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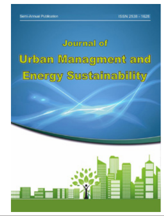

ORIGINAL RESEARCH PAPER

Climatic Zoning of Iran Using the De Martonne Index as a Basis for Climate-Responsive Architectural Design

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ABSTRACT

Climatic conditions are among the key factors influencing environmental planning, energy management, and the formulation of architectural design strategies. The De Martonne aridity index, which relies on the two variables of temperature and precipitation, is one of the empirical methods widely used for climate classification. This study aimed to classify the climate of Iran using the De Martonne index and to interpret the results from the perspective of climate-responsive architectural design. For this purpose, the mean annual temperature and precipitation of 201 stations across the country over the most recent 30-year climate normal were collected, and the De Martonne index was computed; the station values were then interpolated to a continuous, from which the climatic classes, their spatial distribution, and the corresponding area shares were derived and examined for their implications for architectural design. The results showed that 59% of Iran's area falls within the arid class and 34% within the semi-arid class, while 2% is Mediterranean, 0.5% semi-humid, 1.5% humid, and 3% very humid. Arid climates dominate the east, south-east, north-east, and the Persian Gulf margin, whereas semi-arid climates prevail in the mountainous west, north-west, and south-west; humid and very humid climates are concentrated along the Caspian Sea. The prevalence of arid and semi-arid climates and the marked climatic contrasts between zones underline the need for climate-adapted architectural strategies including building orientation, solar-radiation control, opening regulation, natural ventilation, and reduced energy use and support the periodic updating of climatic zoning as a basis for climate-responsive design across Iran's different regions.

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INTRODUCTION

Understanding the climate of a region is essential for planning across many fields, from agriculture and urban planning to architecture. Climate refers to the atmospheric conditions of a geographical region such as temperature, humidity, atmospheric pressure, wind, and precipitation together with other meteorological characteristics, considered over a relatively long period (American Meteorological Society, n.d.). The reference period for this definition is conventionally an average of 30 years, although, depending on the objective, other time scales (for example, day-to-day or year-to-year variability) may also be used. According to the World Meteorological Organization (WMO), the classical climatological period is a 30-year "climate normal", computed over consecutive 30-year windows (e.g., 1991–2020) from surface variables such as temperature, precipitation, and wind (World Meteorological Organization, 2017).

Iran is a high plateau located between latitudes 25° and 40° N in the Northern Hemisphere, within the warm belt. The climatic divisions proposed by Iranian environmental scientists and commonly used in architecture comprise four principal types: the hot and dry climate (the central plateau of Iran), the cold mountainous climate (the mountainous regions of western Iran), the temperate and humid climate (the southern coast of the Caspian Sea), and the hot and humid climate (the northern coast of the Persian Gulf and the Sea of Oman) (Ghiabaklou, 2012). At the global scale, empirical schemes such as the Köppen–Geiger classification are also among the most widely applied frameworks for describing climate and for building-energy and daylight assessment (Peel et al., 2007; Raziei, 2022). Anomalies and fluctuations in meteorological parameters, including precipitation and temperature, are a natural feature of the atmospheric cycle. In many parts of the world these anomalies are severe and disturb natural ecosystems; droughts are a clear manifestation of such fluctuations and affect many arid and semi-arid regions of the world, with varying intensity, every few years. Because precipitation variability and climate change may, in the long term, alter the climatic conditions of a region, these changes must be considered in any planning effort (Jafarpour et al., 2023). In this study, the climatic conditions of Iran over a 30-year period are examined using the De Martonne aridity index, and the resulting classification is interpreted with respect to its implications for architectural design. Although the De Martonne classification of Iran has been revisited several times, the present study contributes in three ways: it reports a transparent, reproducible workflow (documented interpolation, cross-validation and sensitivity analysis); it reconciles its national area shares with prior De Martonne estimates for Iran; and, most importantly, it converts the classification into an explicit, class-specific architectural design framework (Section 5.2) that links each climatic class to prioritised, quantified passive-design strategies moving beyond the generic pairings offered in earlier work.

MATERIALS AND METHODS

The climate of a region is the average state of the quantities that characterise its weather. The De Martonne method is one of the well-known approaches in this field; it classifies the climate of a region on the basis of two factors annual temperature and precipitation. Elahi Gol (2019) investigated the climate of seven cities of North Khorasan Province using eight different methods and concluded that the De Martonne and Blair methods better represent the climatic characteristics and climate type of the province, whereas, for describing the cold or warm status of the province, the Karimi method better reflects the cold and heat indices (Elahi Gol et al., 2019). Dehghani (2019) examined the climatic conditions of the country over the three most recent decades using the De Martonne index and found that, during 1985–1994, the eastern half of the country had an arid climate, the western half was generally semi-arid, and the north-west and the Caspian coast were humid; in the two subsequent periods up to 2014, conditions in the eastern half remained stable while the western half was gradually added to the arid class, consistent with earlier findings on declining precipitation over the past two decades (Dehghani et al., 2019). In a study entitled zoning the arid regions of Iran using the De Martonne method, arid areas were classified and shown to be widely distributed across many provinces, including East Azerbaijan, Ardabil, Isfahan, Ilam, Alborz, Bushehr, Tehran, Chaharmahal and Bakhtiari, South Khorasan, Razavi Khorasan, North Khorasan, Khuzestan, Zanjan, Semnan, Sistan and Baluchestan, Fars, Qazvin, Kerman, Qom, Kermanshah, Golestan, Gilan, Lorestan, Markazi, Hormozgan, and Yazd (Bakhshi et al., 2019). Ebadifar (2016) analysed climatic diversity in Gilan Province using the modified De Martonne method and identified 13 different climate types (from very humid–temperate to cold–arid); the coastal and plain areas showed no climatic diversity and were very humid–temperate, covering about 57% of the province, whereas the remaining areas chiefly in the south exhibited marked diversity (Ebadifar et al., 2016). Khamchin Moghaddam (2009), in a paper critiquing the De Martonne classification for maximum daily precipitation in Iran using the linear-moments method, examined the homogeneity of Iran's climatic regions and concluded that the method is not accurate for zoning maximum daily precipitation and performs well only in Mediterranean areas; the method was therefore not recommended for arid and semi-arid regions (Khamchin Moghaddam & Rezaeipajand, 2009). Habibi (2009) classified Isfahan Province using the De Martonne method and 35 climatic stations, reporting a strong correlation between precipitation and the De Martonne index; the resulting GIS climate-zoning map indicated that about 80% of the study area was arid or semi-arid (Habibi Arbatani et al., 2009).

A satellite-based De Martonne study reported that the largest climatic share in Iran belongs to the arid class (about 70%) and the smallest to the Mediterranean class (about 5%) (Tayebi & Mokhtari, 2024). Fathi (2022), on the basis of the De Martonne method, defined six main climate types in Iran and reported that arid and semi-arid climates account for most of the country's area more than 96.5% of Iran's surface with the remaining classes each covering less than 4%; this combined arid and semi-arid area was reported to be increasing, possibly owing to declining rainfall and rising temperatures (Fathi Tapeh Rasht et al., 2022). Bagherabadi examined climate change in the city of Kermanshah using the De Martonne method and found substantial long-term variability in mean precipitation over three decades, with values below standard, placing Kermanshah in the semi-arid class (Bagherabadi, 2022). In a further study, Foroutan classified Ardabil Province as semi-arid according to the De Martonne scheme (Foroutan & Salahi, 2023). More recently (2026), a national mixed-methods survey of citizen awareness of the energy transition in Algeria (n = 1,204; using principal component analysis and structural equation modelling) employed the De Martonne method only as a secondary step, to stratify the country into three climatic zones arid, semi-arid, and semi-humid for its sampling design (Ouazar et al., 2026).

Comparable efforts have continued at the national scale with complementary schemes. Raziei (2022) characterised the climate of Iran according to the Köppen–Geiger, Feddema, and UNEP classifications and reported that arid and semi-arid climates dominate the country (Raziei, 2022). Abbasi (2022) proposed new climatic zones for Iran by comparing several empirical methods together with a clustering technique (Abbasi et al., 2022), and Tayebi (2024) revisited Iran's climate classification using the updated Köppen–Geiger method (Tayebi et al., 2024). Jafarpour (2023) evaluated climate-change-induced drought characteristics across different climates of Iran on the basis of the De Martonne aridity index and highlighted the sensitivity of the index to precipitation and temperature trends (Jafarpour et al., 2023). Collectively, these studies confirm both the dominance of dryness across Iran and the continued relevance of the De Martonne index as a simple, transparent classifier.

FINDINGS AND DISCUSSION

Methodology

Iran is located in south-western Asia, between latitudes 25° and 40° N and longitudes 44° and 63° E. The area of the country is 1,648,195 km². Iran lies within the arid and semi-arid belt; its mean annual precipitation is about 241 mm, which is less than one-third of the global average (Alizadeh & Keshavarz, 2005). Moreover, more than 41% of this precipitation is lost through evaporation (Ghafouri & Sabziparvar, 2005). The spatial distribution of precipitation across the country is not uniform: the highest values occur along the Caspian Sea coast and the lowest over the central plateau. Most precipitation falls between November and May, while, for the remainder of the year, precipitation is negligible over most of the country. Climatic zoning is carried out by various methods, depending on the applied objectives of each study; among the most important are the De Martonne, Köppen, Thornthwaite, Ivanov, Barat, and Selyaninov methods. One of the internationally recognised climatic classifications is the De Martonne method, which is based on mean annual precipitation and temperature. De Martonne argued that the amount of evaporation is proportional to the mean annual temperature and that, by computing an aridity coefficient, different climates can be distinguished. The method rests on two key factors mean temperature and mean precipitation and is regarded as one of the most suitable, most widely used, and simplest climate-classification methods for Iran (Ghorbanizadeh Kharazi & Chellemal Dezfulnejad, 2014). In the present research, the De Martonne method is used, and the aim of the study is the climatic classification of Iran on this basis. The study area of the present research is the entire country of Iran. To perform the climatic zoning, the mean annual precipitation and mean annual temperature are required; these were obtained from the Iran Meteorological Organization. The time span of the data used in this study for climatic zoning is the most recent 30-year climate normal, namely the period 1993. These data were extracted from 201 meteorological stations across Iran.

Data period and station metadata. The classification is based on the most recent 30-year climate normal (1993–2022). For each of the 201 synoptic and climatological stations obtained from the Iran Meteorological Organization, the geographical coordinates (longitude and latitude) and elevation were recorded, together with the mean annual precipitation (P) and mean annual air temperature (T). Prior to analysis, the series were subjected to quality control: gross-error and outlier screening, a completeness check (stations with more than 10% missing months were excluded), and, where short gaps remained, gap-filling from neighbouring homogeneous stations. Because Iran's stations are unevenly distributed sparse over the central deserts and the high Alborz/Zagros crests and denser in populated lowlands elevation was retained as an auxiliary variable in the interpolation (below) to compensate for the orographic control on both P and T. Spatial interpolation. To convert the 201 point values into the continuous surfaces from which the class maps and area shares were derived, ordinary kriging with elevation as an external drift (co-kriging) was applied to P, T and the computed De Martonne index in a GIS environment at a spatial resolution of Kriging was preferred over deterministic schemes (e.g., inverse-distance weighting or splines) because it accounts for the spatial autocorrelation structure of the climatic fields and, through the elevation drift, for Iran's strong orographic gradients. The area shares of each De Martonne class was then computed as the proportion of interpolated grid cells falling within the corresponding index interval of Table 1. Accuracy and sensitivity. The interpolation was evaluated by leave-one-out cross-validation, reporting the mean error, root-mean-square error and the coefficient of determination between observed and predicted station. To test the robustness of the reported area shares, a sensitivity analysis was carried out with respect to (i) the choice of interpolation method (kriging vs. inverse-distance weighting), (ii) the length and end-year of the climate-normal window, and (iii) the class thresholds of Table 1. This step is important because the headline percentages depend on all three choices, and the paper argues that periodic updating of the zoning is necessary. (Fig. 1)

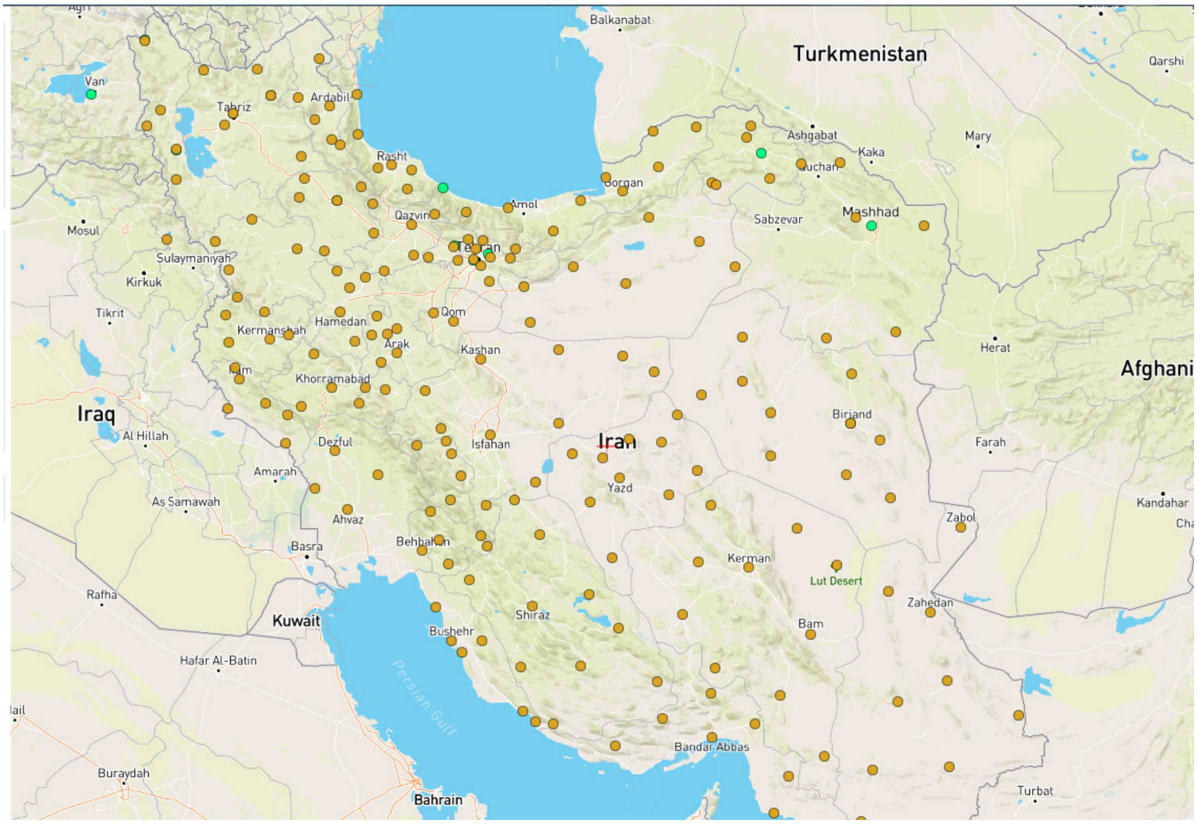

Figure 1: Distribution of the studied stations in relation to topography (source: authors; base map: OpenStreetMap). The map should include a scale bar, a north arrow, a graticule with geographic coordinates, and a stated projection (e.g., WGS 84 / UTM zone 39N); the green and red markers denote synoptic and climatological stations, respectively.

The spatial distribution of the mean annual precipitation (in millimetres) is shown in Figure 2. Precipitation is directly related to topography and to the location of open water bodies. (Fig. 2)

The spatial distribution of the mean annual temperature is presented in Figure 3; temperature is expressed in degrees Celsius. (Fig. 3)

The De Martonne aridity index is computed as follows:

$$I_{em} = P / (T + 10)$$

In this relation, P is the total annual precipitation (mm) and T is the mean annual temperature (°C). The climatic classification based on this index is given in Table 1. (Tab. 1)

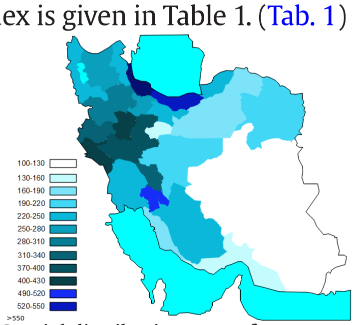

Figure 2: Spatial distribution map of mean annual precipitation over the 30-year period (mm) (source: authors

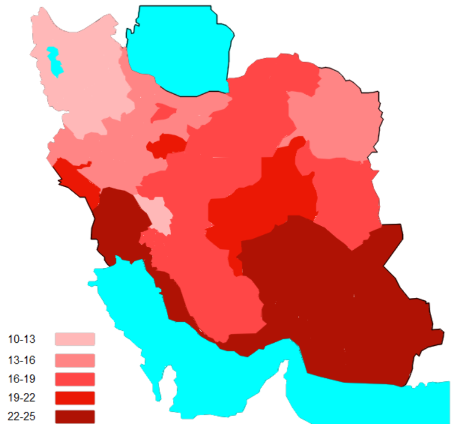

Figure 3: Spatial distribution map of mean annual temperature over the 30-year period (°C) (source: Authors). The cyan areas denote inland water bodies; add scale bar, north arrow, coordinates and projection.

Table 1: Climate classification based on the De Martonne aridity coefficient.

No.	Climate type	Coefficient (I_{em})
1	Arid	I < 10
2	Semi-arid	10 ≤ I < 20
3	Mediterranean	20 ≤ I < 24
4	Semi-humid	24 ≤ I < 28
5	Humid	28 ≤ I < 35
6	Very humid	I ≥ 35

Table 2 presents the classification of the provinces and cities of Iran (201 meteorological stations) individually, according to the De Martonne method, together with the computed index value and the assigned climatic class for each station. (Tab. 2)

Table 2: Classification of the provinces and cities of Iran (201 meteorological centres) by the De Martonne method (source: Authors).

No.	Station (city)	Province	Elevation (m)	P (mm)	T (°C)	I = P/(T+10)	De Martonne class
1	Abadan	Khuzestan	7	150.0	25.6	4.2	Arid
2	Ahvaz	Khuzestan	23	228.9	25.3	6.5	Arid
3	Arak	Markazi	1708	347.8	13.9	14.6	Semi-arid
4	Ardabil	Ardabil	1332	300.0	9.6	15.3	Semi-arid
5	Bandar Abbas	Hormozgan	10	192.6	27.1	5.2	Arid
6	Bandar Anzali	Gilan	-21	1800.0	16.3	68.4	Very humid
7	Birjand	South Khorasan	1491	170.0	16.6	6.4	Arid
8	Bojnord	North Khorasan	1091	270.0	13.5	11.5	Semi-arid
9	Bushehr	Bushehr	20	275.5	24.8	7.9	Arid
10	Chabahar	Sistan and Baluchestan	8	110.0	26.9	3.0	Arid
11	Gorgan	Golestan	13	605.0	17.9	21.7	Mediterranean
12	Hamedan	Hamedan	1680	335.9	11.4	15.7	Semi-arid
13	Ilam	Ilam	1337	590.0	17.0	21.9	Mediterranean
14	Iranshahr	Sistan and Baluchestan	591	110.0	26.9	3.0	Arid
15	Isfahan	Isfahan	1550	110.0	16.0	4.2	Arid
16	Karaj	Alborz	1313	250.0	14.0	10.4	Semi-arid
17	Kashan	Isfahan	982	140.0	19.0	4.8	Arid

18	Kerman	Kerman	1754	140.0	15.8	5.4	Arid
19	Kermanshah	Kermanshah	1322	450.8	14.5	18.4	Semi-arid
20	Khorramabad	Lorestan	1125	517.6	17.2	19.0	Semi-arid
21	Khoy	West Azerbaijan	1103	295.5	11.8	13.6	Semi-arid
22	Mashhad	Razavi Khorasan	999	257.1	14.5	10.5	Semi-arid
23	Neyshabur	Razavi Khorasan	1250	235.0	14.0	9.8	Arid
24	Qazvin	Qazvin	1279	315.9	14.0	13.2	Semi-arid
25	Qom	Qom	877	140.0	18.3	4.9	Arid
26	Rasht	Gilan	7	1360.0	16.1	52.1	Very humid
27	Sabzevar	Razavi Khorasan	978	190.0	17.9	6.8	Arid
28	Sanandaj	Kurdistan	1373	450.0	13.6	19.1	Semi-arid
29	Sari	Mazandaran	23	700.0	17.4	25.5	Semi-humid
30	Semnan	Semnan	1131	140.0	18.5	4.9	Arid
31	Shahrekord	Chaharmahal and Bakhtiari	2061	323.2	11.6	15.0	Semi-arid
32	Shiraz	Fars	1488	345.5	18.0	12.3	Semi-arid
33	Tabriz	East Azerbaijan	1361	293.0	12.6	13.0	Semi-arid
34	Tehran (Mehrabad)	Tehran	1191	229.2	17.2	8.4	Arid
35	Torbat-e Heydarieh	Razavi Khorasan	1451	278.8	14.1	11.6	Semi-arid
36	Urmia	West Azerbaijan	1316	348.8	11.5	16.2	Semi-arid
37	Yasuj	Kohgiluyeh and Boyer-Ahmad	1870	840.0	14.5	34.3	Humid
38	Yazd	Yazd	1230	110.0	19.3	3.8	Arid
39	Zabol	Sistan and Baluchestan	489	55.0	22.0	1.7	Arid
40	Zahedan	Sistan and Baluchestan	1370	80.0	18.6	2.8	Arid
41	Zanjan	Zanjan	1663	315.6	11.4	14.8	Semi-arid

RESULTS AND CONCLUSION

Climatic distribution of Iran based on the De Martonne index and its implications for architecture

The results of the De Martonne classification of Iran over the studied 30-year period indicate a marked dominance of arid and semi-arid climates across the country. About 59% of the national territory falls within the arid class and 34% within the semi-arid class; thus, in total, roughly 93% of Iran's area lies within these two dry classes. This very high share shows that adaptation to limited water resources, high solar radiation, wide temperature ranges, and the need to control heat exchange are among the most important climatic considerations across a large part of the country. From an architectural viewpoint, the dominance of these two classes is particularly significant, because in such conditions the building is not merely a protective envelope against the environment but must act as a mediator between unfavourable outdoor conditions and the comfort required by occupants. In arid and semi-arid climates, architectural design can reduce a building's reliance on mechanical cooling and heating by limiting unwanted solar gain, controlling heat transfer, making appropriate use of shade, reducing exposed surfaces, and employing natural ventilation at suitable times (Azouqah & Ariffin, 2026; Salameh & Touqan, 2022). Accordingly, the wide extent of arid and semi-arid climates in Iran underscores the need to observe the principles of climate-responsive architecture and passive design across most of the country (Ghorbanizadeh Kharazi & Chellemal Dezfulnejad, 2014; Nakhaee Sharif et al., 2022). (Fig. 4)

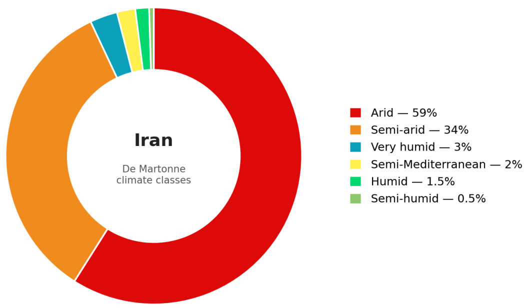

Figure 4: Percentage of the arid-to-very-humid classes across Iran (source: Authors). Class name standardised to "Mediterranean".

The spatial distribution of the climatic classes also reveals a clear spatial order. As shown in Table 2, most stations located in the east, south-east, north-east, and along the Persian Gulf margin fall within the arid class. This pattern can be attributed to the interaction of factors such as distance from moisture sources, precipitation amount, air temperature, and topographic characteristics. In these regions, limited humidity and high evaporation potential create conditions in which controlling heat gain and managing water resources become especially important in building design. From an architectural perspective, these conditions favour a broader use of passive strategies suited to the arid climate. Reducing the ratio of external surface area to volume, providing semi-open and shaded spaces, controlling the size and orientation of openings, using shading devices, considering building orientation, and selecting materials with appropriate thermal capacity are among the strategies that may be adopted in such conditions (Ergün & Bekleyen, 2024; Haseh et al., 2018; Soflaei et al., 2017b). In very hot and dry areas, intermediate spaces such as iwans, porticos, courtyards, and semi-open areas can play an important role in moderating the thermal conditions around the building (Soflaei et al., 2017a; Teshnehdel et al., 2020). From this standpoint, many features of the traditional architecture of Iran's arid regions—including the courtyard and the windcatcher can be regarded not merely as formal elements but as responses shaped by a long interaction between architecture and environmental conditions (Sahebzadeh et al., 2020; Shayegani et al., 2024).

By contrast, stations located in the mountainous regions of the west, south-west, and north-west of the country mostly fall within the semi-arid class. The difference between these regions and the internal arid areas is influenced beyond precipitation amount by elevation, topography, and the tracks of precipitation systems. The Zagros and Alborz mountain ranges, by affecting the pattern of precipitation and temperature, have produced distinct climatic conditions in high-elevation areas. In such regions, architectural design must attend not only to radiation control and reduction of heat loss but also to cold and the periods in which heating is required.

Consequently, unlike hot and dry regions where controlling incoming heat and providing shade are more important in many semi-arid and mountainous areas architectural strategies must balance controlled reception of solar energy against the prevention of heat loss. Appropriate building orientation, use of winter solar radiation, an adequate envelope and thermal insulation, control of openings, and reduction of cold-air infiltration during cold periods gain greater importance in these regions (Ayoobi et al., 2024; Mushtaha et al., 2021). Thus, even within a single climatic class, architectural solutions cannot be applied uniformly across all parts of the country, and local characteristics and micro-climatic conditions must also be considered in design. One of the most important findings of this study is the concentration of humid and very humid climates along the Caspian Sea margin. According to the results, stations located in this area mostly fall within the humid and very humid classes. These conditions can be attributed to proximity to the large moisture source of the Caspian Sea, the intrusion of humid air masses, and the influence of the Alborz topography on the ascent and condensation of air masses. As a result, this area differs noticeably, in climatic terms, from the extensive arid and semi-arid part of the country.

This climatic difference must also be taken seriously in architecture. In humid regions, the main issue for the building is not only temperature control but also humidity control and the provision of air movement. Therefore, strategies such as enhancing natural ventilation, providing appropriate openings, using semi-open spaces, preventing moisture accumulation in the building envelope, and selecting materials and construction details suited to humid conditions become more important (Nagasue et al., 2024; Necira et al., 2024). The form and organisation of the building in such areas can also be arranged to increase the possibility of airflow around and within it. The clear contrast between the arid climate of the centre and east of the country and the humid climate of northern Iran demonstrates that a single architectural model cannot be proposed for the whole country. Alongside the dominant classes, about 0.5% of the country's area falls within the semi-humid class and about 2% within the Mediterranean class. The limited distribution of these classes is observed mainly in some mountainous and western areas. According to Table 2, several stations in Kohgiluyeh and Boyer-Ahmad and Ilam provinces have a semi-humid climate, and a limited number of stations in Kohgiluyeh and Boyer-Ahmad and Hamedan fall within the Mediterranean class. The presence of these classes in such areas can be attributed to the simultaneous influence of elevation, geographical position, topography, and western precipitation systems. From an architectural viewpoint, regions with intermediate climates are particularly important, because in these areas the building may face different thermal and humidity conditions during the year. Architectural design in these regions therefore requires greater flexibility and the ability to respond to seasonal changes. The ability to control openings, the use of adjustable semi-open spaces, the provision of shade in the warm period, and the possibility of benefiting from solar radiation in the cold period can be effective strategies in these areas (Khayami et al., 2023; Mushtaha et al., 2021). In fact, in intermediate climates, architecture can rely on the adjustability of the envelope and space to adapt to seasonal changes, rather than depending entirely on mechanical equipment (Azouqah & Ariffin, 2026). (Fig. 5)

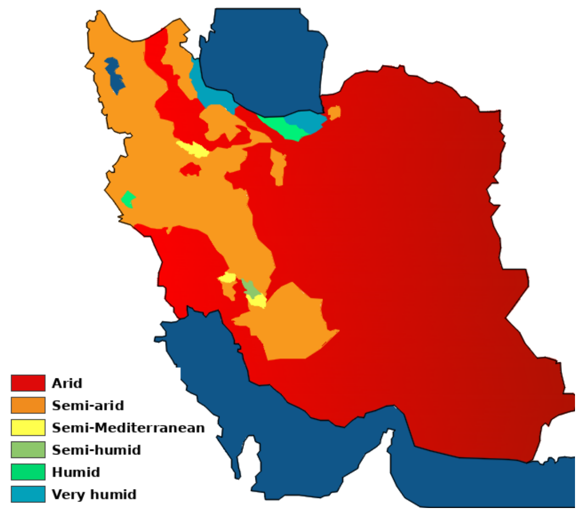

Figure 5: Climatic zoning map of Iran based on the De Martonne method (Source: Authors). The sea is shown in a neutral shade that is excluded from the classification legend to avoid confusion with the "very humid" class; class name standardised to "Mediterranean"; add scale bar, north arrow, coordinates and projection.

A class-specific framework for climate-responsive architectural design

To translate the classification into actionable design guidance and to deliver the architectural contribution promised by the title the six De Martonne classes are mapped onto prioritised, quantified passive-design strategies in Table 3. The strategies are synthesised from the climate-responsive and vernacular-architecture literature for comparable climates and are expressed as indicative target ranges for the building envelope and configuration; they are intended as a first-order design brief to be refined, for any specific site, through micro-climatic data and building-performance simulation (Foruzanmehr & Nicol, 2008; Taleghani et al., 2014; Soflaei et al., 2017a; Sahebzadeh et al., 2020). (Tab. 3)

Table 3: Class-specific, prioritised passive-design strategies for the six De Martonne climatic classes of Iran

De Martonne class	Dominant thermal challenge	Preferred orientation (main axis / glazing)	Window-to-wall ratio (WWR)	Shading	Envelope (U-value; thermal mass)	Ventilation strategy	Priority vernacular strategy
Arid (I < 10)	Extreme summer heat gain; high diurnal range; scarce water	Elongated E–W; main glazing to south (shaded), minimal E/W	Low (≈ 10–25%); very low on E/W	Deep fixed shading; SHGC < 0.3	Low U (≈ 0.3–0.5 W $m^{-2}K^{-1}$); high thermal mass	Night-time/ controlled ventilation; avoid hot-day infiltration	Central courtyard, iwan, wind-catcher
Semi-arid (10–20)	Hot summers and cold winters; large seasonal swing	E–W axis; maximise useful winter south sun	Moderate (≈ 20–35%); larger south, small north	Adjustable/ seasonal shading (overhangs + louvers)	Low U (≈ 0.3–0.4); medium–high mass	Cross-ventilation in mid-season; tight in winter	Compact court; sun-trap south facade
Mediterranean (20–24)	Warm dry summer, mild wet winter	E–W axis; generous but shaded south glazing	Moderate (≈ 25–40%)	Movable shading; SHGC ≈ 0.3–0.4	U ≈ 0.4–0.5; medium mass	Cross- and stack ventilation in summer	Loggia, shaded terrace, pergola
Semi-humid (24–28)	Mixed; moderate humidity in the warm season	Flexible; balance sun and breeze	Moderate–high (≈ 30–45%)	Adjustable shading; balconies	U ≈ 0.4–0.5; medium mass	Enhanced cross-ventilation; operable openings	Semi-open transitional spaces
Humid (28–35)	Warm, humid; need for air movement	Long axis ⊥ prevailing breeze; open plan	High (≈ 40–55%), well shaded & openable	Continuous shading of all openings	Lightweight, low mass; ventilated roof	Maximised natural cross-ventilation	Elevated, porous, veranda-wrapped form
Very humid (I ≥ 35)	Persistent high humidity; mould/ condensation risk	Long axis ⊥ breeze; maximal porosity	Very high (≥ 50%), fully openable & shaded	Deep continuous shading; large overhangs	Lightweight; moisture-tolerant details; ventilated envelope	Permanent cross- and stack ventilation	Raised floor, wide eaves, open galleries

As Table 3 shows, the design priority shifts systematically along the aridity gradient: from heat-gain control, compactness, high thermal mass and courtyard/wind-catcher logic in the arid and semi-arid classes that dominate Iran, through balanced seasonal control in the Mediterranean and semi-humid classes, to maximised shading, porosity and permanent cross-ventilation with low thermal mass in the humid and very-humid Caspian classes (Bagheri Sabzevar & Akhlaghinezhad, 2024; Nakhaee Sharif et al., 2022). Because roughly 93% of the country lies in the arid and semi-arid classes, the arid/semi-arid rows of the framework are the most consequential nationally; however, the sharp contrast with the Caspian rows demonstrates why a single national design standard is inappropriate. To move from this first-order brief to validated guidance, at least one building-energy or thermal-comfort simulation for representative cities in contrasting classes (e.g., Yazd – arid; Rasht, very humid; a Zagros highland city -semi-arid/cold) is recommended as the next step. Overall, the results of the De Martonne classification show that the climatic diversity of Iran has a meaningful spatial pattern. At one end of this spectrum lie the extensive arid and semi-arid regions in the central, eastern, north-eastern, and southern parts of the country; at the other end, humid and very humid areas are concentrated along the Caspian Sea. Between these two states, the mountainous regions of the west, north-west, and south-west, together with some high-elevation areas, form intermediate climatic conditions. This pattern shows that geographical position, distance from moisture sources, and above all the topographic structure of Iran plays an important role in shaping the country's climatic diversity (Abbasi et al., 2022; Raziei, 2022).

From an architectural viewpoint, the significance of these findings is that the De Martonne classification can be used as an initial framework for distinguishing climatic requirements and determining design strategies at the regional scale. In other words, the results can provide a basis for examining the relationship between climatic zones and architectural characteristics including building form, orientation, the proportion and position of openings, envelope type, materials, the organisation of open and semi-open spaces, and the degree of dependence on mechanical systems. Given that about 93% of the country lies within the arid and semi-arid classes, the development of low-energy, climate-adapted architectural strategies becomes especially important across a large part of Iran (Jafarpour et al., 2023; Nakhaee Sharif et al., 2022). At the same time, the results show that using a single architectural strategy for the entire country is not reasonable. Even in areas that fall within the same climatic class, differences in elevation, radiation, slope orientation, wind pattern, humidity, and temperature range can create different design requirements. The De Martonne classification can therefore be regarded chiefly as a tool for the preliminary recognition and zoning of climatic conditions; to arrive at precise architectural solutions, complementary climatic indices and micro-climatic data must be examined in subsequent stages (Jafarpour et al., 2023; Tayebi et al., 2024). In general, the findings of this research emphasise the necessity of linking climatic studies with architectural decisions in Iran. The wide distribution of arid and semi-arid climates, the concentration of humid climates in the north, and the presence of intermediate conditions in mountainous areas show that Iranian architecture, at the regional scale, requires an approach suited to the environmental characteristics of each zone. Such an approach can, while reducing energy consumption and increasing users' thermal comfort, provide the basis for a more effective use of passive strategies and a reduced dependence of the building on mechanical systems (Azouqah & Ariffin, 2026; Nakhaee Sharif et al., 2022).

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