FULL LENGTH ARTICLE

Investigating climate responsive solutions in vernacular architecture of Bushehr city

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Abstract As the main concern in sustainability is consideration to climatic conditions, climatically compatible design is the closest way of getting the maximum advantage of renewable sources of energy, while at the same time the design minimizes the undesirable effects of the construction in the environment and causes coordination with sustainability. From this point of view, the Bushehr traditional fabric, which is located in northern side of the Persian Gulf shore in south of Iran, is distinguished as a city with a unique vernacular architecture and climatically adapted urban design.

Climatic design in Bushehr traditional city is seen in several characteristics including urban morphology and urban orientation, as well as architectural design and architectural elements of buildings such as Shenashir. The main reason of using all these solutions and strategies in vernacular architecture of Bushehr was to be adapted to climatic condition (a hot and humid climate) and therefore using the environmental potential to provide comfort for its occupants, which are the main purposes of sustainable development.

As a result, this research attends to investigate these climatic solutions and their advantages as an idea to develop and use in contemporary architecture in order to reach sustainability. To this end, qualitative methodology based on a descriptive–interpretative approach is applied in this research for analyzing appropriate climatic solutions in vernacular architecture of Bushehr.

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Introduction

Preserving environment is the most important issue of today’s world in which human being has to reduce energy consumption [1]. As it is clear, worldwide around 40% of energy is consumed in buildings [2]. Due to population growth, increased urbanization and improvements of living standards most of energy consuming buildings will be located in the urban centers of the developing world. The depletion of energy resources and the risk of climate change are demanding for a sustainable development path based on renewable sources of energy and
energy efficiency [3]. Sustainability is a complex word and involves a lot of conceptions and considerations but one of the most important questions included in the meaning of this word is the tolerance of ecological pressure in buildings. In sustainability term, the most important thing to start is to build energy efficient and non-toxic houses and to eliminate the use of non-renewable resources [4]. Good energy efficiency homes provide better environments for people living in them as well as reducing the impact on the natural environment [4]. On the other hand, the basic philosophy of climate responsive design lies upon the evaluation of climatic influence and the optimization of building environmental performance [5]. In other words, we are trying to minimize the resource consumption and environmental impact through cooperation with external climate. As a result, climate responsive design can play a significant role in reducing energy consumption of buildings without compromising modern living standards [5].

Hence, studying vernacular architecture of our ancestors especially Bushehr could be a proper source for investigating their solutions for adaptation with climate conditions and reducing energy consumption. To this end, the research objective was investigating solutions and their advantages for designing vernacular architecture of Bushehr, which are in accordance with climate condition and sustainability.

As a result, the research attends to answer the following question.

What are climatic solutions in Bushehr vernacular architecture and their solutions to be adapted with climatic conditions and sustainability?

To answer this questions some measures should be taken into account:

First, the exact meaning of vernacular architecture to investigate its concept should be studied. Then, Bushehr city’s background and its vernacular architecture in three scales of the urban fabric, the architecture unit and at the scale of architectural details should be investigated through library research and their accordance with Bushehr hot and humid climate condition should be analyzed. On the other hand, the relationship between climatic design and sustainability should be analyzed through library research for finding out that how climatic design in vernacular architecture of Bushehr reaches a sustainable development.

Concept of vernacular architecture

Vernacular buildings are architectural products that emerged as a response to the requirements of societies before the industrial period and to the insurmountable limits created by the region and climate, and because of the unique interaction between human mind and experience gathered by observing natural phenomena [14]. Vernacular buildings, either individually or a whole settlement, are the best examples of the harmony among human behavior, building and the natural environment [14]. It contains inherent, unwritten information

### Table 1

<table>
<thead>
<tr>
<th>Scholars/researchers</th>
<th>Sustainability</th>
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<tbody>
<tr>
<td>Martinez [4]</td>
<td>• Considering the local climate conditions and the integration of the new building with the surrounding</td>
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<tr>
<td>SAM, HUI [5]</td>
<td>• Minimize the resource consumption and environmental impact through cooperation with external climate</td>
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<tr>
<td>Walsh [6]</td>
<td>• There is a symbiotic relationship between the concept of sustainable development and the reality of climate change</td>
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<tr>
<td>Munasinghe [7]</td>
<td>• Potential impacts of climate change on sustainable development</td>
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<tr>
<td>Emas [8]</td>
<td>• Importance of intergenerational equity</td>
</tr>
<tr>
<td>Joshi et al. [9]</td>
<td>• Sustainable development requires that the rate of depletion of non-renewable resources should foreclose as few options as possible</td>
</tr>
<tr>
<td>Harris [10]</td>
<td>• Maintain a stable resource base</td>
</tr>
<tr>
<td>Zhang et al. [11]</td>
<td>• Sustainable growth relies on the preservation and efficient use of the country’s land, water, and forests, as well as other natural resources</td>
</tr>
<tr>
<td>Salkin et al. [12]</td>
<td>• Focuses on all laws and policies that affect environmental quality and the availability of natural resources</td>
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Table 1 lists some scholars’ point of view about sustainability. All these scholars believe that adaptation with climatic conditions and reducing energy sources have significant impacts on reaching a sustainable development and sustainability. Studies and experiences have proven that vernacular architecture of our ancestors had been an appropriate source for studying and re-using their solutions in designing buildings [13].

Foundations of Iran vernacular architecture have been derived from the nature and its great deal of energy (sunlight, water, wind and soil). Additionally, it is contextual, earth-dependent, which is an integral part of the environment [13].
about how to optimize the energy performance of buildings at low cost using local materials [15]. Besides, it seems that it is the result of the hundreds years of optimization to provide a comfortable shelter in a local climate using available materials and known construction technologies [16]. Paul Oliver is one of the first researchers who investigated vernacular architecture and its concepts. He believes that vernacular architecture is a genre of architecture that grows within communities in which it could adapt itself with social, climatic and technological conditions during ages. Additionally, it is compatible with values, economics, lifestyle and the originated cultures [17]. Thomas Hubka has a similar theory about vernacular architecture and he believes that we could not consider vernacular architecture unconsciously since this architecture is the product of human ingenuity and intelligence [18]. Amos Rapoport also implies the existence of inner abilities in creating vernacular architecture. He believes that the man-made products or constructions of vernacular people are in relation to the usage of their inner capability more than their need for controlling the environment. He assumes that architects try to make a balance between architecture and nature [19].

Edward Brian finds out preserving the environment as the most important issues in today’s world and he implies that human has no solution except reducing energy consumption and he should use passive systems of energy for environmental comfort in buildings [1].

Javad Babak Rad writes an article about this issue in art and people journal and he believes that in southern regions of Iran, architects have found out that how the type of buildings and their orientation should be to become efficient and adaptable with different seasons and various climate conditions along with using the most resistant materials [20].

It has been elicited that vernacular architecture has a particular priority in human societies mainly because this type of specific designing has not been costly and it has been in adaptation with environment and climatic conditions. Fig. 1 indicates some conceptual diagrams about vernacular architecture from some scholars’ points of view.

**Bushehr city background and its characteristics**

Bushehr city is the Capital of Bushehr Province in Iran, which is located in northern side of the Persian Gulf shore and it has settled in hot and humid region of Iran [21]. Bushehr is considered as the most important port near Persian Gulf boarder. Although in recent years many transformations have occurred in this city and its urban public spaces, its vernacular fabric is unique and it has been formed based on its climate position. Fig. 2 shows Bushehr traditional city map.

Civilization has long history during ages in this region. It has an ancient historical background, which had been developed by king Nadir [22]. The city had considered as a south gate of Iran for cultural relations and exchanging ideas [23].

![Fig. 1 Conceptual diagrams of vernacular architecture from some scholars’ points of view (Produced by the authors).](image-url)
For analyzing architectural characteristics of Bushehr city, its skeletal features should be analyzed in three different scales such as the scale of the urban fabric, the scale of the architecture unit and the scale of architectural details [24].

The scale of urban fabric

Since Bushehr city has been located in hot and humid climate, its old texture is compact, dense and continues Fig. 3.

New studies show that there is a meaningful relationship between a sustainable city and the concepts of density or compaction so that providing climatic comfort and preserving energy would be done by diminishing surfaces of buildings which face with sunlight [25]. The presence of the sea cool breeze within the fabric along with the existing vacancy of buildings for wind circulation is the most important factor in dividing the fabric of the city to smallest possible blocks Figs. 4 and 5.

Extraversion of buildings and having the least common faces in neighborhoods with the purpose of using wind flow have divided the fabric of the city into isolated blocks Fig. 6.

Additionally, Bushehr city has a dense texture and narrow alleys in its old quarters in which the widths of some alleys have not been further than a meter and a half [24]. The proportion of height to width of these alleys is mostly ten to one. It is worth mentioning this proportion is just seen in just old quarters of Bushehr city Fig. 7.

Besides, all blocks have been surrounded by tight narrow allies with high closeness and tall multi-story walls for the purpose of having the maximum windward faces. This form of texture also makes large shadows for buildings especially for passages [24].
Structure of public spaces

Road networks have been shaped with an organic hierarchical order, which is as a result of temperature, humidity, orientation to wind flow, the earth’s natural topography, possession and socioeconomical characteristics. Passages are exposed to dominant winds from north and northern west [24]. Besides, all alleys stretch along the sea for transferring the cool breeze of the sea within the fabric. Alleys with low width and spiral format along with suspended balconies provide essential spaces with wind draft and suitable conditions for spending warm seasons [24]. Fig. 8 shows a conceptual diagram of the alley toward the sea.

Orientation of a building

The most significant climatic factors that affect the ventilation’s condition in hot and humid cities are regional winds. Regional winds are produced because of the difference in atmospheric pressure, uneven distribution of solar radiation and the differences in the air density [26]. Hence, by the correct orientation of houses there would be a great deal of regional wind flow inside buildings. There are various regional winds in Bushehr city including Regular and seasonal wind, Lehmir wind, the Northeast wind (Ghos wind), North wind and Sohaili Wind [24]. All these regional winds made the city form based on making use of the optimal wind currents Fig. 9.

The scale of the architectural unit

This scale has been shown in different aspects such as using passive systems, semi-open spaces, rooftops and low heat capacity materials [24].

Utilizing passive systems by means of architectural elements

The existence of the central courtyard in internal heart of a building is considered a useful passive system that is in a way that can easily make better use of the wind flow [26]. In
each space with opening windows toward the central courtyard and toward alleys, transverse ventilation would be created which can reduce the intensity of heat and damp Fig. 10.

Besides, the high closeness of the central courtyard makes the open space act like a ventilator for indoor spaces, which makes the air exited and tall walls make the courtyard stay in shadows [26].

**Semi-open spaces in buildings**

Shenashir and large porches such as Tarmeh, which are toward the dominant wind, include semi-open spaces that have been used in upstairs Fig. 11.

These spaces have important impacts on infiltration of wind inside the building. Shenashirs have wooden safeguards and roofs, which have two roles. The first one is that they are in front of the closed space and avoid it from the intense solar radiation [24]. Another role is that it can reduce the wall’s temperature because of the made shadow on the outside surface [24]. Besides, its netted body will make the air infiltrate Fig. 12.

Since both Shenashir and Tarmeh are roofed spaces, which have been covered with wooden shutter blinds and straw sun shades in front of the permanent wind draft, they will become cooler than other spaces of the building and they will allow the desirable wind to infiltrate inside spaces [24].

Furthermore, semi-open living spaces are usually toward desirable wind and semi-open mediating paces are in the four corners of the yard. The combination of semi-open spaces...
induces the airflow upward upstairs through semi-open corridors. Openings, which are toward outside the buildings, will strengthen this system [27]. Additionally, the combination of open and semi-open spaces in these houses and their relation with living spaces produce wind flow in closed living spaces and the central courtyard [27]. All semi-open corridors act like a chimney and bring out the heat inside the house through suction Fig. 13.

**Rooftop**

The form of the skyline in urban spaces is compatible with the use of wind flow in Bushehr old fabric. Since people can make use of the rooftop for sitting, all skylines have been shaped like the wooden parapets, which have been attached to each other [24]. The enhancement of the building’s height and the usage of the rooftop as a last surface of the building will provide the maximum use of the wind draft [24]. Since the sun shines near the seashore daily, the earth’s surface will become warmer than the sea and as a result, the air next to the earth’s surface will elevate and substitute with the cool breeze of the sea. At night, the earth’s surface will lose its heat and the sea water is warmer than the earth. Therefore, the warm air will elevate from the

![Fig. 15 Wooden components in Dehdashti edifice (Bushehr) (Produced by the authors).](image)

![Fig. 16 The low heat capacity of wood, straw and Sedimentary rock compared to other materials (Produced by the authors).](image)

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<thead>
<tr>
<th>Table 2</th>
<th>Climatic solutions in Bushehr vernacular architecture (Produced by the authors).</th>
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<tbody>
<tr>
<td><strong>Climatic solutions in Bushehr vernacular architecture</strong></td>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td>The dense skeletal form</td>
<td>Making shadows of buildings and preventing the intense sun penetration</td>
</tr>
<tr>
<td>Tall alleys with high closeness</td>
<td>Making shadows of buildings and preventing the intense sun penetration</td>
</tr>
<tr>
<td>Building’s orientation with consideration of wind flow direction</td>
<td>For the maximum use of the gentle cool breeze</td>
</tr>
<tr>
<td>Locating passages toward the sea</td>
<td>For having the maximum windward faces</td>
</tr>
<tr>
<td>Central organization of spaces</td>
<td>For creating proper ventilation</td>
</tr>
<tr>
<td>The existence of windows toward the central courtyard and toward alleys</td>
<td>For producing transverse ventilation</td>
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<tr>
<td>Using of Shenashir and Tarmeh</td>
<td>For the maximum use of the wind draft and preventing the penetration of the intense sun</td>
</tr>
<tr>
<td>Using Rooftops at nights</td>
<td>For the maximum use of the wind draft</td>
</tr>
<tr>
<td>Using of materials with the low heat capacity</td>
<td>Adaptability with hot and humid climate</td>
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sea and the cross-current will move to the sea from the earth [21]. This cool breeze is sensible from the shore and because of its distinct direction it can easily be used for ventilation of the building. To recap, all houses’ roofs are flat and could be used for night activities such as sleeping Fig. 14.

Low heat capacity materials in buildings

In hot and humid regions, the usage of materials with low heat capacity, which do not accumulate heat, is better and more useful [21]. Thus, wood is the best material in these regions mainly because the day’s heat accumulates on the woods surface and it will perish by the cool breeze of the nights [21]. As a result, woods are used in making sunshades, doors and windows Fig. 15.

In addition to the usage of woods, some materials such as straw, limestone, coral stone and sedimentary rock are used because of their accessibility in this region and their low heat capacity compared to other materials. Fig. 16 shows the various materials’ heat capacity. As it is clear, wood and straw have the least heat capacity compared to other materials such as steel, glass or concrete which are used in today’s construction.

Conclusion

Vernacular architecture of Bushehr with specific weather conditions represents different logical solutions for providing human’s comfort conditions. The results of this research show that vernacular architecture of Bushehr was a climate responsive architecture, which is an important factor in sustainability. Vernacular residents in this region used some climatically adaptable solutions for maintaining their buildings from harsh outside climate. They built their houses based on the minimum sunlight penetration and the optimal usage of wind currents with several solutions. Some of the most important methods and technologies for adaptability with climatic factors are shown in Table 2.

These findings from vernacular architecture of Bushehr city shows that these city solutions in designing buildings could be a good example of climate responsive design. Since one of the most important aspects of reaching sustainability and sustainable development in cities is adaptability with climate conditions and reducing energy consumptions, climatic design, which are seen in vernacular architecture of Bushehr could be a good source for preventing energy consumption, air pollution in cities and decreasing physical and mental damages which are related to overusing technology. Using climatic solutions in contemporary constructions in cities with similar weather conditions has some implications such as decreasing a great deal of energy by making use of renewable energy sources such as wind and sun in a proper way. Besides, reducing energy consumption with utilizing climatic solutions, makes city reach one of the most important aspects of sustainability.

Conflict of interest

The authors declare that they have no conflict of interest.

References


