the southern facade of the building open at least at a 30-degree angle.
•Expanding and elongating the building plan in the east-west axis.
•Allocating south-facing spaces for living areas.
•Anticipating building materials with high thermal capacity and dark-colored surfaces.
•Using walls with heavy construction materials on the southern facade.
•Creating porch and outdoor spaces protected against wind.
•Using suitable shades for windows.

Reducing the Effect of 120-day Winds and Dusty Winds on Buildings

• Considering the direction of the dusty winds in the orientation of structures.
•Enclosing the building with monolithic or relatively tall walls, or using designs with a central yard and opening internal spaces to the courtyard.
•Using vegetation cover to protect the building against winds.
• Using compact and dense tissue.
• Placing small windows in the wind direction.
•Considering lattice walls and wooden lattice valves for the protection of windows, openings and louvers.

Reducing Building Heat Loss

•Covering the outer margins of the building with evergreen bushes and plants.
•Using compact and dense floor plans.
•Maximizing the use of shared walls and creating a continuous structure.
•Designating less important spaces, such as storerooms, as thermal insulation.
•Avoid large windows, especially on northern facades.
• Using movable screens behind windows as thermal insulation.
•Incorporating thermal insulating sheets within openings.
•Utilizing various types of curtains, movable

insulating screens, and window flaps to prevent heat loss from openings.
•Making the most of direct sunlight in the eastern and southern facades of the building.

Reducing the Impact of Wind on Building Heat Loss

•Covering wind-facing facades with soil and ensuring internal courtyard design for light penetration.
•Using compact floor plans and creating complexes with dense structures.
•Designing appropriate building forms to minimize the impact of severe winter winds on exposed fronts and considering the use of single-story buildings.
•Implementing various windbreakers, such as trees, walls, and fences.
•Minimizing the number of openings and entry doors in the building.
•Fully protecting the main entrance using trees, fences, and landscaping.
•Using integrated and insulated doors on wind-facing facades.
•Considering the dominant direction of winter winds when determining the building orientation.
•Ensuring proper sealing of all doors, windows, and openings.

Regulations and Restrictions on the Opening of Buildings in Sistan Erea

●Due to the hot weather throughout the year, it is recommended that approximately 20% of the surface of the facade should be dedicated to the opening of the northwest side.
● Given the 120-day wind direction, if applicable, the north and west of the north side of the building be designed without openings, and if necessary, a maximum of 10% of the surface of the facade on these two fronts - with necessary measures - should be allocated to the opening. Mesh walls in front of openings, trees, and vertical canopy should be used to prevent sandstorms from entering the building.
● Openings are not recommended on the western side of buildings.
•Windows should be at least 30 cm below the roof to avoid energy dissipation.
● Embedding reflecting surfaces outside the window
● Using double-sided openings
● Using evergreen plants alongside external walls
● Using materials with high thermal capacity in walls and ceilings
● Porcelain brick or stone seat in the depth of the ground to reduce thermal leakage.

Exchange of the Building

After reviewing and analyzing existing residential buildings in Sistan, solutions and designing principles were recommended for the regional buildings given the climatic conditions. The proposed models provide examples for the construction of residential buildings, which encompasses all the environmental conditions and the above-mentioned criteria. Buildings should be structurally robust and economically feasible for the rural areas of Sistan; therefore, the ceiling dome cover was included as one of the attributes of Sistan's housing identity. Still, it was tried to maintain the identity and authenticity of the accommodation as much as possible. Livestock and poultry spaces as one of the main spaces of local traditional houses are not included considering the principles, health issues, and recommendations required by Jihad Keshavarzi Organization regarding human living spaces. The focus of this study was on climate adaptive architecture and the impact of wind and sunlight on buildings in the Sistan region. In the design of proposed patterns for contemporary housing in Sistan, less attention has been paid to other architectural aspects, including identity, aesthetics, functionality, and structural elements, considering the research objectives.

As shown in model No. 1 and in Figure 12, the most important points to be considered in this project are:
1) The pattern of the central courtyard, which is an old pattern in the desert areas of Iran, including Sistan, is used in the design.
2) The rooms are accessed and lit from the central courtyard to prevent the effects of severe sunlight and mitigate the effects of sandstorms.
3) On the northern front, exposed to 120-day winds, the strength of the wind is reduced to a great extent and the air is freshened with the installation of a water pond and lattice walls in front of the openings;
4) Broken intermediate access between the central yard and the northern yard somewhat reduces the intensity of the wind, causing the deposit of dust and preventing the storm from entering the interior spaces.
5) Gardens and trees in the yard will freshen the air and shading reduce the speed of the storm; and

6) Simple clay paintings and other decorations inspired by the architecture of Sistan add to the physical identity of the building and the harmony of the design with the rural texture (Figure. 12).

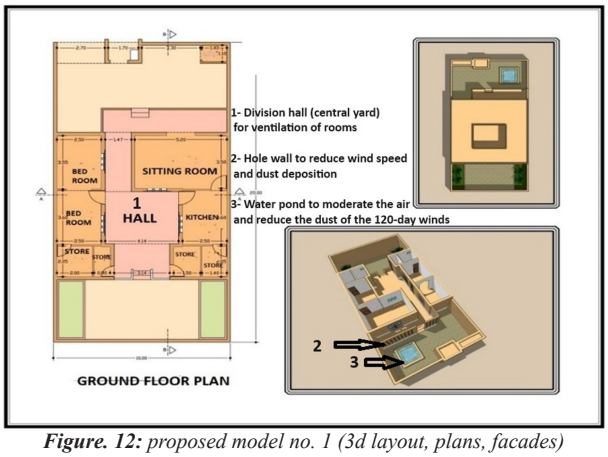


Figure. 12: *proposed model no. 1 (3d layout, plans, facades)*

As can be observed in Pattern No. 2 and the accompanying images, the use of a U-shaped pattern and the access and daylighting of rooms from the central open space are implemented to mitigate the impact of intense sunlight. The northern facade is closed off to reduce the intensity of sandstorms that predominantly occur from that direction. The ground floor spaces are designated for storing agricultural products, while the upper floor rooms are designed for the residents' living quarters. The U-shaped plan is oriented towards the east, which is favorable for wind direction. The most important design points to be addressed in this model with an emphasis on the role of the climate are:

1) The u-shaped pattern to dispose of inappropriate winds and attention to the direction of proper winds.
2) No window on the northwest side to reduce the impact of storms.
3) Using lattice walls for disposing of sandstorms;
4) Using water for freshening the air.
5) Using trees as a windshield, air freshener, and shade, and,
6) Using a gray façade and simple decorations inspired by Sistan architecture (Figure. 13).

Discussion

Historical and traditional residential architecture in the Sistan region has always been coordinated and adapted well to the environmental conditions, notwithstanding the harsh climatic conditions and the 120-day winds that cause sandstorms throughout the year. As the findings showed and to create

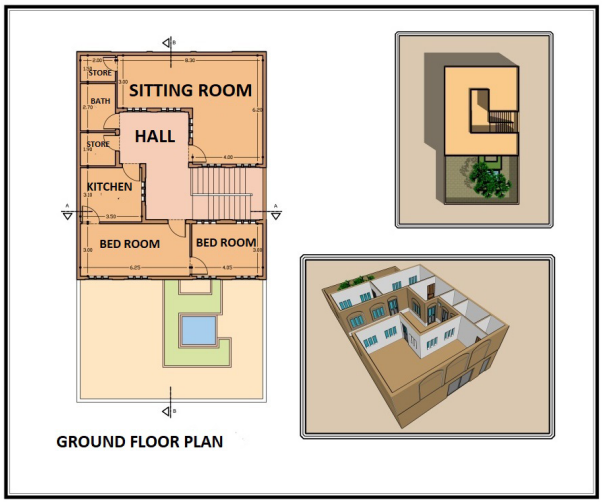


Figure. 13: *Proposed model no. 2 (3d design, plans, facades)*

climatic, economic, social and cultural stability in the contemporary architecture of this area, creating solutions such as paying attention to the proper orientation of buildings to benefit more from wind energy and natural air convection and better use of sunlight; using nature and green spaces to soften the air and prevent dust from entering home spaces with natural methods and man-made obstacles; shading walls and awnings; and the use of new and inexpensive materials and technologies suitable for the climatic and cultural conditions of the people are recommended.

Based on the research findings, the implementation of strategies such as considering the proper orientation of buildings to maximize the utilization of wind energy and natural ventilation, and optimizing the use of sunlight, utilizing nature and green spaces to purify the air and prevent the entry of dust, are recommended. This can be achieved through natural and artificial means within the home spaces, as well as the use of shading walls and canopies. Additionally, incorporating new and affordable materials and technologies that are suitable for the local climate and cultural conditions can contribute to the stability of the region in terms of climate, economy, society, and culture in contemporary architecture.

Conclusions

Based on the research done, it seems that the ancient and traditional architecture of the Sistan region has been able to achieve good solutions despite the harsh climatic conditions and especially the 120-day winds of Sistan to achieve relative

human comfort conditions, and importantly this was materialized using locally available traditional and cheap materials, the appropriate orientation of buildings, and architectural elements such as windmill and kharkhana. But unfortunately, the contemporary architecture in this region has not been able to imitate its traditional counterpart. There are several reasons for this, among the most important of which are notable the spread of western patterns in the contemporary architecture of Iran, and the lack of attention to the climate and environmental and cultural conditions of the Sistan region. It seems that by using the principles and rules that were observed in the past architecture of Sistan and despite the advancement of technology and materials, it is still possible to create an up-to-date architecture that fits the climatic and environmental conditions of Sistan. One of the most efficient methods to use in contemporary architecture, inspired by the historical architecture of Sistan, is the use of introverted plans and a central courtyard to stop strong winds and adjust the temperature of the inner spaces using trees and water ponds in the yard.

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