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Original Research Article

Investigating the Art of Biophilic Design in the Visual Aspect of Dezful Architecture

Mohsen Ghanbarizadeh[1]; **Mohsen Bina**[2]

1. M.A. in Architecture, Faculty of Architecture and Urban Planning, Jundi-Shapur University of Technology, Dezful, Iran.
2. Corresponding Author, Assistant Professor of Architecture, Faculty of Architecture and Urban Planning, Jundi-Shapur University of Technology, Dezful, Iran.
E-mail: bina@jsu.ac.ir

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Abstract

Introduction: The applied art of biophilic architecture examines the psychological impacts of the human-nature connection and offers strategies for improving it through space design. This research aims to investigate the application of biophilic design in the traditional architecture of Dezful and to examine the hypothesis that biophilic architectural features exist in the architecture of Dezful and that these features contribute to the quality of this traditional fabric.

Research Method: The data collection method was through library research, and analyses were conducted on case studies using library studies and field research. In the research process, analytical-descriptive techniques were employed, and the patterns were compared with buildings and urban fabric.

Findings: Fourteen biophilic architectural models were investigated in three parts of Dezful's traditional architecture. Some models, according to the findings, are reflected in public places and passageways, while others are reflected in houses. The average model reflection in public places, passageways, and houses was 81%. The analysis showed that the first six models, namely nature in space, were present in all case studies, though the equality of some models was lower and that of others was higher. The average of 88% for nature in space indicated that nature's presence in traditional public and private architectural spaces was extremely important. An average of 87% was obtained in the second part, namely natural similarities. In the third part of the patterns, namely the nature of space, the results indicate that landscape and shelter are observed in both indoor and urban spaces, and patterns of mystery, risk, and danger are seen more in urban spaces and, in a few cases, in some houses.

Conclusion: Biophilic design proves the positive psychological effects of the presence of nature in the built environment. In Iranian traditional architecture, the connection between nature and architecture is emphasized by using environmental conditions and natural patterns, and the city of Dezful, as a symbol of Iranian traditional architecture, clearly shows it. The relationship between nature and architecture is one of the most important factors that has made Iran's traditional architecture valuable, a topic on which 14 biophilic architecture models are based.

Keywords

Biophilia, Biophilic Design, Nature and Architecture, Traditional Architecture, Dezful

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Introduction and Problem Definition

The applied art of biophilic architecture is an innovative approach that paves the way for a nature-based dialogue between architectural spaces and a set of human dependencies and instincts, where natural forms and patterns play the role of vocabulary and grammar. The features and qualities addressed in biophilic architecture, in addition to access to daylight, fresh air, and plants, include various characteristics such as fractals, symmetry, similarity, and complex hierarchies, which can indirectly evoke a sense of nature in humans. In biophilic design, efforts are made to strengthen the connection between architecture and nature by using natural patterns or environmental conditions in the built space. Research in this field shows that specific elements and conditions in nature significantly benefit human health. It has also been proven that biophilic elements lead to reduced stress, improved cognitive performance, emotions, and creativity. Nowadays, people envision the future of architecture and urban planning as being increasingly characterized by the dense concentration of buildings, the reduction and collapse of the surrounding natural environment, and the separation of people from natural systems and processes. This type of architecture exacerbates climate and weather changes and undermines the rights of future generations. The idea of biophilic design (nature-loving) originated from this disheartening perception of future environments. A city that responds to natural conditions and stimuli can undergo its evolutionary process. Conditions and stimuli such as sunlight, air, water, plants, animals, landscape, and ecosystem are essential for the maturation, functional advancements, and, ultimately, the survival of humans. Biophilic design is, in fact, an effort to bridge the gap that has emerged between contemporary architecture and the need for humans to connect with the natural world. It is an innovative approach emphasizing the importance of maintaining, enhancing, and restoring the beneficial experience of using nature in the built environment. Iranian architecture is a value that possesses a high level of quality, but in terms of quantity and unified amount remaining in the form of an urban fabric, only a few cases can be mentioned; such as Yazd, Dezful, Kashan, Isfahan, and Shiraz, each of which provides a suitable ground for researchers in their own specific contexts. What is more prominent in Dezful's architecture than in others, and seems to the researcher to be worthy of study and research, is its connection with nature. Nature, due to the presence of the ever-flowing Dez River, the always-green trees, and the unique geography of the region, has become intertwined with the lives of the people and manifested in the architecture. Moreover, given the importance of nature-loving and its proximity to the architecture and urban fabric of Dezful, this research aims to re-recognize Dezful's architecture from the biophilia perspective. In this research, the issue considered is whether the qualities and characteristics of biophilic architecture, as presented by theorists in this field, exist and are observed in Dezful's traditional architecture. This issue has been proven through a qualitative analysis method by being present in the old fabric of Dezful. The present research seeks to answer the questions of whether there is a basis for biophilic design principles in Dezful's traditional architecture and, if so, what these bases are. What is the relationship between the good feeling and satisfaction from being in traditional architecture and the biophilic nature of the architecture?

Research Method

The method of data collection for the subject visualization was carried out using library methods and analyses conducted on case studies. The data was gathered through library studies and field research, and analytical-descriptive techniques were employed in the research process. The patterns were compared and matched with buildings and urban fabric. Initially, the theoretical foundations of the subject, including the biophilia hypothesis, biophilic architecture, and traditional Dezful architecture, were addressed. Considering that the patterns and characteristics were presented by experts in various classifications, and due to the overlaps, they were presented in a table encompassing all qualities and characteristics, along with a designed sample of the features. Subsequently, through the exploration and investigation of Dezful architecture, the proposed hypothesis was proven, namely the existence of biophilic architectural features and qualities in the traditional fabric of Dezful. The selection of case studies was conducted as follows: some selected cases were valuable houses that no longer exist today, and some were in poor condition, which warranted their inclusion in this list. The remaining cases were selected as follows: Initially, the list of national heritage sites in Dezful architecture was reviewed. Cases that had undergone significant changes were removed from the list. The priority for selecting houses and cases was those for which good information was available, followed by those that were more accessible. Considering that the number of samples collected is large, a case study has been provided below to illustrate how the case studies are examined.

Research Background

Biophilia means love of nature. The term biophilia was first used by «Fromm» in (1964) to describe the psychological tendency to be attracted to all living and life-giving things. This word is lexically a noun that entered the «Webster» dictionary in 1979 and means the innate human ability to connect and form intimate bonds with other forms of life and creatures in nature. The term biophilia is also literally defined as a love for life and living beings or systems of life. «Wilson», a professor of biology at Harvard University, used this term in his book entitled «Biophilia», published in (1984), and elaborated on the biophilia hypothesis. Biophilia is also understood in Persian as love for nature, which is rooted in the genetic makeup of humans. Biophilic architecture, derived from the theory mentioned above, is a new branch in architectural design that scientifically examines the effects of nature on humans, introduces human biological responses, and provides design solutions. Many studies have been conducted on the topic of biophilia, and as mentioned, Wilson was the first to propose the biophilia hypothesis. «Kellert et al» compiled all the studies conducted in this field up to that time in his book «Biophilic Design». This book was published in (2008) in the form of 23 chapters. Subsequently, «Browning», the founder of the Terrapin Green company, who also presented his hypotheses in the book «Biophilic Design», expanded them in (2014) and introduced them in the form of 14 patterns, providing design diagrams for the patterns. «Kellert» also proposed 24 features categorized into three groups as the field progressed and provided design diagrams. This research continues to this day, and the field is still advancing. In this study, the structure considered for biophilic architecture includes the features introduced by «Browning» in the article «14 Patterns of Biophilic Design». The reason for this choice is that most of the articles and books that have been worked on in this field have been examined and analyzed from the perspective of psychology and urban design. «Browning» is one of the first architects to work in this area,

and years of research in this field, with the help of psychologists and ecologists, have led to these results. These patterns have been developed through extensive interdisciplinary research and empirical evidence by individuals such as «Heerwagen», «Rachel and Stephen Kaplan», «Kellert» and others, and have utilized over 500 publications that have worked in this field. After reviewing interdisciplinary studies in architecture, psychology, and ecology, the following 14 patterns were selected for examination in biophilic design.

The structure of Biophilic Design Principles by William Browning in 2014

The structure of biophilic principles examined in this study is categorized into three groups and a total of 14 patterns in Table 1:

Table 1. Biophilic Architectural Patterns. Source: Browning, 2014.

Nature in space	Natural similarities	The nature of space
Visual connection with nature: A view of natural elements and living systems**.**	**Biomorphic forms and patterns:** Symbolic references to reliefs, patterns, textures, etc., that exist in nature.	**Landscape:** An unlimited view for monitoring and contextualization.
Non-visual connection with nature: Auditory, tactile, olfactory, and gustatory stimuli that create positive and intentional references to nature, living systems, or natural processes**.**	**The relationship between materials and nature:** Materials and elements from nature that reflect local ecology and geology through a small process.	**Shelter:** A place to distance oneself from environmental conditions where individuals are protected from behind and above.
Irregular sensory stimuli: Random and fleeting connections with nature.	**Complexity and order:** Rich sensory information accompanied by a spatial hierarchy, similar to what happens in nature.	**Mystery:** Exploration to gain more information obtained through relatively limited views or other sensations that attract individuals to delve deeper into the environment.
Thermal variability: Minor changes in air temperature, humidity, airflow, and surface temperature that resemble natural environments.		**Risk and danger:** An identifiable threat accompanied by reliable protection.
Presence of water: Conditions that enhance the experience of a place through seeing, hearing, or touching water.		
Dynamic light: Changes in the intensity of light and shadow to create conditions that occur in nature.		
Connection with natural systems: Awareness of natural processes, especially seasonal and temporal changes.		

Research Findings

According to the conducted research, the suggestions for biophilic design with an environmental psychology approach include creating opportunities for social interactions by designing suitable places for people to meet and gather both inside and outside the

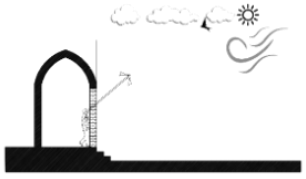
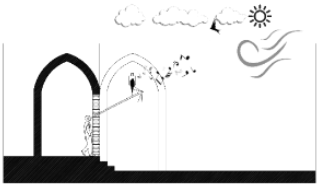
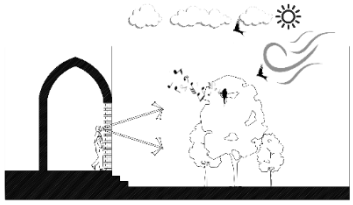
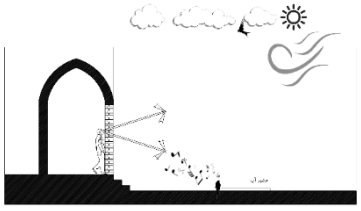
building, circulation systems and layouts to foster friendly interactions, and designing features that guide people towards the space and encourage them to communicate and converse. Creating territories in designs, providing opportunities for relaxation by creating calm spaces with sensory stimuli, connecting with nature, beautiful views, outdoor seating, and walkways with attractive scenery, creating sensory variability through access to daylight and changes in color, pattern, texture, and natural ventilation, preparing spaces for activities like cycling and walking to enhance connection with nature, and walking among entertaining and pleasant landscapes, instilling a sense of equality in the design to show concern for the health, well-being, and tranquility of all building residents, visitors, and other users. Additionally, attention to providing personal privacy through framing private and individual spaces, creating appropriate distances from others, enabling the adjustment of social interactions by passing through spaces or manipulating personal space, opportunities for learning and information exchange, and creating entertaining and beautiful scenic views through nature-inspired design, complex patterns, and organic forms.

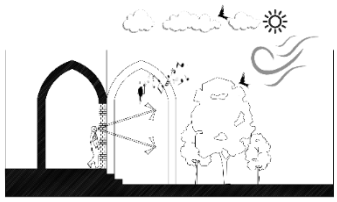
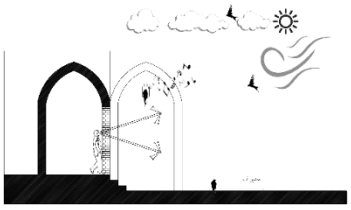
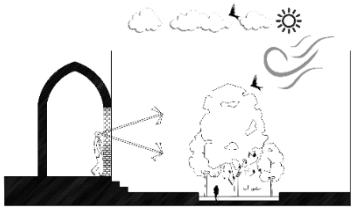
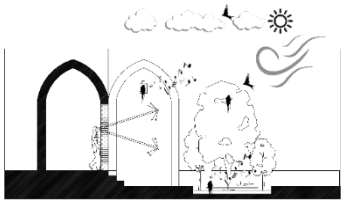
Nature in Space

In general, 7 patterns of nature in space are related to the physical presence of nature in indoor and urban environments and include visual connection with nature, non-visual connection with nature, irregular sensory stimuli, thermal variability, presence of water, dynamic light, and connection with natural systems. In traditional Dezful architecture, housing has been introverted, with the courtyard at the center of the space, and nature has often been defined within houses and other spaces such as tombs and schools. The spaces have been multifunctional, and their use has varied according to changes in temperature and light. Hierarchy in space has been defined, and the connection between spaces has been made through the courtyard or through corridors, which were also directly connected to the courtyard. The lighting is from within the courtyard, and the spaces are utilized based on the amount of light and air temperature. The orientation of the windcatchers is such that the wind is directed into them and through the wind towers into the spaces. In most courtyards with sufficient space, there is a pond or a small pool where most activities in the courtyard take place. Additionally, Sidra trees have been planted for shading in larger courtyards. Besides these factors, the urban study, topography, presence of the Dez River, and diverse plant and animal life are reasons for creating these patterns in the city. A general principle that applies to almost all traditional structures in Iran is their harmony with the residential environment and climatic factors (Zarei, Naghizadeh, & Hariri, 2012). To examine the first section, biophilic patterns, nature in space, the impact of the central courtyard pattern for the presence of nature in space in traditional architecture has been reviewed in Table 2. This table addresses the least impact of the central courtyard, which is used only for lighting, to its greatest impact, which includes the presence of water, trees, a pigeon loft (Joftkhaneh), and birds. The coverage of the patterns has been examined. In traditional architecture, most daily activities were conducted in the central courtyard. Therefore, the least impact of the central courtyard, in addition to lighting and natural ventilation, is the visual connection with the sky and awareness of weather conditions in all house spaces (Table 2, Section 1). The most positive impact of the central courtyard pattern is in Section 8 of Table 2, where, in addition to the points mentioned in Section 1, elements such as trees, a pigeon loft (Joftkhaneh), and water have been added. These elements attract birds and strengthen patterns 2 and 3, which are non-visual connections and irregular sensory stimuli,

contributing to the quality of biophilic architecture. Combining all the patterns in the first section creates a microclimate in the central courtyard, providing users with a better connection to natural systems.

Table 2. The impact of the central courtyard pattern on the presence of nature in space in traditional Dezful architecture. Source: Authors.

Nature	Pattern Coverage	Diagram
View of the sky Natural ventilation Weather conditions Lighting	Visual perception of nature Connection with natural systems Thermal variability Dynamic light	
View of the sky Natural ventilation Weather conditions Lighting Pigeon loft	Visual perception of nature Non-visual connection with nature Thermal variability Connection with natural systems Dynamic light	
View of the sky Natural ventilation Weather conditions Lighting Presence of birds Vegetation	Visual perception of nature Non-visual connection with nature Irregular sensory stimuli Connection with natural systems Thermal variability Dynamic light	
View of the sky Natural ventilation Weather conditions Lighting Presence of birds Presence of water	Visual perception of nature Non-visual connection with nature Irregular sensory stimuli Connection with natural systems Thermal variability Dynamic light	

Nature	Pattern Coverage	Diagram
View of the sky Natural ventilation Weather conditions Lighting Presence of birds Vegetation Pigeon loft	Visual perception of nature Non-visual connection with nature Irregular sensory stimuli Connection with natural systems Thermal variability Dynamic light	
View of the sky Natural ventilation Weather conditions Lighting Presence of birds Presence of water Pigeon loft	Visual perception of nature Non-visual connection with nature Irregular sensory stimuli Connection with natural systems Thermal variability Presence of water Dynamic light	
View of the sky Natural ventilation Weather conditions Lighting Presence of birds Presence of water Vegetation	Visual perception of nature Non-visual connection with nature Irregular sensory stimuli Connection with natural systems Thermal variability Presence of water Dynamic light	
View of the sky Natural ventilation Weather conditions Lighting Presence of birds Presence of water Pigeon loft	Visual perception of nature Non-visual connection with nature Irregular sensory stimuli Connection with natural systems Thermal variability Presence of water Dynamic light	

For further examination, the presence of each of the patterns in Dezful architecture has been explained as follows:

1. Visual Connection with Nature: In the first part of the discussion on lighting, view of the sky, attention to weather conditions, and natural ventilation are addressed, and as the

number of natural elements in the space increases (Section 8), a stronger visual connection with nature is formed. The strongest part of the visual connection with nature is Section 8, which, in addition to the items mentioned in the first section, includes elements such as pigeon lofts, vegetation, and the presence of water.

2. Non-Visual Connection with Nature: Non-visual connection includes auditory, olfactory, and tactile senses. In the yards of houses, trees and a water pond create a microclimate that attracts birds, whose sounds can be heard in the space. Additionally, through the wind and breeze and the presence of trees, one can feel the rustling of leaves, the falling of leaves, and even, in some cases, the sound of water used in the ponds, creating a pleasant sound of water for us.

Pigeon Loft: The creation of empty spaces for pigeon nests on a brick facade is called a pigeon loft. This work has both decorative and cultural-religious aspects. Creating a pigeon loft on the facade (empty spaces) is similar to facade construction and rhythm repetition.

Ghobile: Sometimes, small holes with the thickness of a brick are found on the main walls. These small holes are positioned at various heights for scaffolding, which sparrows use for nesting (Fig 1).

Fig 1. Pigeon Loft and Ghobile. Source: Naeema, 1997.

3. Irregular Sensory Stimuli: Studies on human responses to random movements of objects in nature and temporary encounters with natural sounds and scents have shown that they support physiological restoration. The aim of this pattern is to encourage the use of natural sensory stimuli that undoubtedly attract attention, thereby enhancing individuals' capacity to cope with mental fatigue and physiological stressors to focus on tasks. When we enter nature, we continuously experience examples of irregular stimuli such as the chatter of birds, the drying and falling of tree leaves and their sounds, and the smell of flowers and plants in the air.

4. Thermal Variability and Airflow: This pattern aims to provide an environment that allows users to experience sensory elements of air changes and thermal changes, enabling the user to control thermal conditions or grant individuals access to varying environmental conditions within a space.

Influential Spaces in Thermal Variability in Traditional Dezful Architecture

1. Transitional Spaces: Notable transitional spaces include hallways, doorsteps, doorways, gates, and areas both inside and outside the home, such as porches, central courtyards, rows of columns, and so on.

2. Porch (Iwan): The porch is one of the historical elements of Iranian architecture, considered a significant innovation in indigenous architecture. This element, designed with a regional approach, is recognized as a ventilation system and provides comfortable ventilation using renewable wind energy. The porch is positioned so that its connection to several rooms facilitates heat exchange from inside to outside and from outside to inside.

3. Windcatchers and Ventilators: To increase the influx of cool air into the building in accordance with the laws of nature, ventilation chimneys can be used in the building design. These chimneys are utilized in various ways, including placement between the basement and the living space to allow cool air from the ground to pass through and be transferred to the residents' living area. In the houses of Dezful, holes have been created to allow the warm air that accumulates in the upper part of the space to escape so that when cool air enters through the windcatcher or openings, the warm air is expelled from the space. The hot and

exhausting summer days in Dezful require cooler air than the surrounding environment. In addition to the methods above, features like sash windows and air transfer spaces between rooms inside buildings and structures like *Sabats* in passageways have played a fundamental role in thermal adaptability (Bina, 2007) (Fig 2).

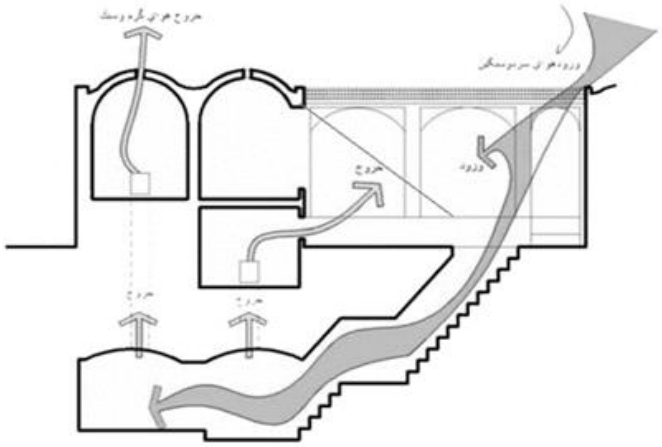


Fig 2. Thermal variability and natural air flow. Source: Bina, 2007, 43.

Presence of Water

The presence of water in Dezful's buildings served both functional and aesthetic purposes in large houses, while in small houses, it was purely functional. In large houses, there was a pond in the courtyard, but in Dezful's small houses, due to the dense fabric and small space of some houses, as well as the semi-humid weather in summer, the pond was omitted from the courtyard. Instead, a small space for water storage was considered in the corners and shaded areas of the building, which was used for daily consumption.

Dynamic Light

This pattern emphasizes the optimal use of daylight in spaces, which can differentiate areas through the interplay of light and shadow and accent lighting. This type of lighting is currently implemented in exhibition spaces and museums, drawing inspiration from traditional architecture. In traditional Iranian architecture, light was not used uniformly; rather, it was always moderated before entering the space. To achieve this, architects have sought to make the best use of daylight through innovative techniques and very simple elements. Although these elements differ in material, type, and application, they all serve the purpose of light admission. At the same time, it should be noted that some of these light-admitting elements also function in air circulation and ventilation in addition to light admission and brightness regulation. In traditional architecture, the main spaces, which have larger area and depth, are located at the center of the longitudinal axis of the courtyards to provide a better view of the courtyard and the sky. In all spaces, the room's depth is always chosen to be less than the depth of light penetration. Thus, a person sitting on the ground can see the sky even at the farthest point in the room, relative to the window. In large halls with deeper king's seats, the height of the window crown has been increased to allow more light to penetrate compared to the room's depth. Choosing a depth less than the light

penetration depth has given the designer flexibility in selecting the window frame and glass type. The main spaces, with larger area and height, are located on the main axes of the courtyard to benefit from the best landscape and lighting conditions. The winter sitting area with a deep porch was on the northern side of the central courtyard facing the sun, while the summer sitting area was built on the southern side of the courtyard, behind the sun. In smaller houses, where the winter and summer sitting areas were not separated, the upper floors were used to take advantage of light and warmth. In traditional Dezful architecture, while architects sought to utilize the best natural light, they also had to protect themselves from the scorching summer heat. This was achieved by creating height in the building and depth in the internal components. «Dezful houses, on average, have twenty-one distinct spaces, about twelve of which are prepared for sitting at different times of the day; however, in some houses, this number has been reduced to five spaces» (Mahdavinia & Javanroudi, 2013).

Connection with Natural Systems

This model aims to raise awareness of natural processes and seasonal and temporal changes that foster a better connection between humans and natural systems. The central courtyard is a small example of the connection between natural systems in homes. As mentioned in Model No. 1, the courtyard of traditional houses is a reflection of the Persian garden. The presence of trees, water, and birds are natural elements, and the creation of pigeon lofts, Ghobiles, and the unique architectural decorations of Dezful by architects are simulated elements of this model.

Natural Similarities

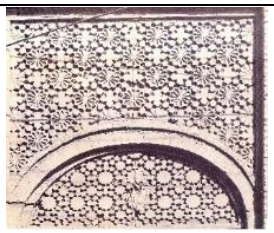
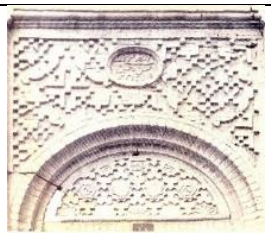
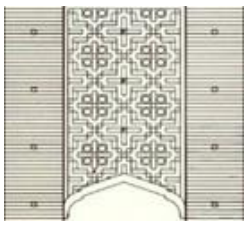
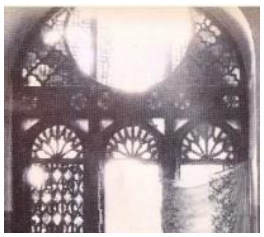
Natural similarities refer to organic, non-living, and indirect patterns from nature, which include biomorphic forms and patterns, the relationship of materials with nature, and complexity and order. This category addresses the use of objects, colors, shapes, and patterns found in nature in decorations such as building facades, artworks, furniture, and decor in the built environment. In traditional architecture, forms and patterns inspired by nature have been used in most buildings, interior and entrance decorations. Natural forms and patterns were used in decorations in the past and are now a source of inspiration for designing various structures. Regarding materials, all the materials used in the buildings in the Dezful texture are traditional and indigenous. For the pattern of complexity and order, fractals have been used in decorations, which will be discussed further.

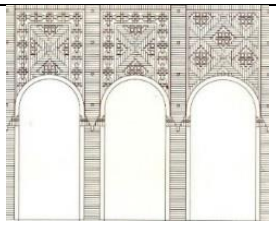
Biomorphic Forms and Patterns

1. Biomorphic: A design style in which an object is shaped to represent an organic and living creature. Essentially, there are two methods for applying biomorphic forms and patterns: A decorative component of a larger design or a pattern for structural or functional design. Both methods are used together. In the architecture of Dezful, in the interior decorations of buildings, entrances, doors, and windows, living patterns such as flowers, plants, and birds, as well as cosmic elements like stars, the sun, and mandalas, have been used. These elements have had significant practical importance in addition to their decorative aspect. Khavun-chini and brick-lining have been essential shading elements. The frieze was used to prevent rainwater from falling on the. Khavun-chinis. Garde-kari was

done for air exchange between the house's spaces, and decorations in doors and windows were used for light diffusion and beautification.

Table 3. Examples of Biomorphic Patterns in the Architectural Decorations of Dezful. Source: Authors.

Brick-lining	 House of Esteghamat .Source: Naeema, 1997.- Use of Plant Patterns	 House in Morshedbakan Source: Naeema, 1997- Bird Motif
Garde-kari	 Source: Naeema, 1997- Use of floral motifs in Gare-Kari	 Source: Naeema, 1997 - Use of floral motifs in Gare-Kari
Khavun-chini	 Source: Cultural Heritage Archive - The use of floral and plant patterns in Khavun-chini, which are also used in Persian carpets.	 Source: Cultural Heritage Archive - The use of floral and plant patterns in Khavun-chini, which are also used in Persian carpets.
Doors & windows	 Source: Naeema, 1997- Plant motifs have been used in the design of doors and windows.	 Source: Naeema, 1997- Plant motifs have been used in the design of doors and windows.

Columns		
	In the design of the capitals, muqarnas has been used, which is derived from the pattern of trees.	In the design of the capitals, muqarnas has been used, which is derived from the pattern of trees.

2. Connection of Materials with Nature: In traditional Dezful architecture, brick is the most commonly used material. The walls were constructed using a combination of brick and adobe, with plaster used in rare cases. The decorations on the walls were also made of brick. Wooden beams were used for the ceilings, which were covered with a layer of straw, reed, and brick. Doors and windows were always made of wood, and the interiors were finished with a mixture of straw and clay or plaster and soil. The floors of buildings and pathways mainly were paved with bricks; in some cases, river stones and compacted soil were used.

3. Complexity and Order: The goal of the complexity and order pattern is to create symmetries and fractal geometries shaped by a coherent spatial hierarchy, resulting in a visually detailed environment that elicits a positive psychological and cognitive response. Given that fractals possess complex and diverse characteristics, excessive use of them in architecture can lead to stress. Type one fractals are observed in some Khavun-chini decorations in Dezful architecture. Additionally, the fractal pattern has been proven in muqarnas. The tree composition is a fractal pattern found in nature. Trees inspire the muqarnas used in capitals. Although the muqarnas used in capitals have fewer details than other decorations, this is also seen in Dezful architecture. Figure 3 refers to the presence of the fractal pattern in brickwork (Khavun-chini) decorations. As indicated, diamond patterns are used in the compositions of these decorations. Each diamond includes motifs in its composition, and each diamond is a combination of a larger diamond with its specific composition. These elements are repeated as far as the decorations continue, exemplifying the fractal pattern. This phenomenon is observed in many architectural decorations in Dezful.

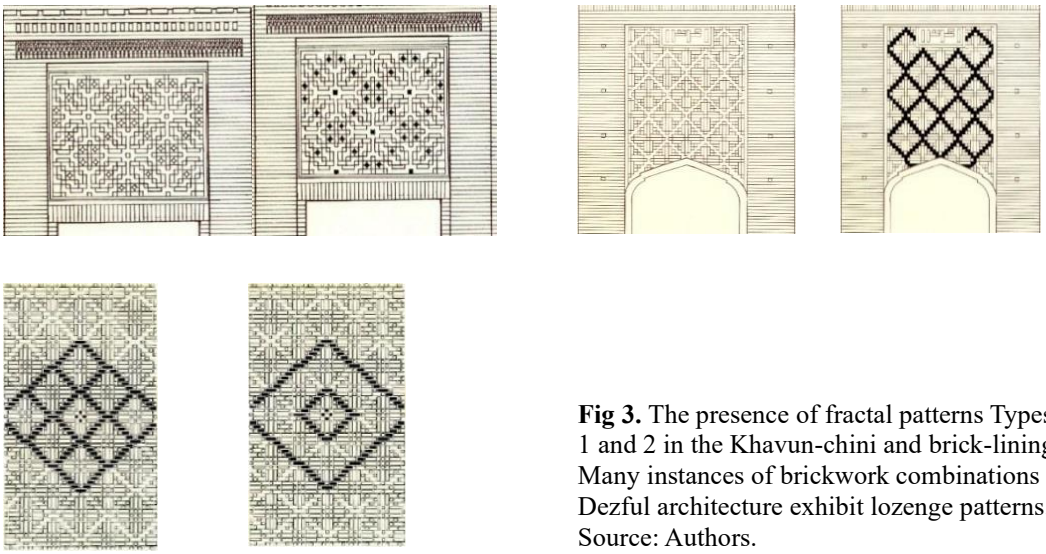


Fig 3. The presence of fractal patterns Types 1 and 2 in the Khavun-chini and brick-lining. Many instances of brickwork combinations in Dezful architecture exhibit lozenge patterns. Source: Authors.

The Nature of Space

The nature of space addresses the spatial position in nature, which includes landscape, shelter, mystery, and risk and danger. This category pertains to our innate desire to see potential beyond the essential environment. Humans are drawn to slightly dangerous or unknown environments, ambiguous views, and moments of revelation, and sometimes even phobia and fear in moments when they feel somewhat secure.

1. Landscape: The purpose of the Landscape pattern is to provide users with suitable conditions to observe the surrounding environment for opportunities and risks. In landscape design, perspective is defined as the view from a high position in a vast environment (Fig 4). There are internal landscapes (Fig 5), external landscapes (Fig 6), as well as shallow and deep landscapes that can occur simultaneously. The complexity and diversity of ways to achieve this pattern have introduced it as a strong model. For internal spaces or dense urban areas, perspective is the ability to see from one space to another, and it is enhanced when there is an opportunity to see through multiple spaces. This has frequently occurred due to the central courtyard pattern within buildings and the region's topography in passages.

Fig 4. The view in the passages and low hills (Bendar) towards the river. Source: Authors.

Fig 5. The view from the riverbank access point in Dezful architecture. Source: Authors.

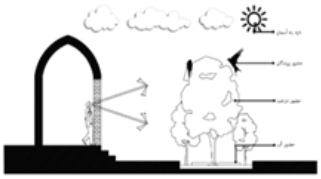


Fig 6. Landscape in the central courtyard
Source: Authors.

2. Shelter: The primary goal of the shelter pattern is to create an environment for users that is easily accessible and protective (a smaller proportion of a larger space). The secondary goal is to limit visual access to the shelter space. The ideal spatial conditions include protection from above and behind the person, preferably from three sides. The location or orientation of the space can also affect the quality of the pattern. Common functions of a shelter include protection from the weather, studying, reducing visibility, a place for conversation, rest and relaxation, and protection from physical dangers. Lower ceiling heights usually characterize indoor shelter spaces. Examples of this pattern include independent or vegetated gazebos and pavilions or half-level structures. Light in shelter spaces should differ from adjacent spaces, and user-controlled lighting enhances its function as a shelter space. The combination of landscape and shelter patterns creates attractive spaces for users. Examples of this pattern in traditional architecture include porches (Fig 7), covered walkways with low heights (Sabat) (Fig 8), covered pedestrian paths, and arcades.

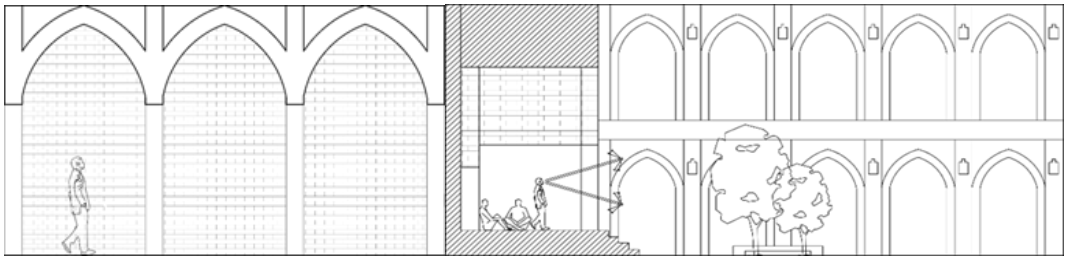


Fig 7. Example of a shelter in the central courtyard-porch. Source: Authors.

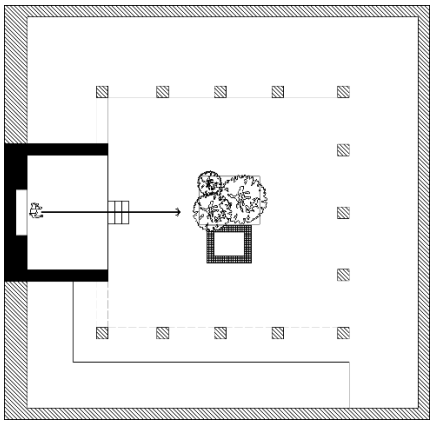


Fig 8. Example of a shelter in the pass ways. Source: Authors.

Fig 9. Mystery - Creating a sense of curiosity along the way. Source: Authors.

3. Mystery (Ambiguity): Mystery describes a place where a person feels they must move forward to see what is in the corners (Fig 9). The goal of the mystery pattern is to create a functional environment that enhances the sense of exploration. While other «nature of space» patterns can be experienced in a static state, mystery requires movement, analysis, and exploration within the space, starting from a positively perceived location. In the

architecture of Dezful, direct paths in passages are rarely used. The paths are winding and derived from the site's lines and topography. In the diagrams below, this pattern is shown in four stages (Figs 10, 11, 12, & 13).

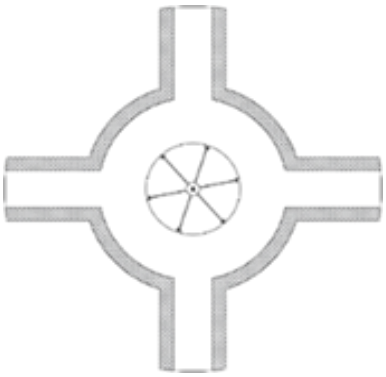


Fig 10. Full view from the center of the square to the streets and around the square. Source: Authors.

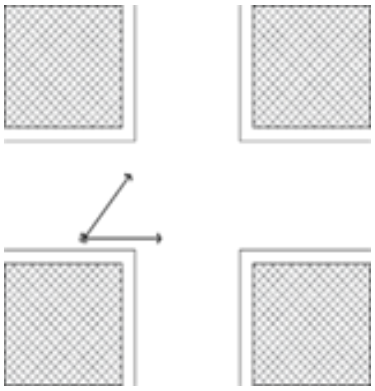


Fig 11. Limited view from both sides. Source: Authors.

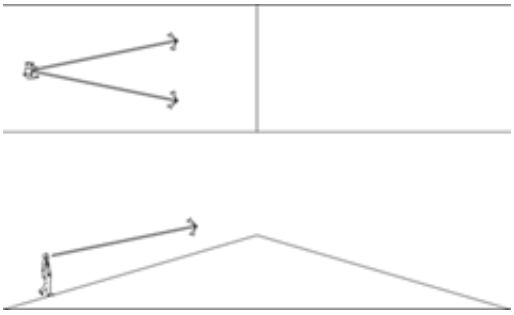


Fig 12. Limited view in the direction of movement. Source: Authors.

Fig 11. Limited view in the direction of movement and around the user - the highest degree of creating a sense of curiosity. Source: Authors.

4. Risk and Danger: Designing spaces that induce fear in the user, while in reality, no actual danger threatens them. This pattern has been one of the most critical considerations in designing spaces such as parks and zoos (Fig 14). With advancements in technology and the creation of diverse materials, many spaces are built following this pattern, such as glass bridges and cantilevered buildings over valleys. It should be noted that the level of risk and danger varies for different age groups and is considered based on the age range of the space users. In the architecture of Dezful, given the maximum use of land and climate, such issues have arisen. Among these issues are the construction of buildings on the edge of cliffs and valleys (Fig 15), narrow alleys between tall buildings (Fig 16), and stairs and paths leading to the valley that change direction along the way (Figs 17 & 18). In the past, such instances were used without considering this pattern and in line with utilizing nature for living. However, today, using past architectural and urban planning experiences, this point is employed in designs to create excitement and attractiveness in the space.

Fig 14. Creating a sense of falling and getting wet - risk and danger. Source: Authors.

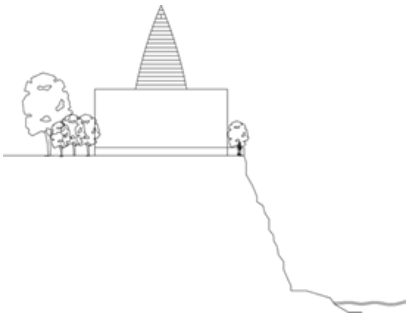


Fig 15. Buildings built on the edge of the abyss - Patterns of risk and danger and landscape. Source: Authors.

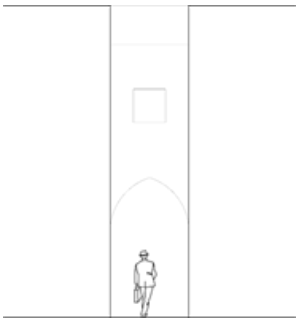


Fig 16. Narrow passages and high walls (Stenophobia) - patterns of risk, danger, and mystery. Source: Authors.

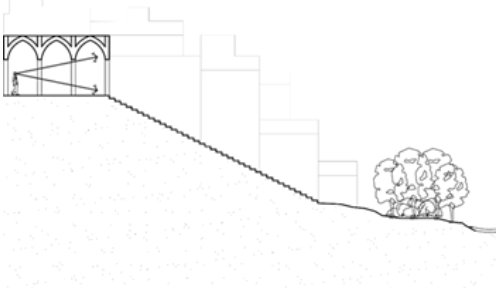


Fig 17. The sense of a cliff before seeing the stairs and access path at the section - Landscape, risk, and danger. Source: Authors.

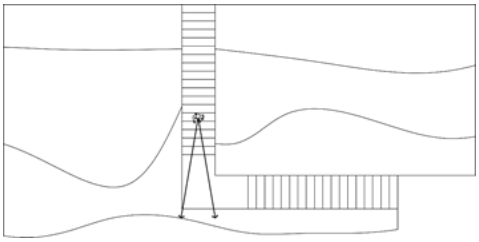


Fig 18. The sense of a cliff before seeing the stairs and access path in the plan - Landscape and risk and danger. Source: Authors.

Table 4 addresses the natural elements, simulations, and patterns present in Dezful's traditional architecture

Table 4. Examination of the Elements of Each Pattern in Natural and Simulated Forms and the Traditional Architecture of Dezful. Source: Authors.

	Pattern	Natural	Simulation	Traditional Architecture of Dezful
1	Visual connection with nature	Natural flow of water, presence of plants, animals, insects	Aquarium, green wall	Central courtyard, the presence of plants and water in the house
2	Non-visual connection with nature	Fragrant plants, the sound of birds, flowing water, natural ventilation, textured materials, ...	Simulation of nature sounds, fabric textures, pets, ….	The pigeon loft, the Qobile, the central courtyard, the presence of plants and water
3	Irregular sensory stimuli	The movement of clouds, the sound of tree branches and leaves, the sound of water, the movements of animals and insects, the commotion of birds, fragrant plants.	Wavy fabrics or ribbed materials that move with light and breeze, the reflection on the water's surface, the sounds of nature in the seasons.	Corbel arch, Khavun-chini, brick-lining. Central courtyard, presence of plants and water in the house.

	Pattern	Natural	Simulation	Traditional Architecture of Dezful
4	Thermal variability	Shade and shadow, solar heat, materials used in the facade, seasonal vegetation density, orientation	HVAC, central control system, window behavior, window performance	Windows and sashes, corridors, Shavadoon, Darize, Sabat, chimneys, and in general, transitional spaces.
5	Presence of water	Ocean, river, lake, lagoon, pond, visual access to rainfall and weather flow	Water wall, artificial waterfall, aquarium, fountain, nature images combined with water, water reflection	The presence of the Dez River in the city and its visual and non-visual connections within the city, the pond in the central courtyard.
6	Dynamic light	Lighting from different angles, direct and indirect light, intensity of illumination, moonlight and starlight, …	Low and high-intensity sources, ambient diffuse lighting, accent lights, personal light control in personal spaces, color-tuning lighting that creates white light during the day and minimizes blue light at night, and …	Light and shade elements, differentiation of spaces with diverse lighting for various uses
7	Connection with natural systems	Weather patterns, geology, animal behavior, insects, flowers, plants.	Simulating day and night light, wildlife habitats, rainwater storage, and patina	Central courtyard, presence of the Dez River
8	Biomorphic forms and patterns	Fabric, carpet, wallpaper, door and window details, texture, sculpture, furniture, wall painting	Structural systems derived from nature (trees), building form, pedestrian paths, fences	Khavun-chini, brick-lining, columns and capitals, plasterers, doors and windows
9	The relationship between materials and nature	Highly detailed creations (wood and leather textures, etc.), natural materials with minimal processing	Wooden or stone walls, structural systems, facade materials, furniture forms, bridges, and pedestrian paths	All consumables have been made from traditional and indigenous materials, and the structures are load-bearing.
10	Complexity and order	Wallpaper, carpet, texture, window and door details, variety of plants, ...	Exposed structure, visible building services system, facade materials, window hierarchy, landscape plan	Creation of Type 1 and 2 fractals in Khavun-chini, brick-lining
11	Landscape	Focal length more than 6 m The height of the partition is less than 1 m	Transparent materials, balconies, narrow pedestrian paths, box stair landings, landscapes including trees, ...	Internal view with the presence of a central courtyard, external view from the passages to the beach and river
12	Shelter	Modular shelter Half-complete shelter Extensive shelter	Spaces with climate protection or visual privacy, spaces for rest and relaxation, reading, ….	Porch (Iwan), Sabat, corridors, and alcoves
13	Mystery	Twisting paths, auditory stimulation, play of light and shadow, …	Light and shadow, sound or vibration and tremor, scent, activity and movement, form and rotation.	Winding paths in the topography

	Pattern	Natural	Simulation	Traditional Architecture of Dezful
14	Risk and danger	Spatial features: elevations, water, gravity, hunting grounds, and predators Perceived dangers: falling, getting wet, getting injured, losing control.	Console, transparent facade, glass railing or floor, passing under, between, or over water, proximity to a beehive or animals, edge of infinity (Louis Kahn's laboratory building)	Building on the edge of a cliff, the feeling of the cliff before seeing the stairs and access path, narrow passages between tall buildings.

Method of Selecting Case Samples

The list of registered national heritage sites in Dezful's architecture was initially reviewed. Items that had undergone significant changes were removed from the list, while those that had been valuable structures but now had no remaining traces were retained. Subsequently, the priority was given to selecting houses and items for which good information was available, followed by those that were more accessible. A case study is presented to illustrate how other examples were examined.

Method of Case Study Analysis (Case Study: Rashidian House)

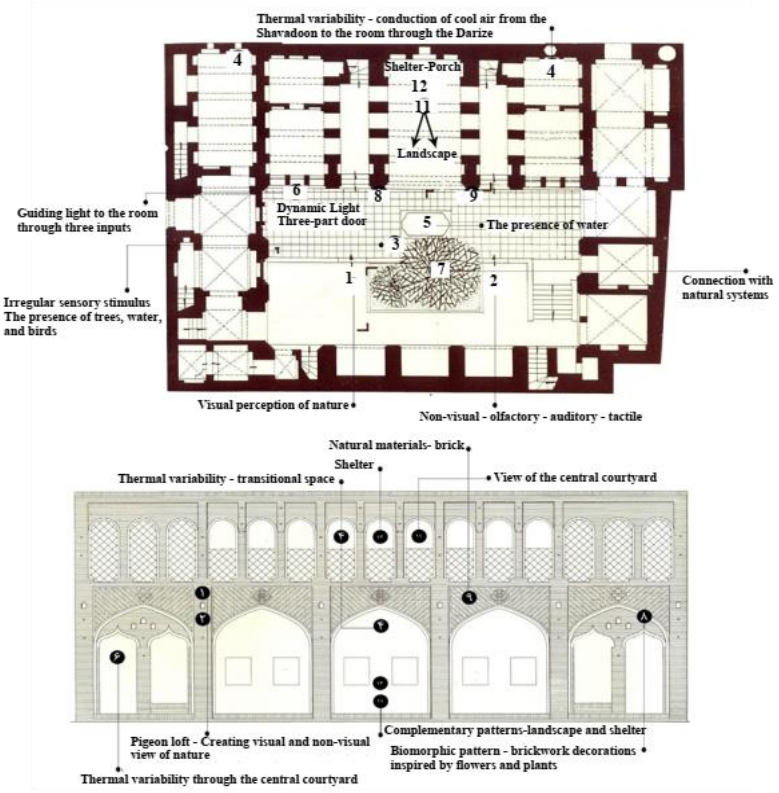


Fig 19. Method of examining the case study of the Rashidian House. Source: Authors.

In Fig 19, one of the samples is displayed to illustrate how the samples were examined. Subsequently, all the examined cases are presented in Table 5. The presence of the pattern in Sample 1 is considered, and if the pattern is not observed in the sample, it is noted. In the summary section, all the present cases are aggregated, and their total is recorded, followed by the calculation of their relative frequency in the final section. Finally, the relative frequency of each sample is also calculated.

Table 5. Examination of the Presence of Patterns in Case Studies. Source: Authors.

Patterns	Examined items	Sohrabi House	Rashidian House	Souzangar House	Zargar House	Tizno house	Gholaghchi House	Daei house	Ghalambor House	Firoozi House	Monument Roudband	Rukn-e-Alam Tomb of Shah	Moezi School	Passages and access routes	Total	Relative frequency of each pattern
Nature in space	Visual connection with nature	1	1	1	1	1	1	1	1	1	1	1	1	1	13	100%
	Non-Visual connection with nature	1	1	1	1	1	1	1	1	1	1	1	1	1	13	100%
	Irregular sensory stimuli	1	1	1	1	1	1	1	1	1	1	1	1	1	12	100%
	Thermal variability	1	1	1	1	1	1	1	1	1	0	1	1	0	11	76%
	Presence of water	1	1	1	0	1	0	1	1	0	1	0	1	0	8	61%
	Dynamic light	1	1	1	1	1	1	1	1	1	0	1	1	1	12	84%
Natural similarities	Connection with natural systems	1	1	1	1	1	1	1	1	1	1	1	1	1	13	100%
	Biomorphic forms and patterns	1	1	1	1	1	1	1	1	1	1	1	1	1	13	100%
	The relationship between materials and nature	1	1	1	1	1	1	1	1	1	1	1	1	1	13	100%
	Complexity and order	1	0	1	1	0	0	1	1	1	0	1	0	1	8	61%
Nature of	Landscape	1	1	1	1	1	0	1	1	1	1	1	1	1	12	92%
	Shelter	1	1	1	1	1	1	1	1	1	1	1	1	1	13	100%
	Mystery (Ambiguity)	0	0	0	0	0	1	0	0	0	0	0	0	1	2	15%

Patterns / Examined items	Sohrabi House	Rashidian House	Souzangar House	Zargar House	Tizno house	Gholaghchi House	Daei house	Ghalambor House	Firoozi House	Monument Roudband	Tomb of Shah Rukn-e-Alam	Moezi School	Passages and access routes	Total	Relative frequency of each pattern
Risk/danger	0	0	0	0	1	1	0	0	0	1	0	0	1	4	30%
Total	12	11	12	11	12	11	12	12	11	11	12	11	12		
Relative frequency of each case	84%	%78	84%	78%	84%	78%	84%	84%	78%	78%	84%	78%	84%		

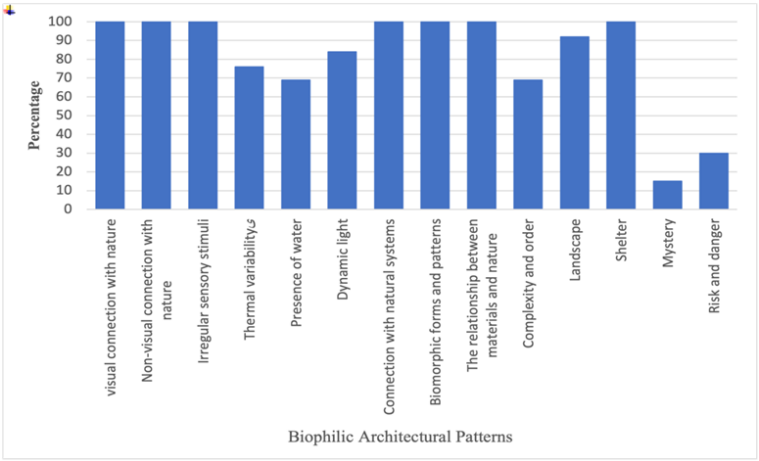


Diagram 1. Histogram of pattern presence in the examined samples based on frequency percentage. Source: Authors.

Conclusion

Studies show that the first six patterns, namely the nature in space section, are present in all case studies, although the quality of some patterns is lower and some higher. The average of 88 percent for the nature in space section well indicates that the presence of nature in traditional architectural spaces, both private and public, has been of great importance. In the second section, natural similarities, an average of 87 percent was obtained. Biomorphic patterns have been utilized in most decorations well. In connection with materials, as examined, all materials used were employed with minimal processing, and the connection between materials and nature plays a significant role in Dezful architecture. In the complexity and order section, it was observed in some cases that more complex patterns than biomorphic patterns were used, and they were mentioned. In the third section of patterns, namely the nature of space, the results obtained indicate that landscape and shelter are well observed in both indoor and urban spaces, and patterns of mystery, risk, and danger exist in urban spaces, with a few instances seen in some parts of the house. In general, some patterns are more commonly seen in residential spaces, while others are found in public

spaces and pathways. According to the results, the average presence of patterns in both homes and public spaces and pathways is 81%. Diagram 1 shows the column chart of patterns in Dezful's architecture. Overall, the results indicate that nature has held a very special place in Dezful's traditional architecture. The science of biophilia and, consequently, biophilic architecture is a new topic, but its manifestation is clearly seen in traditional Iranian architecture. In the past, environmental conditions and the lack of facilities led to the use of nature, whereas today, with the help of biophilia science and biophilic design, we scientifically understand the effects of nature's presence in spaces. Biophilic design proves the positive psychological effects of nature's presence in the built environment on humans. In Iranian architecture, emphasis has been placed on the connection between nature and architecture, utilizing environmental conditions and natural patterns. The city of Dezful, as a symbol of Iranian architecture, clearly demonstrates this. The connection between nature and architecture is one of the most important factors that has made traditional Iranian architecture valuable, a topic on which 14 biophilic architecture patterns are based.

Author Contributions

This manuscript was written with the participation of all authors. All authors discussed the results, reviewed, and approved the final draft of the manuscript.

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Conflict of Interest

The author (s) declare that there are no potential conflicts of interest related to this research, in writing, and publication of this article

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