

Climate Control Strategies Used in Rural Housing: Ardebil Province

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ABSTRACT: The energy crisis and rising concerns about energy conservation have called for a serious reconsideration of planning and design policies in Iran, construction techniques being among its crucial factors. This matter becomes even more critical in rural areas where fewer facilities are present than in the city: lower life condition, lack of professionals, relative distance, and accessibility problems to city facilities are some factors which necessitate rural energy conservation. In this context, the Enghelab-e Eslami Housing Foundation introduced a research project to define climate-compatible design guidelines for rural housing that would reduce consumption of fossil fuels. Since no weather stations were located in these villages, the main obstacle to the researchers meant acquiring the required climatic information. The methodology relies first on regional geographic and climatic conditions, and second on observation of environmental strategies already applied in vernacular architecture of the region, namely residential architecture which has empirically evolved over the years to retain an energy-efficient design. This article covers the results of studying Ardebil Province, which has been divided into four climatic classes, and three architectural classes. Design strategies observed in each of three classes are presented.

Keywords: rural housing, vernacular architecture, architectural classification, climatic classification

1. INTRODUCTION

As the vernacular town and village architecture of Iran shows, fairly comfortable living conditions are provided by means of only employing properties of form and material, with minimum reference to secondary sources of energy. However, contemporary architecture today, follows the modern architectural idiom insensitive to regional diversities. Therefore, it has resulted in the construction of similar buildings all over different climates across the country, demanding an extensive exploitation of fossil energy resources.

The energy crisis and rising concerns about energy conservation have called for a serious reconsideration of planning and design policies in Iran, construction techniques being among its crucial factors. This matter becomes even more critical in rural areas where fewer facilities are present than in the city: lower life condition, lack of professionals, relative distance, and accessibility problems to city facilities are some factors which necessitate rural energy conservation. This calls for research in order to draw climate-compatible design guidelines. It appeared in the first step that since no weather stations were located in these villages, the main obstacle to the researchers meant acquiring the required climatic information. A hypothesis comprising two principles was introduced:

The villagers have come to an understanding of their regional weather and resources through

experience, and have thus adapted their construction and lifestyle to it.

Problems of accessibility to mechanical heating and cooling devices and their fuel have encouraged more environmentally compatible building types that can resist climatic disturbances.

Climatic conditions are thus deducted by analyzing local natural and geographic features, vernacular farming methods and its properties, social/cultural factors, and construction materials and techniques. On the next step, with regard to the previous analysis, we were capable of deriving vernacular design strategies and introduce energy-efficient housing guidelines. This article presents the results of studying rural housing of Ardebil Province as a model in Iran's cold climate region.

1.1 Method and Procedure

First step was to gather regional climatic information (data acquired from 11 weather stations) which was later supplemented by local geographic data, social structure, living conditions and rural building properties, all of which helped to better define a microclimate. Geographic data included location of a village, topography, aspect, vegetation, cultivated produce, and agricultural methods. Climatic information included extremes of high and low temperatures, duration of hot and cold period, humidity, rainfall and frost, wind quality, wind frequencies and direction, and other climatic elements such as fog, snowfall, and etc. Cultural factors included living conditions, settlement status, special architectural functions such as *iwan*, *soffeh*, winter or

summer living areas, *Bahar.band*, underground pens, etc. Information was gathered using both observation methods and interviews with local inhabitants of 60 villages. The data was then imported into Microsoft Excel, which was analyzed using its statistical and filtration tools, and at the end four climatic regions were identified.

Architectural climate control strategies were next identified by examining rural housing construction methods in each region. This included properties and proportions of open, semi-open and closed spaces, connection between spaces, special architectural elements, and construction materials and techniques. Based on these properties, practical building design guidelines could then be expressed.

2. GEOGRAPHIC AND CLIMATIC REGIONS OF ARDEBIL PROVINCE

Ardebil Province is a strip stretching from 36°50' on the North latitude and 47° on the East longitude (referenced from the Greenwich meridian) to 39°40' North and 49° East. Mt. Sabalan's peak elevation measures 4844m, while the lowest point in the province sits on Moqan plain measuring 100m above sea level. Talesh Mountains stretch north-south on Ardebil's eastern border, separating it from the Caspian Sea and preventing moisture from entering the region. Diverse mounts, high latitude, proximity to Caspian Sea, facing Mediterranean air flows and Siberian cold air masses play an important role in weather quality. Based on the acquired local data and geographic/climatic information, four distinct climatic regions were identifiable and are as follows: the Plains, the Foothills, the Very Cold Mountains, and the Cold Mountains, each of which can be identified as having two sub-regions (as zooming in and comparing the accumulated data shows). These regions might also be categorized by altitude, topography, climatic conditions, vegetation or type of produce.

2-1. The Plains

This region embraces Moqan plain which is mainly flat, formed after deposits of Aras River and its branches. It can be divided into two northern and southern sub-regions that differ regarding duration and extremes of hot and cold weather.

2-1-1. Northern Plains

Having less than 300m altitude, mean yearly temperature of 15-17° C, the northern plains possess a relative moderate climate to that of other parts of the province. The mean maximum temperature during the hot period of the year reaches 33-37° C creating a sultry weather. The absolute maximum temperature is 38-40° C. Shading is preferred through daytime for cooling during 5 to 6 months of a year, and should be accommodated further during 3 to 5 months by air ventilation to diminish excess heat and humidity. Night temperatures are rather low (16-20° C), so sleeping outside would be uncomfortable especially near dawn, however sleeping inside the buildings – mostly consisted of massive envelope – would not

cause an annoyance. Summer winds are westward and sometimes strong. Thus, the summer is hot and humid lasting from June to the end of October.

Temperatures during the cold period of the year range from a minimum of -2—2° C in the night to a maximum of 7-11° C during the day. The absolute minimum temperature is -5—10° C. Frost occurs for 1.5 to 2 months yearly. Snowfall happens only a few times, less than 20cm overall in amount, and during the time period between January and March. No blizzards occur in this region, yet fog is evident during fall and winter. Floods rarely occur and are not intense. Interior spaces need heating for 2-3 months 24 hours a day, and for 7-8 months only at night, during which winds have a chilling effect. For about 4 months the wind chill factor may be applicable. Winter winds are west- and southward and quite strong in certain areas. Winters are rather cold overall, lasting from December to end of March, during which comfort is maintained with the use of heating devices.

Grasses and bushes constitute the main vegetation type, while wild trees can also be plotted in the utmost northern areas. The land turns green during April and May. The main occupancy of inhabitants is farming (cultivation of land and raising livestock). Cultivation is by means of irrigation throughout the northern part where wheat, cotton, beet, corn, soy, and summer crops are produced; however in other parts wheat and barley are raised by dry land farming. Livestock include cows and sheep which are maintained in open spaces at summertime and in closed spaces during winter. Still, there are areas in the utmost northern areas that cattle can be maintained outside even some time during the winter. Heaters are used as heating devices; fans along with natural ventilation provide for cooling. Among commonly used architectural spaces are *Iwan*, *soffeh*, and stove room.

2-1-2. Southern Plains

The southern lands of Moqan plain border the foothills with an altitude of 300-1400m, and have a mean yearly temperature of 10.5-12.5° C. The mean maximum temperature reaches 29-32° C in the hottest days, while the absolute maximum temperature doesn't exceed 34-36° C. Shading is necessary for 3 to 4 months for cooling purposes, 1 month requiring also additional efforts for ventilation. Nights are cool during this period with a mean minimum temperature of 16-18° C. Summer in this region is rather hot and lasts from June till the end of October.

Temperatures in the coldest days range from a mean value of 0-3° C during the day to -2—6° C during the night, while the absolute minimum temperature never drops below -15° C. Frost occurs during 2 to 2.5 months yearly. Snowfall occurs only a few times, reaching 20cm in amount. Blizzards rarely occur. Fog is evident some days during fall and winter. As we move forward to south, this sort of meteorological phenomena intensify. Floods rarely happen. Interior spaces need heating for 4-5 months 24 hours a day, and for 7-8 months only at night, during which winds have a chilling effect. For 1 month during the daytime and for 4-5 months during the

nighttime, the wind chill factor may be applicable. Winter and summer winds are west- and southward, with decreasing strength toward the southern highlands. This region's winters are thus cold, lasting from December to end of April.

Grasses and bushes constitute the main vegetation type. The land turns green during early spring. The main occupancy of the inhabitants is farming (cultivation of land and raising livestock). Wheat, barley, and lentil are local crops raised by dry land farming. Livestock include cows and sheep, which are maintained in open spaces at summer days and in closed spaces during summer nights and winter. Heaters are used as heating devices, while fans along with natural ventilation provide for cooling. Among commonly used architectural spaces are *Iwan*, *soffeh*, and stove room.

2-2.The Foothills

This region embraces northern hillsides of Mt. Sabalan, stretching along a steep-sloped valley to the flat lands of Moqan. It can be divided into two eastern and western sub-regions which somewhat differ regarding duration and extremes of hot and cold weather.

2-2-1. Eastern Foothills

Eastern Foothills with 300-1400m altitude has a mean yearly temperature of about 10.5° C. The mean maximum temperature reaches 26-28° C in the hottest days, while the absolute maximum temperature does not exceed 34° C. Shading is necessary for cooling for 4 to 5 months, 1 to 2 month requiring also additional efforts for ventilation. Nights are cool during this period with a mean minimum temperature of 15-16° C. Summer in this region is hot overall and lasts from late spring till the end of summer.

Temperatures in the coldest days range from a mean value of 1-4° C during the day to -3.5—6° C during the night, while the absolute minimum temperature never drops below -15° C. Snowfall happens several times between late fall and early springtime, reaching approximately 40cm in amount. Strong blizzards blow and intense fog is evident during fall and spring. Strong floods run at 5- or 20-year intervals. Winds are either east or westward. Interior spaces need heating for 4-5 months 24 hours a day, and for about 8 months only at night, during which winds have a chilling effect. For 1-2 months during the daytime and for 4-5 months during the nighttime, the wind chill factor may be applicable. This region's winters are thus very cold, lasting from November to early spring.

Grasses, bushes, shrubs, and trees constitute the region's main vegetation type. The land turns green during early spring. The main occupancy of the inhabitants is farming (cultivation of land and raising livestock) and maintaining orchards. Wheat, barley, walnut, apple, and apricot are raised by irrigated or dryland farming. Livestock include cows and sheep, which are maintained in open spaces under shade at summer days and in closed spaces during summer nights and winter. Heaters are used as heating

devices, while natural ventilation alone suffices for cooling of spaces.

2-2-2. Western Foothills

Western Foothills with a 650-1400m altitude has a mean yearly temperature of 11-14° C. The mean maximum temperature reaches 31-33.5° C in the hottest days, while the absolute maximum temperature does not exceed 39° C. Shading is necessary for cooling for 6 months of the year, 3 months requiring also additional efforts for ventilation. Nights are cool during this period with a mean minimum temperature of 14-17° C. Summer in this region is hot overall and lasts from late spring till end of September.

Temperatures in the coldest days range from a mean value of 4-9° C during the day to -0.5—6° C during the night, while the absolute minimum temperature never drops below -20° C. Frost occurs for 2 to 4 months. Snowfall is limited and occurs during second half of fall through winter, reaching approximately 20-50cm and even more in highlands. Strong blizzards blow and intense fog is evident during fall and spring. Strong floods run at 5- or 20-year intervals. Winds are either east or westward and quite strong. Interior spaces need heating for 2-3 months 24 hours a day, and for 8-9 months only at night, during which winds have a chilling effect. During the period of 4-5 months the wind chill factor may be applicable. This region's winters are thus very cold, lasting from November to May.

Grasses, bushes, shrubs, and trees constitute the region's main vegetation type. The land turns green during early spring. The main occupancy of the inhabitants is farming (cultivation of land and raising livestock) and maintaining orchards. Wheat, barley, cherry, walnut, apple, and apricot are raised by irrigated or dryland farming. Livestock include cows and sheep which are all maintained in open spaces at summer days, and in closed spaces during summer nights (in some areas) and winter (in all areas). Heaters are used as heating devices, while fans and natural ventilation provide for cooling.

2-3.Cold Mountains

This region embraces the southern part of the province that loses altitude along two north-south and east-west slopes. This region can be divided into two eastern and western sub-regions which somewhat differ regarding duration and extremes of hot and cold weather.

2-3-1. Eastern Cold Mountains

Higher altitudes of about 1600-2000m have a mean yearly temperature of 8.5-12° C. The mean maximum temperature reaches 27-30° C in the hottest days, while the absolute maximum temperature does not exceed 39° C. Shading suffices for cooling for 4-5 months of the year, 1 to 2 months requiring also air ventilation. Nights are cool during this period with a mean minimum temperature of 12.5-14° C. Summer in this region is moderate and lasts from early June till end of September.

Temperatures in the coldest days range from a mean value of 1-3° C during the day to -5—10° C

during the night, while the absolute minimum temperature never drops below -25°C . Frost occurs for 5 to 6 months. Snow falls during November to March lasting 40-45 days. It reaches approximately 30cm in amount and remains on the ground until First of April. Blizzards blow frequently, sometimes strong and sometimes subtle. Thin fog is evident all year long. Strong floods run at 5- or 12-year intervals. Winds blow either south or northward and are subtle. Interior spaces need heating for 4-5 months 24 hours a day, and for 10-12 months only at night, during which winds have a chilling effect. For 2-3 months during the daytime and for 7-8 months during the nighttime, the wind chill factor may be applicable. This region's winters are thus very cold, lasting from November to early spring.

Grasses, bushes, shrubs, and trees constitute the region's main vegetation type. The land turns green during early spring. The main occupancy of the inhabitants is farming (cultivation of land and raising livestock) and maintaining orchards. Wheat, barley, alfalfa, and grains are raised by irrigated or dry land farming. Its fruit produce is mainly apple and pear. Livestock include cows and sheep which are all maintained in open spaces at summer days and in closed spaces during summer nights and winter. Heaters, furnaces and provide for heating. Moreover, sun-facing winter living areas are dwelled in during the cold period. Natural ventilation provides for cooling of spaces.

2-3-2. Western Cold Mountains

Lower altitudes of about 1000-1600m have a mean yearly temperature of $8-11^{\circ}\text{C}$. The mean maximum temperature reaches $33-36^{\circ}\text{C}$ in the hottest days, while the absolute maximum temperature does not exceed 41°C . Shading suffices for cooling for 6-7 months, 4 months requiring also air ventilation plus evaporative cooling by means of plants and bodies of water. Nights are cool during this period with a mean minimum temperature of $15-17.5^{\circ}\text{C}$. Summer in this region is slightly hot and lasts from June till end of September.

Temperatures in the coldest days range from a mean value of $-1-4^{\circ}\text{C}$ during the day to $-8-12^{\circ}\text{C}$ during the night, while the absolute minimum temperature drops to -25°C . Frost occurs for 3 to 4 months. Snow falls between December and March lasting about 30 days. It reaches approximately 20cm in amount and remains on the ground until late March. Blizzards occur rarely. Thin fog is evident through the cold half of the year. Floods run at 5- or 10-year intervals and are usually strong. Winds blow either south or northward and are subtle. Interior spaces need heating 3-4.5 months 24 hours a day, and 9-10 months only at night, during which winds have a chilling effect. For 1-2 months during the daytime and for about 7 months during the nighttime, the wind chill factor may be applicable. This region's winters are thus cold, lasting from November to early spring.

Grasses, bushes, cypress, plane tree, pine and willow tree constitute the region's main vegetation type. The land turns green during early spring. The main occupancy of the inhabitants is farming

(cultivation of land and raising livestock) and maintaining orchards. Wheat, barley, alfalfa, grains and summer crops are raised by irrigated or dry land farming. Its fruit produce is mainly apple, pear, cherry and walnut. Livestock include cows and sheep which are all maintained in open spaces at summer days and in closed spaces during summer nights and winter. Heaters, furnaces and winter living areas provide for heating, while fans along with natural ventilation provide for cooling of spaces.

2-4. The Very Cold Mountains

This region embraces the central part of the province, bounded by non active volcanic mountains of Sabalan on the west, and by Talesh Mountains on the east. This region can be divided into two eastern and western sub-regions which somewhat differ regarding duration and extremes of hot and cold weather.

2-4-1. Western Very Cold Mountains

Western areas bordering Mt. Sabalan have about 1000-1600m altitude and a mean yearly temperature of $7-10^{\circ}\text{C}$. The mean maximum temperature reaches $25-27^{\circ}\text{C}$ in the hottest days, while the absolute maximum temperature does not exceed 36°C . Shading suffices for cooling for 3-4 months of the year. Nights are cool during this period with a mean minimum temperature of $9-11^{\circ}\text{C}$. Summer in this region is moderate and lasts from early July till end of September.

Temperatures in the coldest days range from a mean value of $1-4^{\circ}\text{C}$ during the day to $-7.5-13^{\circ}\text{C}$ during the night, while the absolute minimum temperature drops to -20°C . Frost occurs for 5 to 6 months. Snowfall occurs numerous times, reaching approximately 30-40cm in amount. Strong blizzards blow in this region. Thin fogs appear and subtle winds blow. Interior spaces need heating for 5-6 months 24 hours a day, and for 9-10 months only at night, during which winds have a chilling effect. For 1-2 months during the daytime and for about 7 months during the nighttime, the wind chill factor may be applicable. This region's winters are thus very cold, lasting from mid-fall to early spring.

Grasses and bushes constitute the region's main vegetation type. The land turns green during early spring. The main occupancy of the inhabitants is farming (cultivation of land and raising livestock). Wheat, barley, potato, and beet are raised by mainly irrigated and sometimes dry land farming. Its fruit produce is mainly apple, pear, cherry and walnut. Livestock include cows and sheep which are all maintained in open spaces at summer days and in closed spaces during summer nights and winter. Heaters, furnaces and *kursis* (low blanket-covered tables under which a furnace burns and household sit around with their feet inside it) provide for heating, while natural ventilation suffices for cooling of spaces.

3. STRATEGIES USED IN RURAL ARCHITECTURE

In order to derive vernacular climate control strategies that also serve energy conservation purposes, a thorough assessment and analysis of local architecture of each described region was carried out. In a broad sense, the main climatic difficulty in this province is its cold weather, and the best solution to it is making use of solar radiation, shelter from winds, and minimizing heat transfers via the building envelope. As a result, heat loss and exposure to wind should be minimized during the rather long period of cold, while solar heat gain should be more efficiently considered. During the hot period of the year however, solar radiation should be avoided while benefiting from air ventilation.

By comparing the vernacular architecture to these basic principles, some design strategies uncover that can be further assessed to determine their compatibility with the regional climate. Properties of mentioned regional classifications with an emphasis on architectural qualities are discussed next.

3-1. Rural Texture

3-1-1. Density

In the Plains, the rural texture is disconnected and buildings are detached. Houses are flat-roofed one-storey buildings typically without a fenced yard. A few villages were observed to have gabled roofs.

In the Foothills, the rural texture appears contiguous and relatively dense composed of attached buildings. Houses are one or two-storey flat-roofed (sometimes gable-roofed) buildings having fenced yards.

In the Cold Mountains, rural texture is contiguous, dense, and sometimes stepped, composed of buildings compactly situated. Houses are one or two-storey flat-roofed (sometimes gable-roofed) buildings having fenced yards.

In the Very Cold Mountains, rural texture appears contiguous and very dense, composed of attached buildings with compact plan types. Houses are typically flat-roofed courtyard houses.

3-1-2. Orientation of Buildings

In the Plains and in the Foothills, the main orientation is toward South, whereas in the other two regions – the Cold Mountains and the Very Cold Mountains – it is toward both East and South.

3-1-3. Proportional Mass and Space

In the Plains and in the Foothills, the area of open spaces is greater than closed spaces, whereas in the Cold Mountains and the Very Cold Mountains, the area of courtyards casually equals that of closed areas.

3-2. Rural Housing

3-2-1. Arrangement of Spaces

In the Plains and Foothills, animal and human living spaces are casually arranged along a single-layered plan on the different borders of the yard. Main living area in the double-strayed houses of the Foothills is located on the second floor.

In the Cold Mountains, animal and human living spaces are continuously arranged alongside yard borders. In stepped villages, the ground floor normally comprises service and animal areas, while the second floor has the main living area.

In the Very Cold Mountains, animal and human living spaces are embraced by service areas.

3-2-2. Relationship of Open and Closed Spaces

In the Plains, usually a gallery connects the rooms to the yard, whereas animal spaces directly open onto it. Rooms have either large or multiple openings.

In the Foothills and in the Cold Mountains, separate summer or winter living rooms are built. Winter rooms have smaller window sizes. A gallery or an *lwan* provides the transition of an open yard into the rooms, whereas animal spaces directly open onto the yard. In the Very Cold Mountains, people sometimes cover this gallery (or *lwan*) with wooden boards or plastic or thatch to close it.

In the Very Cold Mountain region, both animal and human living spaces open into a gallery before entering the yard. An intermediate space separates animal areas from human living area, providing a roofed connection eliminating the need to cross the yard during winter. Separate summer or winter living rooms are built. Winter rooms have one small window and a furnace under the floor.

3-2-3. Heat-Emitting Spaces

Heat-emitting spaces such as the stove chamber and the kitchen in the Plains are located remotely from the main living areas. In the Foothills and in the Cold Mountains, beside the winter stove chamber, an open stove is also built with a hanging roof. In the Very Cold Mountains, houses have an open summer stove located in the corner of the yard and a closed stove chamber for winter.

3-2-4. Animal Areas

Aside from roofed animal areas, a *Bahar.band* which is a no-roof summer area is built in most Plains houses and some Foothills houses for use during warm weather. Animal areas in stepped villages of Cold Mountain and Very Cold Mountain regions occupy the ground floor, and in flat villages are surrounded by service areas.

3-2-5. Material

Among construction materials used are stone, mud and sometimes lime concrete for foundations. Walls are built with stone and mud and mud-brick. In the Plains, some straw matting walls are occasionally observed. Roofs are made of timber and boards or straw matting, with wooden posts and wooden doors and windows. Final finishing of surfaces is of mud plaster.

4. CONCLUSION: FINAL CLASSIFICATION IN ARDEBIL PROVINCE

A detailed assessment of similar and dissimilar architectural qualities of a vernacular climate-compatible design finally enabled us to classify the province into three architectural classes:

4.1 The Plains/Western Foothills

Cold weather is less extreme as compared to other regions, and humidity relatively high. Rural texture looks more disconnected and open spaces take up larger areas than closed spaces. Roofs are generally flat although sometimes gabled. Rooms are connected to the yard via a gallery or an *Iwan*, whereas animal spaces directly open onto the yard. Rooms have either large or multiple openings. Animal areas are single-layered spaces alongside borders of the yard, usually consisting of an open summer space called *Bahar.band*.

4.2 The Cold Mountain/Eastern Foothills

It is colder and less humid in this region as compared to the previous class. Rural texture is contiguous, relatively dense and sometimes in a stepped form. Open spaces take up approximately the same square footage as closed spaces. Houses are attached and densely built. Roofs are flat although sometimes gabled. Few openings are cut into the winter living areas. Rooms are connected to the yard via a gallery or an *Iwan* that is sometimes closed off temporarily during the cold period. Animal spaces directly open onto the yard, and are single-layered spaces alongside its borders. In stepped villages animal areas occupy the ground floor, whereas main living areas are located on the second floor. A summer stove chamber is built under a hanging roof.

4.3 Very Cold Mountain

This is the most extreme and the longest lasting cold region. Its humidity levels are also the lowest. Rural texture is contiguous and very dense. Open spaces take up less area than closed spaces. This means that houses are compactly attached while small courtyards open inside them. Houses are one-storey high and flat-roofed. Few openings are cut into the winter living areas. Human and animal living spaces are surrounded by service areas. A gallery connects rooms and animal spaces with the courtyard, and an intermediate space separates human and animal areas. There is usually a furnace underneath the floors of winter living areas.

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