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Wind Towers

Architecture, Climate and Sustainability

Edited by
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Glossary

Aub-anbar An Aub-anbar is a traditional reservoir or "cistern" of drinking water in Persian antiquity. The Persian phrase literally means "water reservoir." Aub-anbars are one of the indigenous systems for passive cooling and storing of water. They are used to store the cold drinking water in winter so that it can be used or consumed in the hot seasons of the year. Aub-anbars are in fact covered and isolated cisterns which were built lower than the ground surface or in the mountains. The main function of Aub-anbars was to provide chilled water for the towns, villages, fortresses, caravan routs, and caravanserais.

Bazaar The word "bazaar" is used to refer to several different types of market places in the Middle East, where the word originates; it refers to a central open market where a large number of goods can be found for sale. The word "bazaar" comes from a Pahlavi word, baha-char, which means "place of prices." The word was adopted into the Persian language as "bazaar," and then became widespread throughout southern Asia and the Middle East.

Ice-houses or traditional ice-makers In the past, another complementary structure to the Aub-anbars used by people was ice-houses or traditional ice-makers. Those structures used passive cooling methods that would produce ice, taking advantage of low temperature in the freezing cold nights of the winter. The founders and creators of those structures, using their talent and simple architectural elements, developed a collection of ice-houses in the margin lands of villages and towns. The stored ice in winter was used to make the drinking water cold and enjoyable in summer.

Kavir Kavir is the same as desert, a hot and arid region.

Qanat (or subterranean canals) Qanat is composed of a number of vertical wells called shaft and one or more approximately horizontal wells called corridor underground, with a slope less than the slope of the ground surface. The structure carries the underground water in the mountains and relatively high areas to the low plains by means of gravity force. The vertical wells are used for the digging of the underground tunnel, repair, and maintenance (dredging) of the Qanat.

Contents

Chapter 1
Introduction

For centuries, Wind Towers, **Baudgeers**, were used in the past and are presently used in some regions of Middle East and Egypt where hot and dry climate exist, for maintaining cool air circulation and cooling inside the buildings as well. In fact, the main purpose of Baudgeers has been to create natural ventilation and cooling by exchanging air between the outside and the building inside at an appropriate time during the day. Another use of Baudgeers was to maintain a natural circulation of air in public cistern, **Aub-anbars**, and helping to keep the water cold.

In Iran particularly and those countries which have the use of Baudgeers consider them a novel buildings of beautiful architecture in addition to their functions. In the southern cities and marginal regions of the deserts of Iran, the people built Baudgeers of different forms and sizes [1, 2]. Baudgeers have four-sided (Fig. 1.1), six-sided (Fig. 1.2), or eight-sided (Fig. 1.3) cross sections and in some cases have been circular (Fig. 1.4).

In studying the traditional architecture and the urban texture of the central, southern, and desert cities and villages in Iran, they revealed that the factors influencing their buildings design are mostly the harsh weather and climate conditions such as hot and dry or hot and humid climate and strong seasonal winds. This had a significant role in the construction, materials, and use of Baudgeers [3]. Harsh climate and undesirable geographical conditions are the kinds of phenomena that man, through centuries, has always been confronting and trying to use his expertise to control them. The towns and villages which are located in the marginal areas of the desert and hot dry regions have their own peculiar and architectural style. Intensive heat of the Sun, the cold air of the night, little rain, dry air with very low humidity, strong winds with sand storms, and considerable differences in the diurnal temperature and between sunny and shaded areas are some of these peculiarities [4].

The opening variation used in Baudgeers in Iran is to maximize exchange of air between them and the outside environment. Also this depends on the prevailing wind; for example in Egypt the opening some time is single facing the sea and called **Wind Catchers**.

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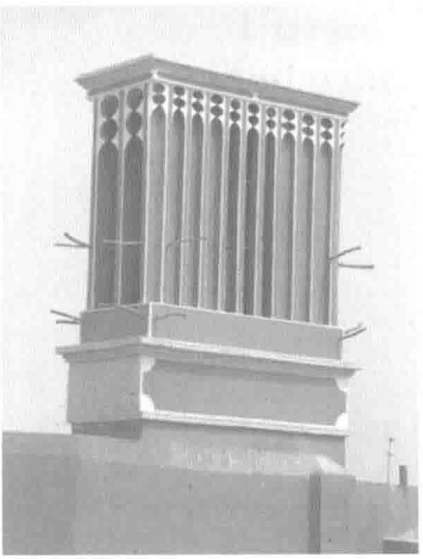

Fig. 1.1 A four-sided Baudgeer with rectangular cross section in Yazd (Baudgeer of Zargar Bashi House)

Fig. 1.2 A view of an Aub-anbar in Yazd with six-sided Baudgeers

Figure 1.5 shows pictures from desert (Kavir) in Iran; Figs. 1.6, 1.7, 1.8, and 1.9, respectively, show topographic map, climate atlas, winds atlas, and thermal atlas of Iran. Figure 1.10 displays some regions of Iran and other countries in the Middle East and Egypt where Baudgeers have been used in their buildings.

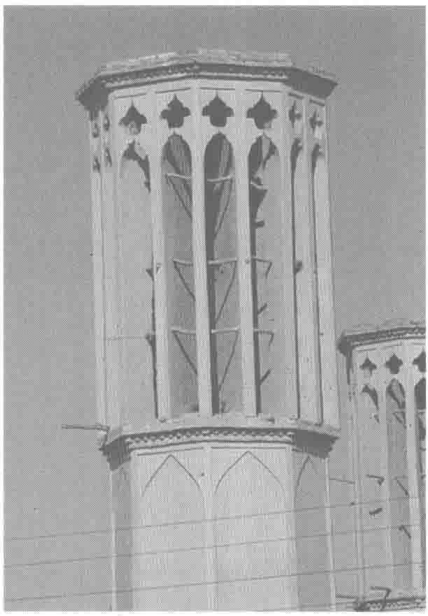

Fig. 1.3 A view of an Aub-anbar in Yazd with two eight-sided Baudgeers

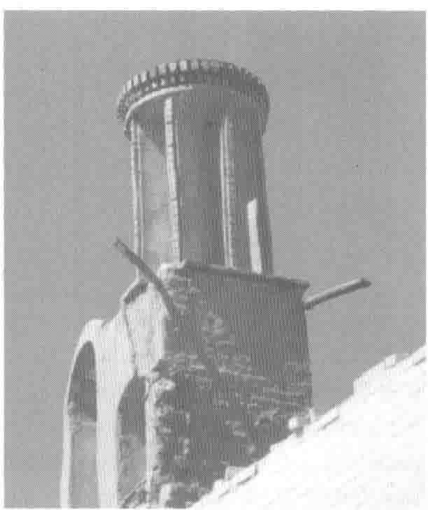

Fig. 1.4 A view of cylindrical Baudgeer in Yazd

The people who lived in these areas, over the centuries, perfected certain solutions to confront the harsh climatic and geographical conditions, some of which were by building in cluster or closer concentration of buildings in certain locations, and digging subterranean canals for many kilometers to transfer the water from the mountains to their desert areas. This is a thoughtful and improved technique named digging **Qanat**, constructing public Aub-anbars to supply drinking water in summer and building houses with high and thick walls made of bricks and clay to benefit from the concept of **Thermal Mass** which takes 12-h or more to let the temperature from the outside in the summer months reach the inside of the house

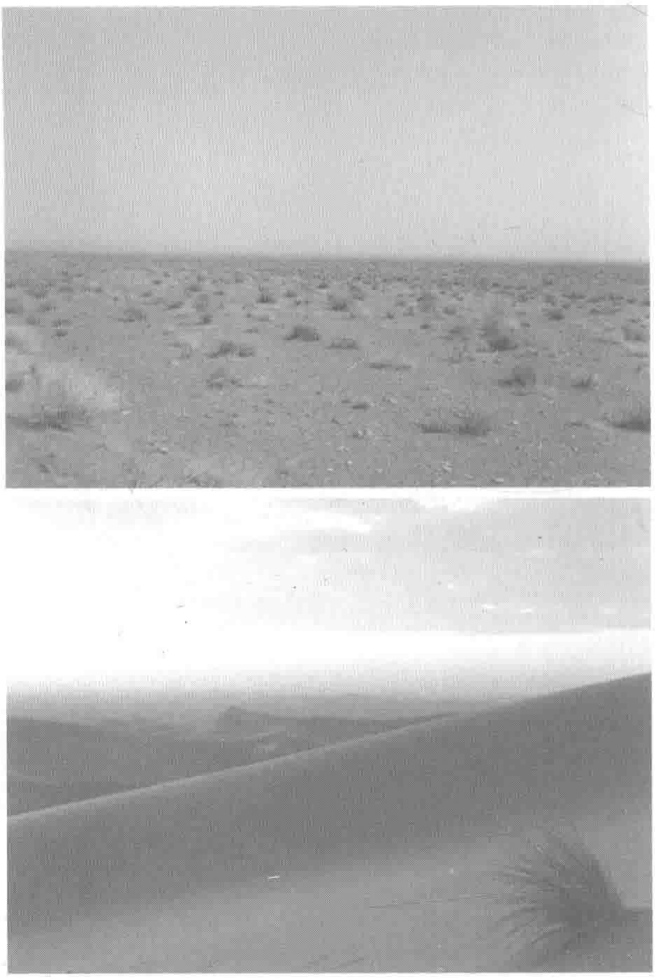

Fig. 1.5 Pictures from desert in Iran

and hence they kept the house temperature in relative comfort. These walls were both insolating barrier and thermal mass barrier. At night, transferring some part of cool air due to night radiation with the sky into the buildings while replacing the inside hot air from the daytime. The outcome of this process was the reduction of the internal heat gain into the building [6]. Using domes and vaults for the roofs of such buildings were another factor in reducing the internal heat gain [1, 2]. The great distance between the domes and vaults and the floor of the rooms caused the heat to be collected under the roof area while the lower part of the room stay relatively cooler for people to carry out their daily activities [1, 2, 7]. The use of narrow alleyways is rather narrow and in some instances covered with domed roofs, called Sabat in Farsi (Fig. 1.11).

Another important feature of the areas in desert to achieve cooling is the use of mud and mud-brick as the main construction material in their buildings. This practice is older than the civilization of Pars. It is worth mentioning that the main reason for the use of mud and mud-brick in buildings was, on one hand, the lack of other

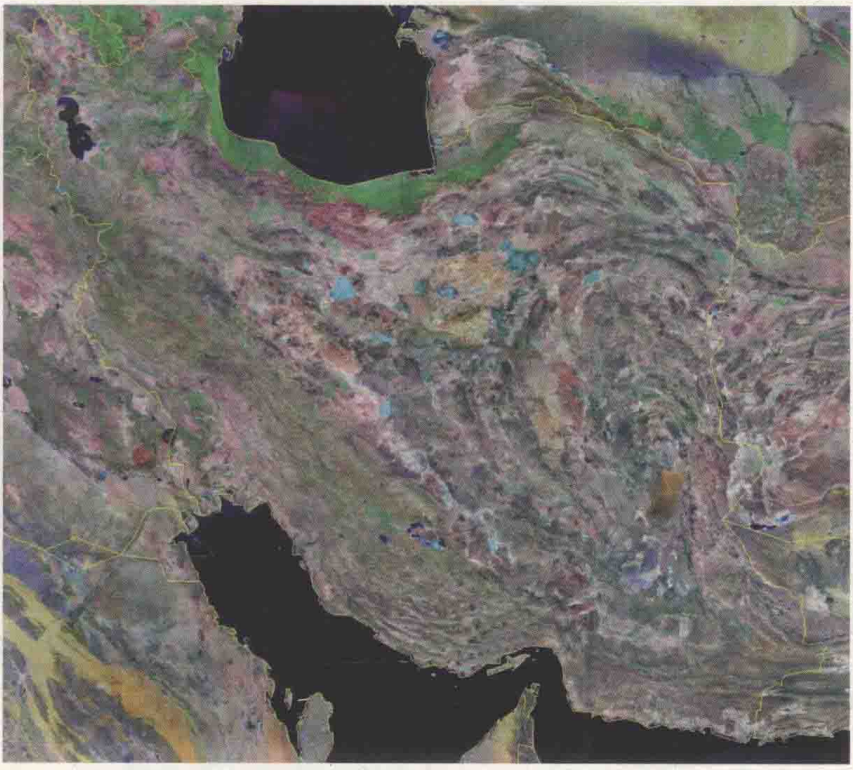

Fig. 1.6 Topographic map of Iran

types of materials such as stone, wood, and cement, and on the other hand, the low cost and good practice to use the indigenous materials due to its suitability in reducing the heat gain [6, 8].

Construction of Baudgeers is considered one of the most significant undertakings of Iranian creative engineers and architecture. Baudgeers, while being beautiful and decorative, have had an important and efficient role in the circulation of the air inside buildings, Aub-anbars, and basements in a natural way, without consuming fossil fuel or using machinery to achieve comfort.

Since seasonal and daily natural winds are one of the main characteristics of climate conditions variation in desert region, Baudgeers were constructed in such a way that their openings are facing the direction of the prevailing wind and preferably the wind coming from a region with pleasant odur.[1] The upper portion of Baudgeer was kept open on one, two, four, six, or eight sides in such a way that the top was closed and the inner passage led the air into the building or the reservoir. The inner passage was divided into four, six, or eight sectors, using partitions and bricks (except for one-way wind towers), to align the wind direction in the entry

[1] Both pleasant and unpleasant winds blow in Yazd. One of these pleasant winds blow from the northwest of the province which is called "Isfahani Wind." The coolness of this wind has been the main reason for building Baudgeers in Yazd [9].

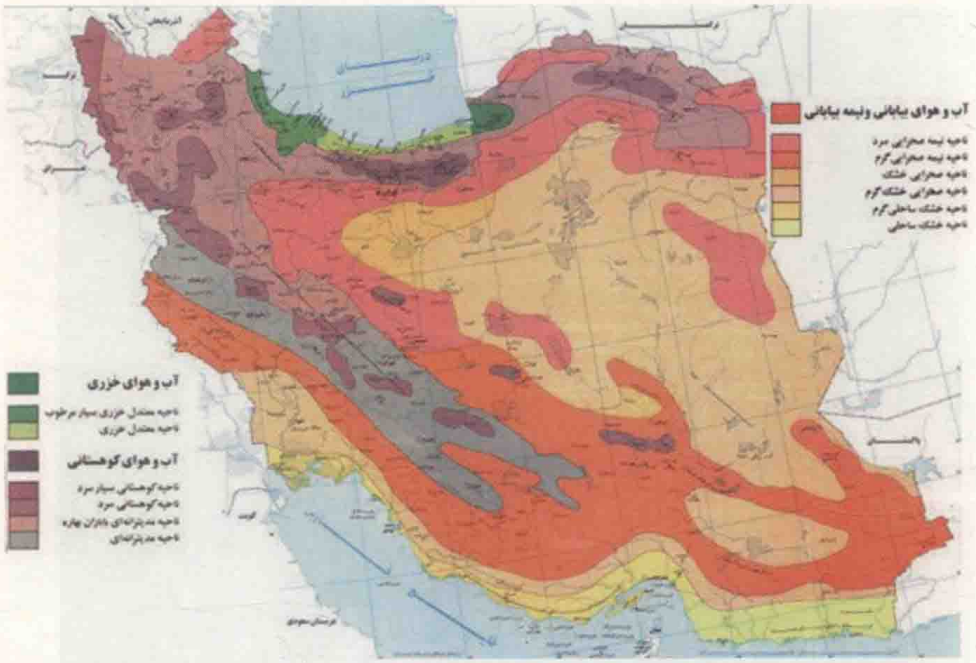

Fig. 1.7 Climate atlas of Iran

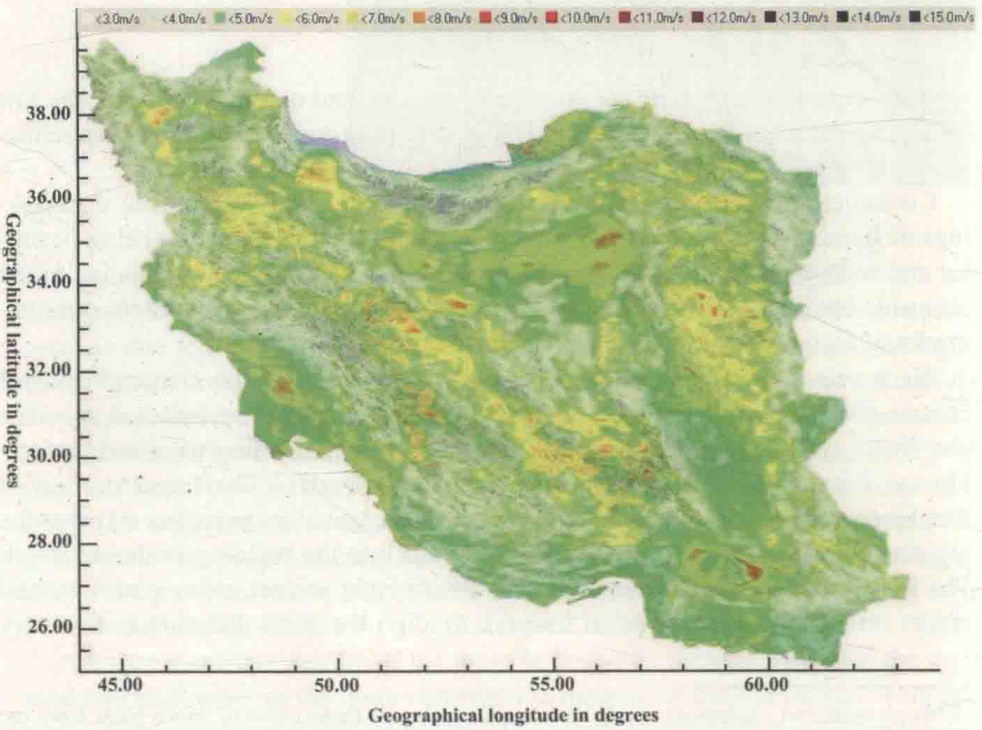

Fig. 1.8 Wind atlas of Iran at 50 m elevation longitude in degrees, latitude in degrees

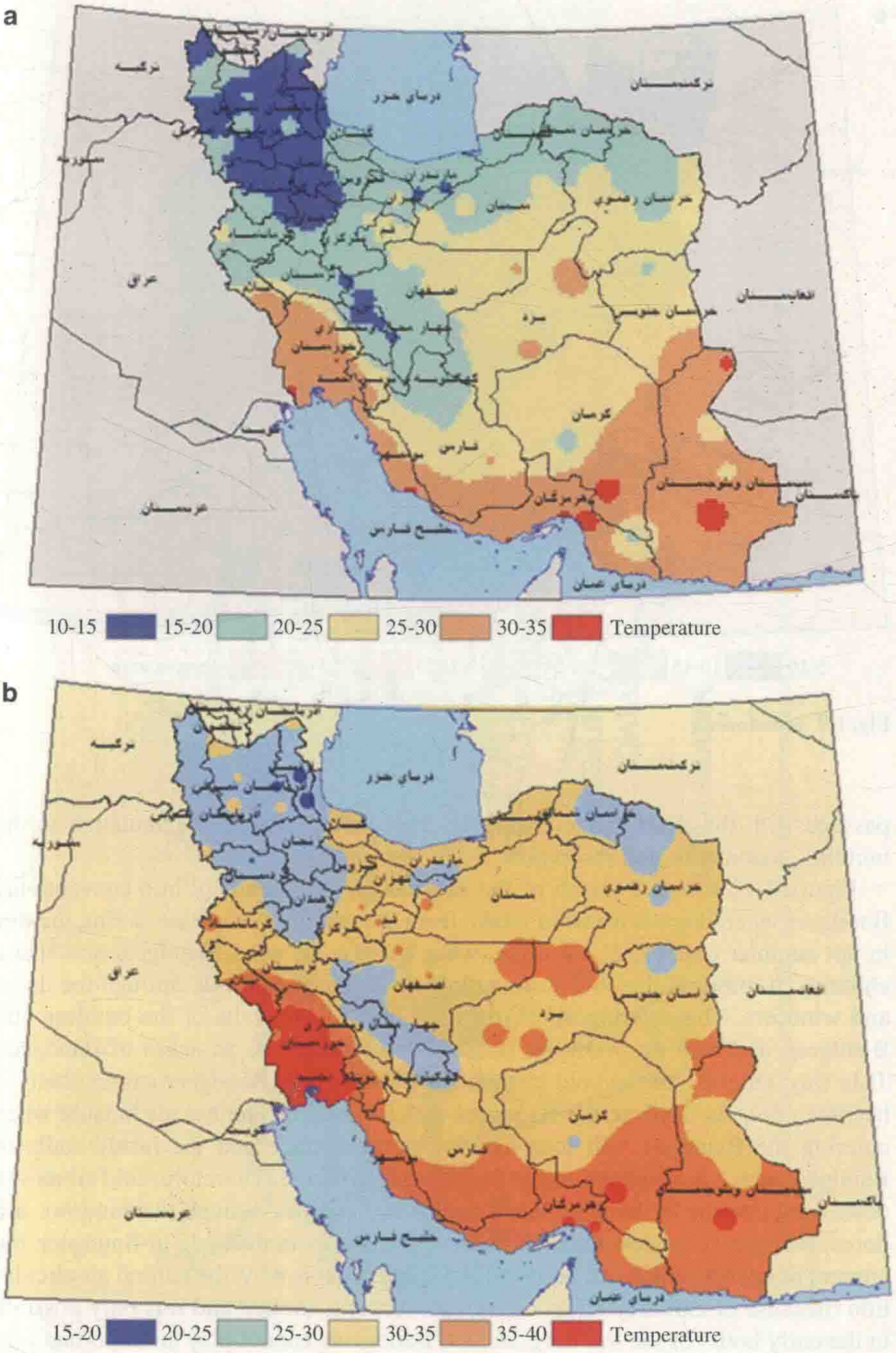

Fig. 1.9 A thermal atlas of Iran in 2007: (**a**) Distribution of the average temperature in spring, (**b**) Distribution of the average temperature in summer and (**c**) Distribution of the average temperature in autumn

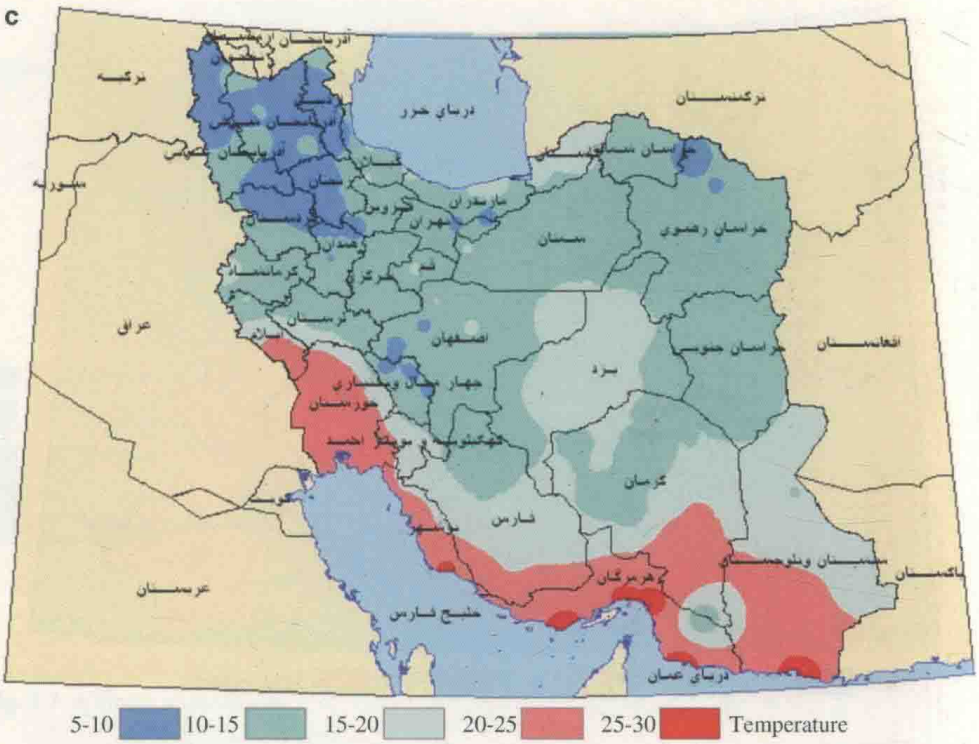

Fig. 1.9 (continued)

passage with the shaft of the Baudgeer. This would create air circulation in the building, basements, and reservoirs.

Figure 1.12 shows a sketch of the continuous air movement in a conventional Baudgeer when there is no wind intake from the outside as the case during the day in hot summer time [1, 2]. At night, when there is no wind, Baudgeer acts like a chimney. It draws in the cool surrounding air of the night inside through the doors and windows. The entering air absorbs the heat of the walls of the building and Baudgeer, and then the warm air is exhausted through the passages of Baudgeer. This way, entering of the cold air into the building and Baudgeer causes them to become cool. At daytime the Baudgeer acts in reverse. The hot air outside when entering the Baudgeer will lose its heat to the surface and the inside walls of Baudgeer which has became cooler from the night before. Therefore, cold air moves downward into the building by being denser and escapes through the windows and doors. Because of the low mass and heat of the energy in the body of Baudgeer, the amount of energy which can be saved is limited. That is why, the natural air circulation (because of chimney effect or buoyant force) is limited and it is only possible in the early hours of the morning. In fact, Baudgeers cannot play an important role in the absence of the wind.

Wind movement creates a pressure difference between the entry passage of Baudgeer and the building's doors and windows which establishes air circulation

Fig. 1.10 Some of the regions in Iran, and neighboring countries of the Middle East as well as Egypt which are enjoying the use of Baudgeers