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Topography and climate of Mount Karanfil (Pozantı/Adana)

Muhammed Çetin^{1*} and Ali Meydan²

Abstract

The goal of this study is to investigate the impact of the topographic features of Mount Karanfil and its surroundings on the local climate. Mount Karanfil, located in the Mediterranean Basin, has a unique ecological position due to its topography. This study analyzed temperature, precipitation, and wind conditions at Mount Karanfil from 1980 to 2018 using data from the General Directorate of Meteorology (MGM). The temperature indices were calculated using the Clima data and the ArcGIS v10.5 software package. The temperature indices series was analyzed using cluster analysis in ArcGIS v10.5 before being used to calculate the maximum and minimum temperature and precipitation values for each month. The spatial estimation method IDW interpolation was then applied to these data. The initial analysis showed significant differences in temperature, precipitation, and wind conditions between this location and others. This may be due to the southern aspect of the landscape, which receives more precipitation than other slopes and is affected by south-oriented sectoral winds that bring abundant precipitation to the southern slopes. The results of the temperature indices analysis showed that evaporation tends to increase on hot days with high maximum temperatures compared to days with low minimum temperatures. The Emberger bioclimatic index also confirmed the typical Mediterranean climate of mild, rainy winters and hot, dry summers. In addition to the regional climate and geology, the geomorphologic conditions of the mountainous mass and the specific valley profiles of the Ecemis stream and Cakit stream (such as the strait valley) were found to influence the local climate. These valley profiles, which are composed of narrow and deep dolomitic and limestone layers, showed differences in climate due to their slope, elevation, and aspect, as analyzed using digital elevation models with a resolution of 10–20 m. These topographic analyses revealed that elevation decreases and humidity increases in alluvial valley floors.

Keywords Mount Karanfil, Topographic variables, Climate features, IDW interpolation

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*Correspondence:

Muhammed Çetin
muhammed.cetinn.66@gmail.com

¹ Ahi Evran Vocational and Technical Anatolian High School,
50160 Nevşehir, Turkey

² Faculty of Education, Department of Social Sciences Education, Nevşehir
Hacı Bektaş Veli University, 50300 Nevşehir, Turkey

Introduction

Climate is a system that includes observed climatological extremes and various forms of statistical variability, including extreme weather events. It determines the character and vegetation development of a region in terms of weather events (Şensoy et al. 2020). With the aid of current technological advances in climatology through GIS, the relationship between climate and topography can be more effectively revealed (Chytrý et al. 2022; Al-Ansari 2021; Diogo and dos Santos 2021; Mallard and Salles 2021; Whang et al. 2021; Lavrillier and Gabyshev 2021; Hokansan 2021; Hosseini et al. 2021; Keshavarz and Moqadas 2021; Xu et al. 2021; Zeroual et al. 2020). This allows for solutions to be proposed for regional

climatic differentiation problems. The recent diversity of topo-climatic studies in mountain biome areas has increased our understanding of this orographic-climatic belt, with its micro and macro relief (Çetin 2020; Mangone et al. 2021; Matavelli et al. 2022). Topography, or the relief of a place, refers to the diversity of elevation, aspect, orography, slope, and landforms (such as mountains, deep valleys, steep slopes, plains, and plateaus). All of these topographic features influence regional climate and may cause differences in terms of climate development in terms of its general distribution and area of influence. In other words, in studies based on topography, climatology, hydrography, hydrology, and the natural environment, the climate type of an area can be revealed by examining various data, particularly temperature. The distribution of climate types on a global scale varies primarily due to latitude, terrestrial and marine atmospheric circulation, landforms, location, and altitude (Birsoy and Ölgün 1992).

Additionally, general ocean circulation and large-scale movements in the atmosphere contribute to energy transfer on Earth by carrying warm water masses towards the poles and cool water masses towards the equator (Türkeş 2017). Climate classifications, which aim to systematically group and divide climatic conditions based on their characteristics, are a significant subject in climatology (Türkeş 2010). These classifications are important for science and practice as climatic conditions directly and indirectly affect geomorphological planning, agricultural systems, settlement types, transportation systems, tourism activities, and vegetation development. In research based on climate science and hydrology, it can be difficult to reveal the climatic characteristics of a place. In light of these difficulties, it is important to examine all the climatic elements of that area together (Birsoy and Ölgün 1992). In this context, determining the climate type is a complex task and has been a significant issue in climatology. The increase in methods used for climate classifications is also high (Birsoy and Ölgün 1992). To understand the climate of the world, many analysts have proposed climate principles and formulas and offered solutions (such as Thornthwaite 1948). In this regard, climate classifications by Thornthwaite (1948), De Martonne (1942), Erinç (1965), and Emberger (1954) have been applied.

Study area

Mount Karanfil is a mountainous region located between 37°36' north latitudes and 35°03' east longitudes in the south of Aladağlar. It is mostly surrounded by medium-high mountains, high mountains, and medium-altitude plateau areas, with a ratio of 3% in terms of macro landforms (Çetin 2020). The study area has an average elevation of 3675 m, with slope values ranging from

a minimum of 0–3% to a maximum of 30.1–100%. The main areas where this change is most noticeable are the steep slopes and peak points in the east of Dagdibi, as well as the narrow and deep valley profiles cleaved by the Ecemis Stream and Cakıt Stream, which run in a north–south direction. The study area is bordered by Osmaniye in the east, Kayseri in the northeast, Nigde in the northwest, and Hatay in the southeast (Fig. 1).

The present study synthesizes existing literature on mountain biome ecosystem vulnerability assessments across the world's mountain regions (Thakur et al. 2021). The synthesis reveals a globally substantial number of studies are available on the mountain topography systems and climate structure assessments. Mountain regions also a quarter of the world's forest (Hamilton 2002; Gradstein et al. 2008; Spehn et al. 2010), which provide a range of ecosystem services to at least half on humankind (Grêt-Regamey et al. 2012; Sears et al. 2017).

Mountains are also home to 50% of global biodiversity hotspots, which support approximately one-quarter of the world terrestrial biological diversity (Hamilton 2002; Spehn et al. 2010; Price et al. 2011). The mountains facing imminent environmental conditions (such as complex geomorphology systems, a lot of climate structure diversity) changes, which affect biotic and abiotic ecosystem, and ultimately sustainability. Mountain biome areas have been recognized highly sensitive and vulnerable to climate change (Grabherr et al. 2000; Michelsen et al. 2011; Kozyr 2014). Most of the study area is geologically within the Aladağ structural unit, which is in the Upper Devonian-Maastrichtian age range. In terms of environment and rock characteristics, sublittoral (carbonate and clastic rock) pebbles are dominant (Özgül 1976). All rock units except for the Upper Triassic rock units are metamorphosed and positioned on the Geyik Mount and Bolkar units (Fig. 2). Previous studies on Mount Karanfil and its surroundings have focused on basic structural features (Robertson et al. 2022), as well as the flowering flora (Yeşeri 2003), glacial-tectonic geomorphology, and glacial geochronology (Sarıkaya et al. 2012, 2014; Köse et al. 2019a, b). However, the topographic development, along with the climate structure, changes the climatic, orographic, and bioclimatic environmental conditions of mountain biome areas. Therefore, this study aims to demonstrate IDW interpolation analysis and physical changes based on morphology (such as slope, elevation, and aspect) in Mount Karanfil, which is part of the Mediterranean basin.

To reveal the general climate characteristics of Mount Karanfil and its surroundings, field observations were carried out between 2018 and 2020 and natural observations were obtained. As a result of thermodynamic modifications, there are differences in temperature conditions

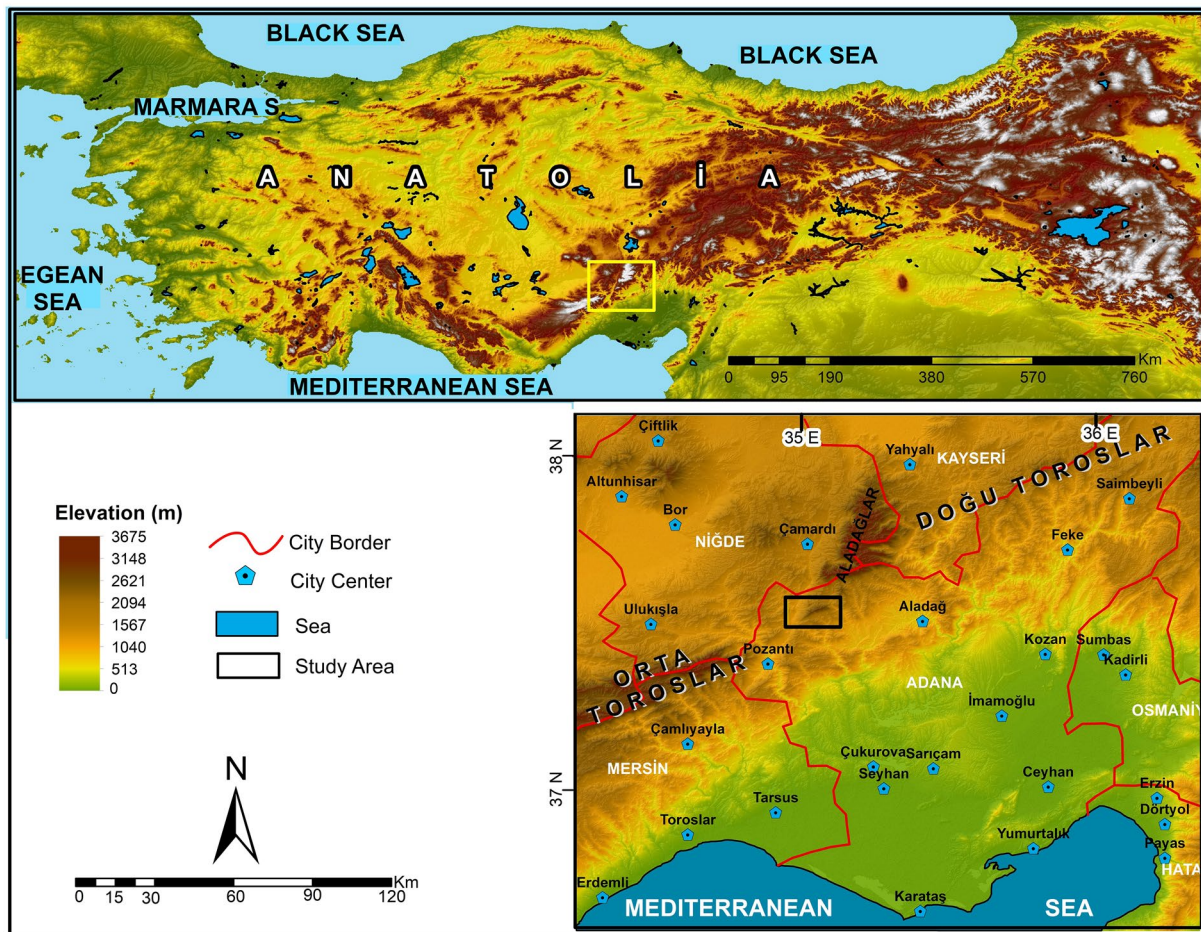


Fig. 1 Location map

depending on topography and surface shapes (such as slope, elevation, and aspect), continentality, and the shape and direction of the mountains. This relationship can be seen in the northwest of the Ascıbekirli (Pozantı) settlement and on the north and southeast slopes of the Dagdibi (Pozantı) settlement. Increases in moisture content are observed in valley profiles, slopes, and ridge areas where thermodynamic modifications are elevated. Precipitation due to frontal systems also contributes to dynamic elevation developments along a warm front. The eastern and southeastern slopes of the study area are surrounded by winds carrying moisture. Therefore, there are differences in plant species and compositions between the northern slopes and the other southern slopes.

Material and methods

Dataset utilized

Temperature and precipitation datasets comprising monthly and annual values of minimum and maximum temperature, monthly precipitation, and winds from

1980 to 2018 were used in this study. The study period was chosen because it spans 30 years and the complete dataset was readily available for stations. The dataset was obtained from the General Directorate of Meteorology (MGM) and Climate data. Figure 3 shows the satellite image of meteorological stations in the study area. (Fig. 3).

Initial data analysis

A preliminary analysis was conducted on the temperature, precipitation, and winds frequency dataset. Time plots were constructed for monthly and annual maximum and minimum temperature/precipitation to provide a general overview and insights into the distribution of the data.

Temperature and precipitation indices

Monthly and annual values of maximum and minimum temperature and precipitation datasets from 1980 to 2018 were used to calculate IDW interpolation using the

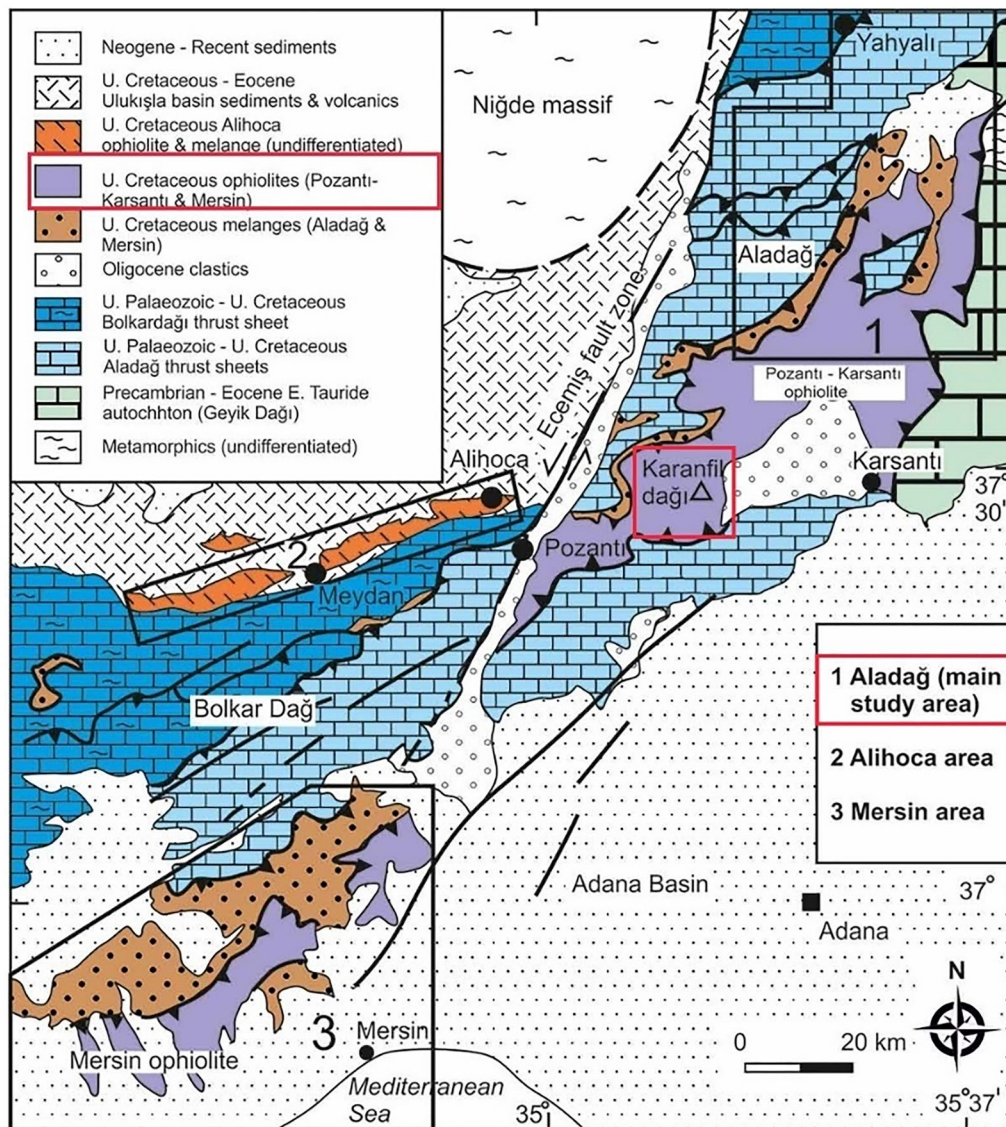


Fig. 2 Simplified tectonic and geological view study area (revised from Robertson et al. 2022)

spatial estimation method. This technique is based on the determination of cell values for non-sampled points with the help of values for known sample points (Adriyanshah et al. 2022; Baykal et al. 2022; Biswas et al. 2020; Kurniawan et al. 2021; Kulmatov et al. 2021; Masoudi 2021; İrcan 2020). The cell value is calculated by considering various points moving away from the cell of interest and depending on the increase in distance. The data is usually evaluated locally, revealing a deterministic process by which the comparison is made. Daily temperature and precipitation indices were not calculated because no sensors representing daily temperatures, daily highest temperatures, daily lowest temperatures, or daily precipitation, minimum and maximum precipitation values

were found in the database of meteorological stations in the study area. Data quality checks were conducted to identify data from the General Directorate of Meteorology (MGM) and Climate data. In this study, only stations with complete data were analyzed, and stations with data not close to 30+ years were not included in the analysis. The temperature analysis stations are Yazıcık, Kamışlı, Hamidiye, Dagdibi, and Sutluk stations.

Statistical procedures

Statistical methods, on the other hand, apply data-based models to predict climate analysis. For example, Türkeş (2017) discusses the annual temperature average difference, which is calculated as the difference between

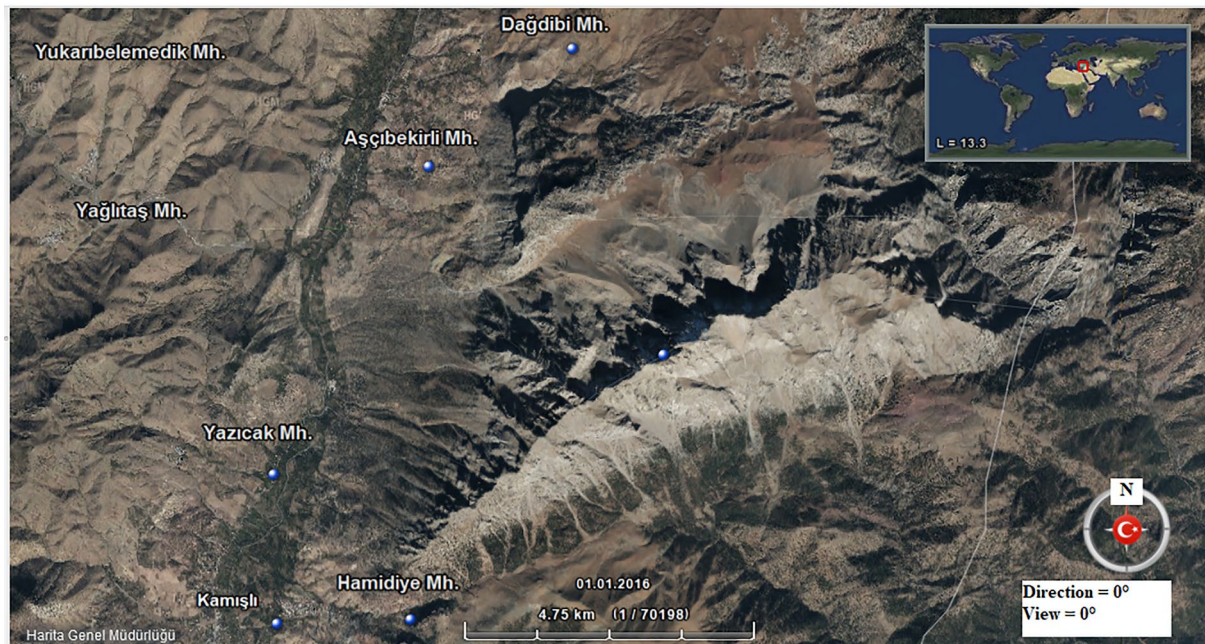


Fig. 3 Satellite image of meteorological stations in the study area (Drawn from HGM Sphere Atlas Editor- 19/05/2022)

the warmest and the lowest average temperatures in a year. YSF is also preferred as the main indicator of terrestrial and marine nature. In this context, an increase in YSF indicates an intensification of terrestriality, while a decrease in YSF is an indicator of marine conditions (Türkeş 2017). The highest average temperature values were recorded at stations in the south and southwest. In this context, the process used in the climate analysis mentioned in the example is given in formula 1.

$$YSF = T_{\text{hottestmonth}} - T_{\text{coldestmonth}} \quad (1)$$

Parametric statistical data such as Erinç (1965) index based on total annual precipitation and maximum temperature averages, Thornthwaite (1948) indices based on precipitation regime and precipitation intensity values, De Martonne (1942) index based on drought, and Emberger (1954) bioclimatic index, which is preferred in determining the bioclimatic layers of stations and the principles of Mediterranean climate, are used to control the climate analysis processes.

Results and discussion

Topographic variables on the temperature and precipitation activity of the study area.

A number of recent studies have dealt with the mountain biomes area the climate challenge and consider strategies protected area managers might take to adapt their conservation efforts (Batllori et al. 2017; Hannah et al. 2007; Langdon and Lawler 2015). Unfortunately,

scientific recommendations for effective topo-climatic environment management are often too theoretical or vaguely defined to be implementable in practice (Halpin 1997; Monzón et al. 2011). Even-well structured recommendations are often based on little scientific data. As result, these recommendations can be difficulty apply, are targeted to certain areas (Langdon and Lawler 2015) or based on a limited sample of case studies (Monzón et al. 2011). On the other hand, environmentally heterogeneous allow for adaption of species under the different climates (Thomas and Gillingham 2015). Heterogeneity elevation, aspect, and slope result in a diversity of climates such that species can make smaller spatial adjustments to track suitable climatic conditions (Carroll et al. 2017; Littlefield et al. 2017; Lawrence et al. 2021).

In other words, mountainous landscapes are especially prone to natural disturbance events like avalanches, these disturbances can remove inertia from a system (such as non-reproductive long-lived individuals) support accelerated establishment of new species and structures, enabling species populations to adapt more quickly to changing climate conditions (Jentsch and Beierkuhnlein 2003). Diversity in environmental conditions can indicate the resilience and adaptive capacity mountain biomes in the face of environmental conditions change (Loarie et al. 2009; Langdon and Lawler 2015). High topographic heterogeneity within a temperature or precipitation rises and falls shifting climatic conditions (Önol 2012). In addition, mountain biomes areas show the a high topographic heterogeneity can create a high environmental

diversity due to- for example- difference in solar radiation, precipitation, temperature and wind exposure (Scherrer and Körner 2011).

Considering the average temperature results of the stations in the study area by months, the highest average value was measured at the Hamidiye station (11.25 °C). The lowest monthly average temperature values were measured in Sutluk and its surroundings (10.1 °C). Significant decreases were observed in the winter temperature tolerances in the centers located around the north and west. These decreases are associated with the topographical conditions of the area, drought, and continentality (Fig. 4, Fig. 5, Fig. 6). Considering the monthly average temperatures, there is a decrease in temperature tolerances from S to N (Table 1). Because go to the north, there is a significant decrease in temperature as a result of the increase in altitude.

According to the calculated values, when the annual average temperatures are taken into account, there are differences between the high and low areas in terms of relief. The hottest spots are seen in the areas located in the south and southwest of the area. Temperature averages increase from north to south, depending on the effect of continentality and altitude. The uniform hilly areas in the north and northeast of the study area had the

lowest mean values (around 10.5 °C and 11.0 °C averages) (Fig. 7) (Çetin 2020).

When the annual average temperature difference values are examined, the difference between the hottest month and the coldest month in the study area is 11.3 °C at Yazıcık station, 12 °C at Kamışlı station, 11.2 °C at Hamidiye station, 11 °C at Dagdibi station, and 10.5 °C at Sutluk station (Table 2). The annual average temperature differences of the existing stations are around 10–11 °C and its multiples. The decreases and increases in the annual average temperature results at the stations draw attention as an expression of continentality.

The geomorphology of the study area plays a significant role in determining the climate characteristics, particularly in January. The transition from low to high elevation is gradual, with a mountainous area followed by a plateau area. These steps are characterized by slopes of approximately 150–250 m and are marked by valleys that are split by permanent and seasonal rivers. The valley floors are formed by the Ecemis Stream in the NW and the Cakıt Stream in the E-SW axis. Asymmetric and decimetric slopes, which are prone to erosion, can be found in the transition from low to high areas. The coldest conditions in January are found in the mountainous areas, while the hottest spots are located in the S-SW of the area. The annual temperature potential also varies based

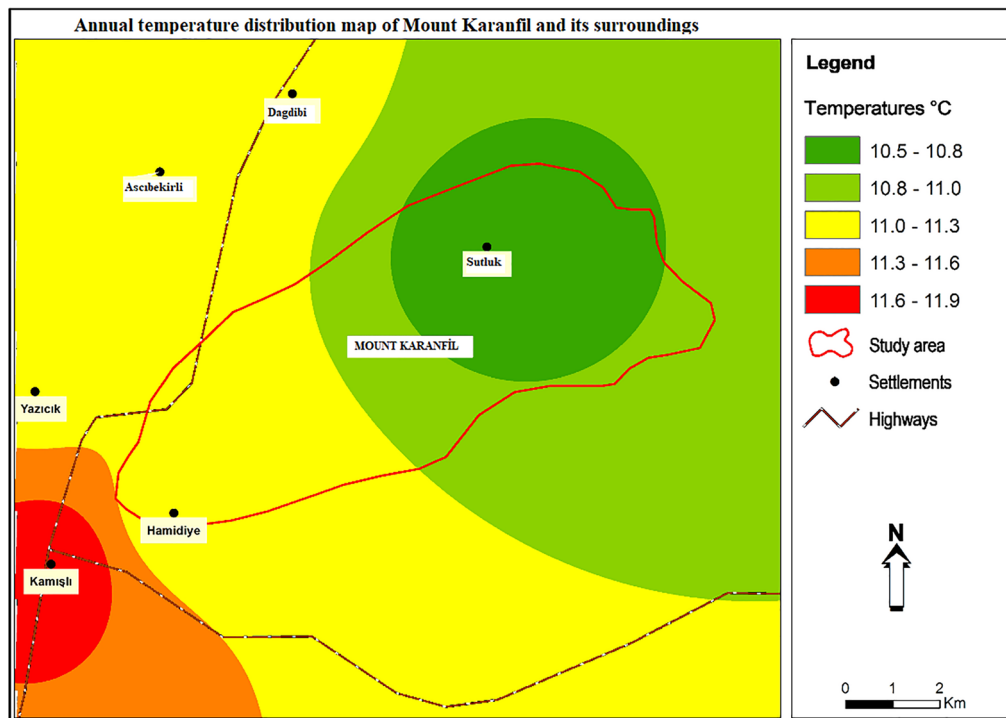


Fig. 4 Annual temperature distribution map of Mount Karanfil and its surroundings

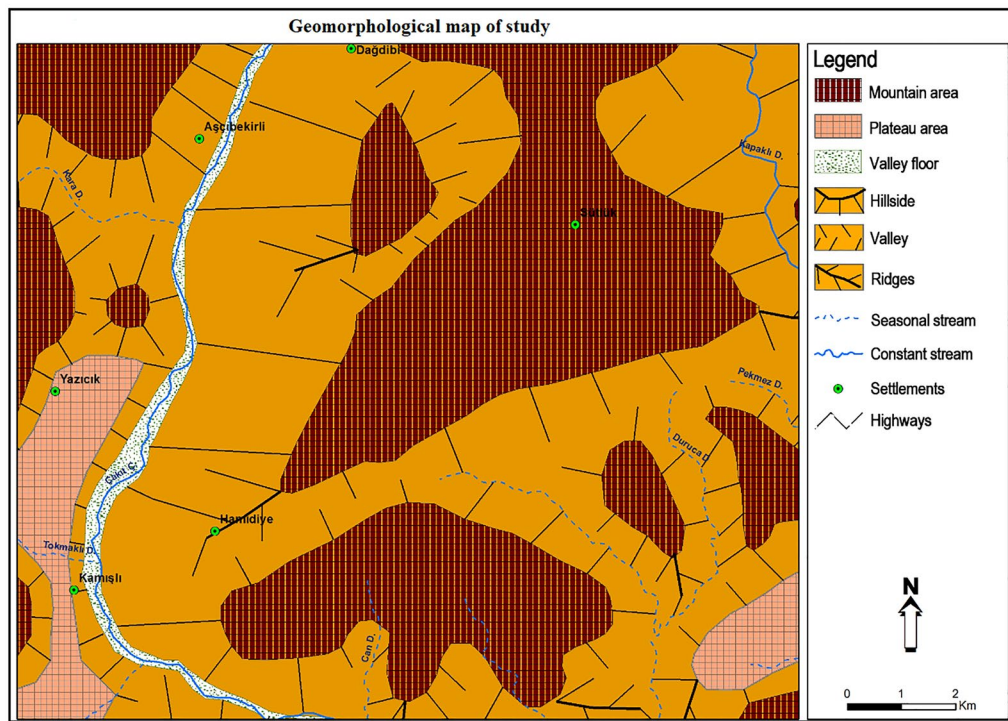


Fig. 5 Geomorphological map of study area



Fig. 6 The mount fronts and avalanche paths in the Ascibekirli area and its surroundings, which contribute to the geomorphology systems

on altitude and the level of continentality, with temperatures tending to increase from N to S. In terms of annual precipitation, the wettest parts of the study area are the S and SW slopes, single hilly areas, and other high parts. The distribution of annual precipitation is also influenced by topography and surface shape. The E-S section of the study area is impacted by winds carrying moisture, which bring precipitation to the E-S and SW-SE slopes in winter

and reduce the occurrence of hydrological and meteorological drought in the summer season. However, winds from arid areas that enter the region can increase evapotranspiration and transpiration, negatively affecting the ecological conditions of the region.

The topography of the study area, including the surrounding mountain fronts, plays a role in the development of faulting, erosion, and the deposition of sedimentary deposits. These uplifted areas along active faults form mountain fronts that are bounded by block-sized structures (Fig. 8). One of the hydrographic elements contributing to the geological structure of the study area is the strait valley system formed by the Çakıt Stream, which is surrounded by high mountainous masses on both sides (Figs. 5 and 9). The narrow and deep valleys in the Dagdibi neighborhood of the Karanfil Mountain, which gained their morphological appearance during the last glacial maximum, are an example of this (Figs. 8 and 10). Dagdibi represents a typical Mediterranean mountain climate, characterized by cool summers with rare orographic precipitation and snowy, cold winters. The south-facing slopes of the mountain, which are exposed to fog and orographic precipitation caused by the rise of humid air from the Mediterranean Sea during the summer period, are suitable for the growth of productive forests and meadows (Fig. 11).

Table 1 Monthly average temperature values of the stations in the study area

Months	J	F	M	A	M	J	J	A	S	O	N	D	Average
Stations													
Yazıcık	0.6	2	5.5	10.2	14.3	18.6	21.9	21.7	17.9	12.8	7.3	2.7	11.2
Kamışlı	1.3	2.7	6.3	10.8	15	19.1	22.6	22.4	18.6	13.6	8	3.3	11.9
Dagdibi	−0.4	1.1	4.6	9.5	13.6	17.7	20.9	20.8	17.2	11.9	6.6	1.8	10.4
Hamidiye	−0.5	2	5.5	10.1	14.3	18.4	21.7	21.7	18	12.8	7.4	2.6	11.25
Sutluk	0.5	1.9	4.5	9.1	13.2	16.6	18.6	18.7	15.8	11.4	7	2.9	10.1

**Fig. 7** Kamışlı and surroundings are characterized by a strait valley process

The temperature values in July, as shown in Fig. 5, demonstrate that the summer months are hot, with average temperatures hovering around 21 °C. The highest temperatures in July are found in the regions located in the SW of the study area, where the influence of the Mediterranean climate is most pronounced. When examining the temperature values in July, it can be seen that the lowest average temperatures are found in the regions located in the NW of the study area (Çetin 2020).

To understand the relationship between precipitation and the ecological conditions of the study area, 38 years of observation data from selected stations between 1980

and 2018 were analyzed (<https://mgm.gov.tr/kurumsal/istasyonlarimiz.aspx?il=Adana> 25.03.2022). The IDW Interpolation method and Thornthwaite were used to analyze the precipitation conditions in the area and present the results in the form of figures, graphs, and tables. Based on this analysis, the maximum tolerance for annual average precipitation was found to be at the Sutluk (545 mm) station and its surrounding area. The station with the lowest annual average precipitation was the Yazıcık (502 mm) station (Table 3).

The rainiest parts of the study area are the S-SW slope areas, as well as uniform hilly areas and other high areas. In contrast, the N-NE slopes of the study area have relatively lower levels of precipitation compared to other stations. In addition to elevation, abiotic factors such as aspect and slope also contribute to the variation in annual precipitation averages in the area (Fig. 6 and 12). It is important to consider not only the annual precipitation totals, but also the distribution of precipitation throughout the year, particularly during the vegetation period, as this can significantly affect plant growth. While the highest annual average precipitation value is found at the Sutluk station with 545 mm, it is followed by Kamışlı with an average precipitation of 539 mm (Figs. 7 and 13).

When examining the precipitation values in the study area during January, it can be seen that the ridge and hilly units in the NW section of the S-SW part have the highest average precipitation. In contrast, the N-NE slopes have the lowest average precipitation in January, considering the topography and surface forms (Fig. 14).

Table 2 Annual average temperature difference of stations in the study area

Station and observation time data	Latitudinal location	Elevation (m)	Annual avg. temperature difference
Yazıcık (38 year)	37°35'N–34°56'E	1294	11.3
Kamışlı (38 year)	36°45'N–35°25'E	1133	12
Dagdibi (38 year)	37°33'N–34°58'E	1355	11.2
Hamidiye (38 year)	37°38'N–35°0'E	1296	11.2
Sutluk (38 year)	40°7'E–29°49'E	1300	10.5



Fig. 8 A section of the narrow and deep valleys recorded at 2500 m in the Dagdibi neighborhood of Karanfil Mountain and its surroundings



Fig. 9 Dagdibi represents a typical reflection of the Mediterranean mountain climate recorded in the mountain environment, represented by cool summers with rare orographic precipitation and snowy and cold winters

When examining the average precipitation values in July, the highest values are found in the N-NW and SE-SE and the topographical units in their vicinity (Fig. 15). Similar to January, the topography and surface forms play a significant role in the distribution of precipitation (Fig. 13, Fig. 16, Fig. 6 and Fig. 12, 17) (Çetin 2020).

The climate classifications of Thornthwaite (1948), De Martonne (1942), Erinc (1965), and Emberger (1954) were used to understand the efficiency of precipitation in the study area. The analysis of the climate in the region showed that it has different climate types in terms of precipitation regime, precipitation efficiency index, and bioclimatic characteristics. According to Thornthwaite, all stations except for Sutluk are characterized as having an arid, less humid, 1st degree mesothermal, and moderately watery in winter, semi-marine, moderately warm climate type. However, the Sutluk station is classified as having a humid 1st degree mesothermal and marine medium hot climate type, with a moderate water deficiency in the summer. According to De Martonne, the climate is between semi-humid and step-humid. According to Erinc, the climate is low-humidity, and according to Emberger, all stations except for the center of Sutluk

are located in the Mediterranean bioclimate layer with low precipitation and cool conditions (Çetin 2020).

Thornthwaite climate structure of the study area

The Thornthwaite climate classification method has been widely used in recent studies (Feddema 2005; Yilmaz and Çiçek 2016; Özüpekçe 2021; Çolak and Memişoğlu 2021; Yilmaz 2020a, b; Yilmaz and Sevindi 2020b; Kaymak 2020). This method, developed by Thornthwaite (1948), is based on the principle of precipitation-evapotranspiration and temperature-evapotranspiration (Dönmez 1972). In the Thornthwaite index, an excess of water is recorded in areas where precipitation exceeds evaporation (Yilmaz and Çiçek 2016). There are essentially two main roles in the Thornthwaite classification: precipitation-evapotranspiration and temperature-evapotranspiration (Dönmez 1972). This method is based on the temperature-evapotranspiration principle, which reveals the annual distribution of water accumulated in the soil and the potential evapotranspiration values (Dönmez 1985). The Thornthwaite index is used to classify climates based on precipitation intensity and temperature intensity. Table 4 lists the climate classes of the stations based on the Thornthwaite precipitation intensity index. Upon examination of Table 4, it was found that the Sutluk station had the highest rainfall intensity index (20.6) and was classified in the B1 humid climate type. The other stations were classified in the C1 arid-less humid climate type.

The determination of the precipitation regime index is another important step in the Thornthwaite climate type classification. Table 5 shows the index intervals of the stations based on the precipitation regime index. Upon examination of Table 5, it can be seen that the Sutluk station has the highest precipitation regime index value, while the Hamidiye station has the lowest. While the Sutluk station experiences an increase in s2 water in the summer and has a moderate climate type, the other stations experience an excess of s2 water in the winter and also have a moderate climate type. The main purpose of using the Thornthwaite Precipitation Regime Index in this research is to understand the relationship between precipitation regime rates and the climate type of the centers in the study area and its surroundings, and to better understand the climate structure of the area.

The Thornthwaite water balance analysis of the Yazıcık station is shown in Table 6. When examining Table 6, it can be seen that the accumulated water reaches its highest levels in January, February, and March, and the soil is considered to be 100% saturated in these months. The monthly average temperature at the station is 11.29 and the monthly temperature index is 48.41. The excess water seasons at the station are observed in January, February,

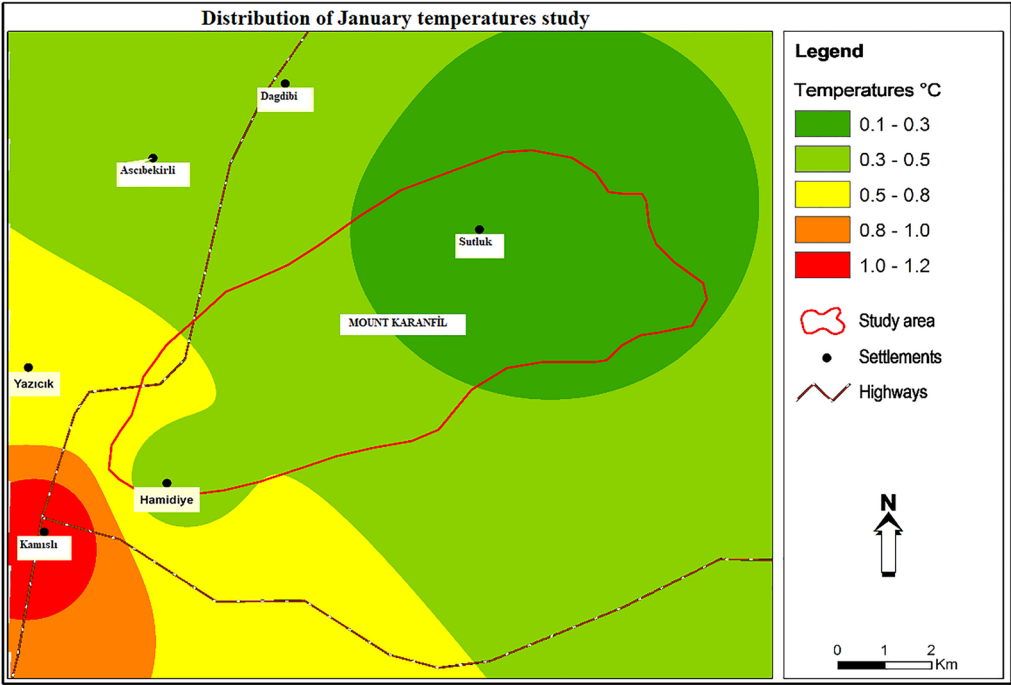


Fig. 10 Distribution of January temperatures study area

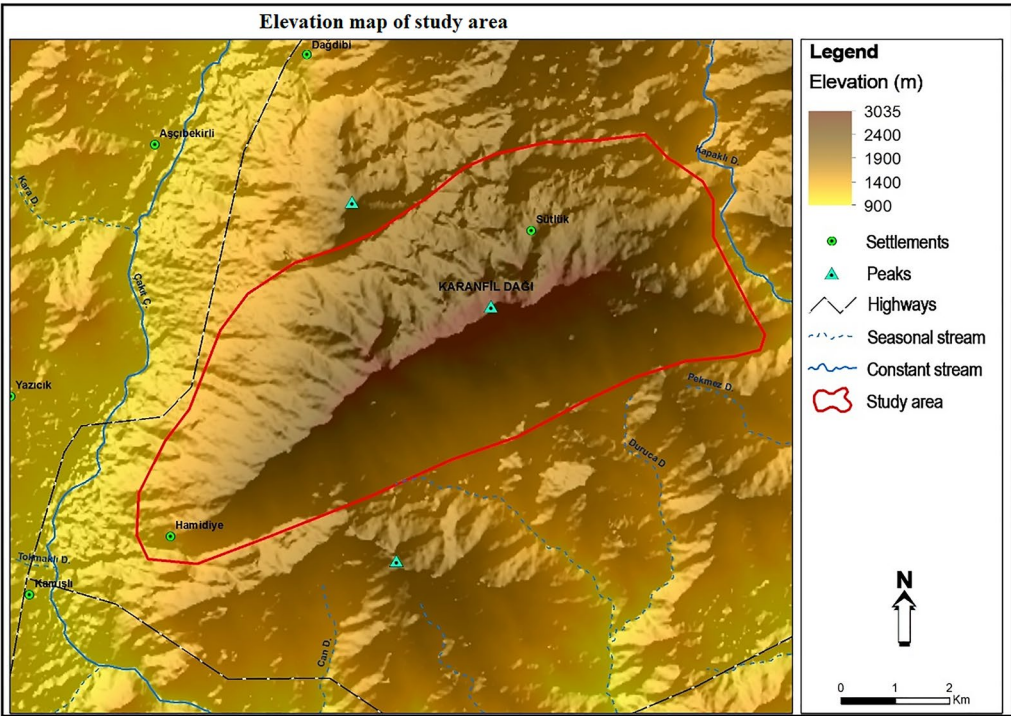
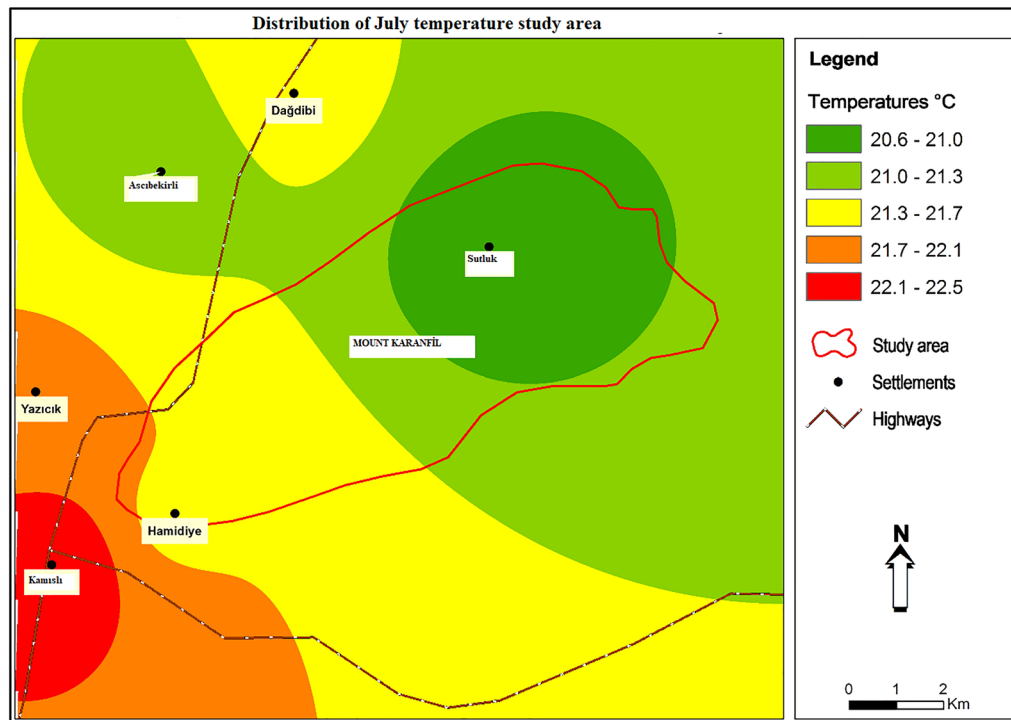


Fig. 11 Elevation map of study area

Table 3 Annual average precipitation values of stations in the study area

Months	J	F	M	A	M	J	J	A	S	O	N	D	Total (mm)
Station													
Yazıcık	62	53	60	58	60	29	7	6	13	34	48	72	502
Kamışlı	71	59	64	60	61	29	7	6	13	36	53	80	539
Hamidiye	64	55	61	59	61	29	7	6	13	35	49	74	513
Dagdibi	59	51	58	58	60	29	7	5	13	34	47	69	490
Sutluk	84	70	67	63	61	44	25	21	31	55	66	95	545

**Fig. 12** Distribution of July temperature study area

March, and April, while the months with water deficiency are the summer months following the dry period after May. This situation can be attributed to the influence of warm and rainy winters and hot and dry summers on the Thornthwaite water balance of the station. The month with the highest humidity is January. Based on the Thornthwaite water balance calculations, the Yazıcık station has an arid and less humid, first-order mesothermal, semi-arid marine moderately warm climate type due to the increase in water in the winter (Çetin 2020).

Similarly, the Hamidiye, Kamışlı, and Dagdibi stations also have an arid and less humid, first degree mesothermal, semi-arid marine moderately warm climate type due to the increase in water in the winter. However, the Sutluk station was determined to have a humid, first-order

mesothermal, marine moderately hot climate type with moderate water deficiency in the summer (Table 7). This means that the Sutluk station has higher levels of humidity and a moderate deficiency of water during the summer months compared to the other stations.

Erinç climate classification of the study area

The “Rainfall Activity Index” developed by Erinç in 1965 is important in determining the climate type in Turkey. Erinç’s formula was examined in six different classes by considering the distribution of vegetation formations. According to the researcher’s interpretation, this formula represents the conditions in Turkey better than other formulas. For example, according to the De Martonne method, Kars, Yalova, and Bursa may all be considered

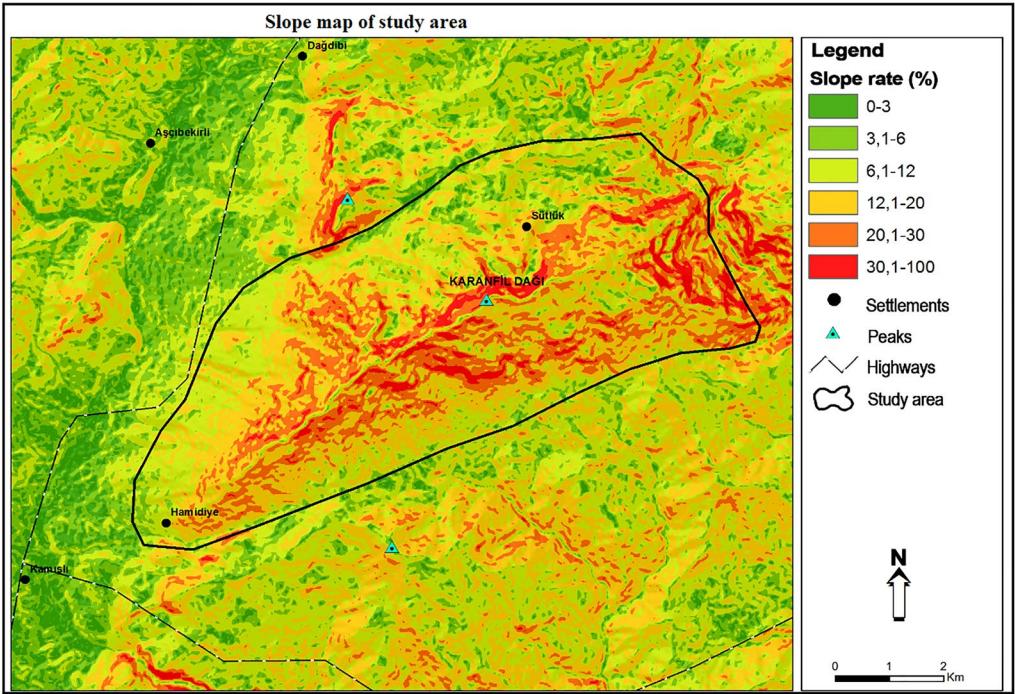


Fig. 13 Slope map of study area

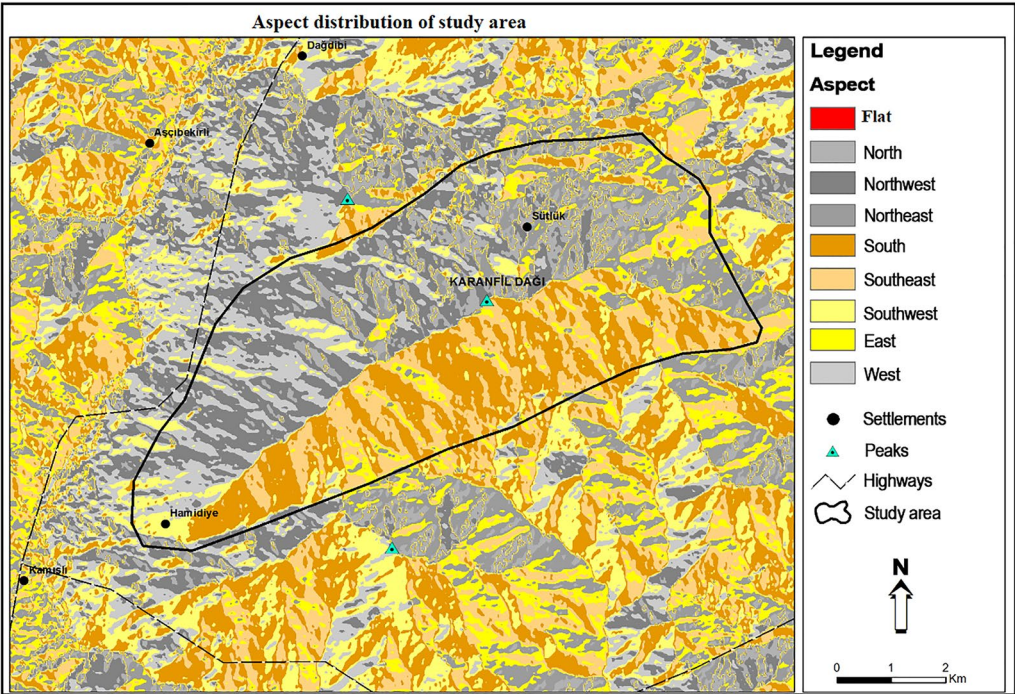


Fig. 14 Aspect distribution map of the study area

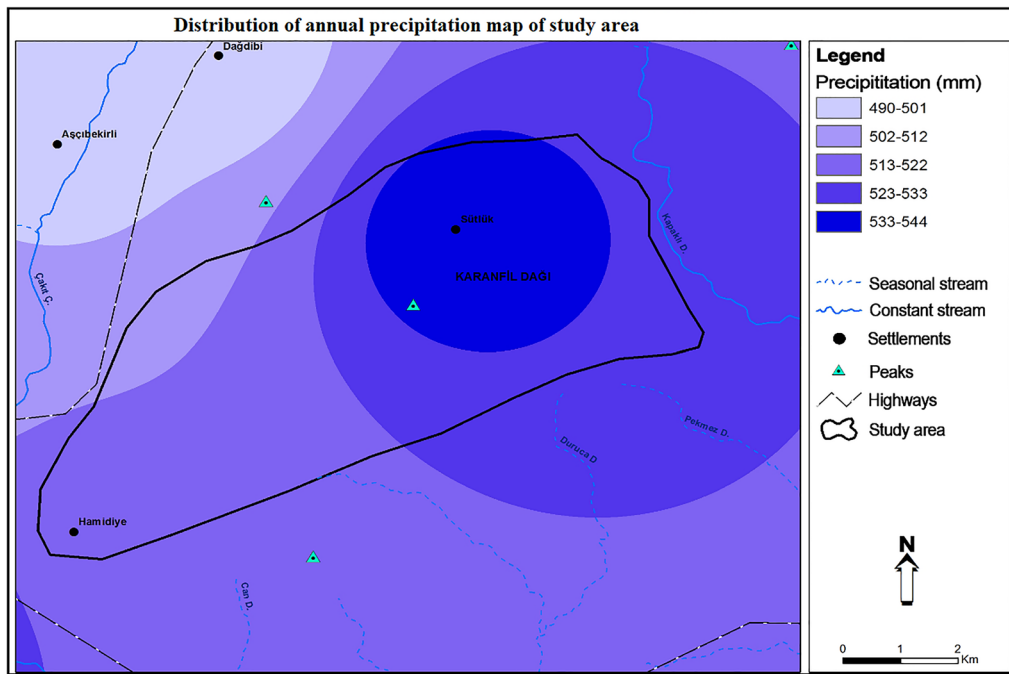


Fig. 15 Distribution of annual precipitation map of study area

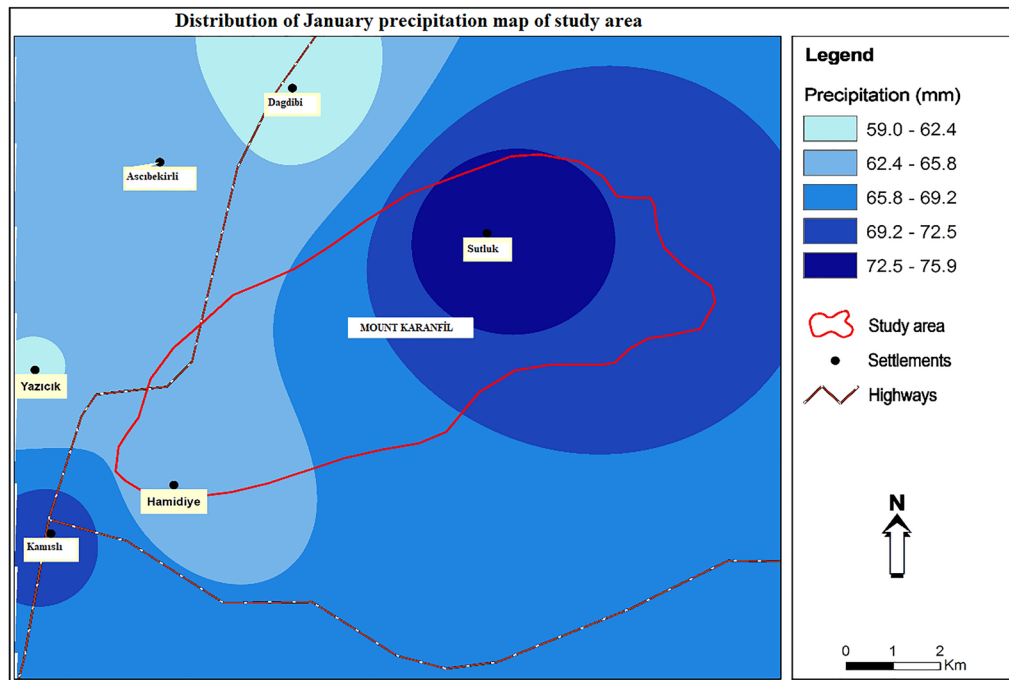


Fig. 16 Distribution of January precipitation map of study area

more humid than each other. However, the Erinç formula shows that Bursa and Yalova are more humid than Kars by grading the differences (Erinç 1984). As can be seen,

various climate classification methods that consider climatic variables at a global scale and in Turkey are often used in research related to the natural environment.

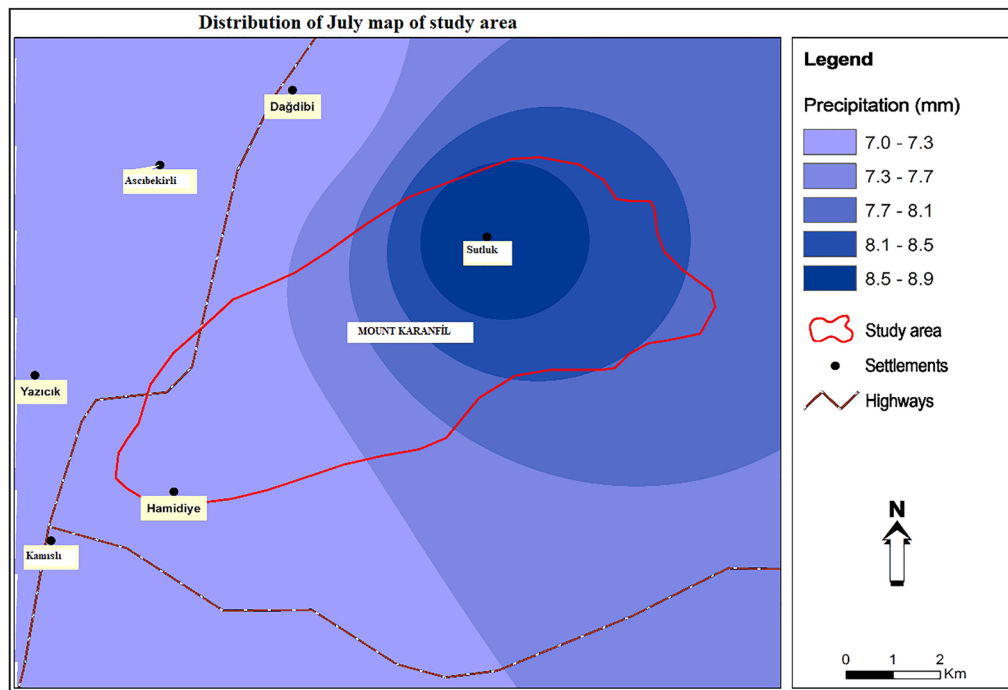


Fig. 17 Distribution of July map of study area (Çetin 2020)

Table 4 Thornthwaite precipitation intensity index

Station and observation time	Precipitation effectiveness index	Climate type	Coordinate values
Yazıcık (1980–2018)	– 4.1	C1 arid-semi-humid	37° 35' N–34° 56' E
Kamışlı (1980–2018)	– 4.3	C1 arid-semi-humid	36° 45' N–35° 25' E
Hamidiye (1980–2018)	– 4.4	C1 arid-semi-humid	37° 33' N–34° 58' E
Dagdibi (1980–2018)	– 4.2	C1 arid-semi-humid	37° 38' N–35° 0' E
Sutluk (1980–2018)	20.6	B1 humid	40° 7' N–29° 49' E

Table 5 Thornthwaite precipitation regime index

Station and observation time	Precipitation regime index	Climate type	Coordinate values
Yazıcık (1980–2018)	51.4	s2 The water increase is in the winter season and moderately	37° 35' N–34° 56' E
Kamışlı (1980–2018)	52.5	s2 The water increase is in the winter season and moderately	36° 45' N–35° 25' E
Hamidiye (1980–2018)	51.2	s2 The water increase is in the winter season and moderately	37° 33' N–34° 58' E
Dagdibi (1980–2018)	51.3	s2 The water increase is in the winter season and moderately	37° 38' N–35° 0' E
Sutluk (1980–2018)	98.5	s2 Water increase in summer and mid	40° 7' N–29° 49' E

Another climatic classification method preferred in research is the Erinç Climate Classification. In this index, the average temperature and the amount of precipitation are proportional to each other. However, the results obtained using this index show that terrestrial regions

have a more humid structure (Çetin 2020). Therefore, Erinç uses the maximum temperature value as the basis for the index instead of the average temperature (Bacanlı and Saf 2005) (Fig. 18).

This index is calculated as:

Table 6 Yazıcık Thornthwaite water balance (Çetin 2020)

	J	F	M	A	M	J	J	A	S	O	N	D	Anu
Par													
AYT	0.6	2.0	5.5	10.2	14.3	18.6	21.9	21.7	17.9	12.8	7.3	2.7	11.29
ASI	0.04	0.25	1.16	2.94	4.91	7.31	9.36	9.23	6.9	4.15	1.77	0.39	48.41
DPE ^a	1.16	5.27	18.7	40.7	62.3	86.7	106.4	105.2	82.6	54.23	26.8	7.69	–
DPE ^a	1.01	4.48	19.34	44.86	75.41	105.77	131.96	122.04	85.1	52.6	23.05	6.46	672.08
ATY	62.0	53.0	60.0	58.0	60.0	29.0	7.0	6.0	13.0	34.0	48.0	72.0	502.0
BSAD	9.51	0.0	0.0	0.0	15.41	– 76.77	– 7.82	0.0	0.0	0.0	24.95	65.54	–
Bir.Su	100.0	100.0	100.0	100.0	84.59	7.82	0.0	0.0	0.0	0.0	24.95	90.49	–
Etr	1.01	4.48	19.34	44.86	75.41	105.77	14.82	6.0	13.0	34.0	23.05	6.46	348.2
Sn	0.0	0.0	0.0	0.0	0.0	0.0	117.4	116.04	72.1	18.6	0.0	0.0	323.88
Sf	51.48	48.52	40.66	13.14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	153.8
A	25.74	50.0	44.59	26.9	6.57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	153.8
NO	60.39	10.83	2.1	0.29	– 0.2	– 0.73	– 0.95	– 0.95	0.85	– 0.35	1.08	10.15	–

AYT-Total monthly precipitation ASI- Monthly average temperature (°C), ASD—Monthly temperature value, DPE^a- Unadjusted PE, DPE- Adjusted PE, BSAD-Monthly accumulated water change, Bir.Su- Accumulated water-, Etr- Actual Evapotranspiration, Sn—Water shortage (d), Sf—Water excess (s), A- Flow, NO- Humidity ratio

Table 7 Sutluk thornthwaite water balance (Çetin 2020)

	J	F	M	A	M	J	J	A	S	O	N	D	An
Par													
AYT	0.5	1.9	4.5	9.1	13.2	16.6	18.7	18.6	15.8	11.4	7.0	2.9	10.02
ASI	0.03	0.23	0.85	2.48	4.35	6.15	7.37	7.31	5.71	3.48	1.66	0.44	40.06
DPE ^a	1.52	6.89	18.25	40.42	61.53	79.71	91.2	90.64	75.39	52.14	30.06	11.11	–
DPE	1.38	6.06	18.8	43.25	71.37	92.46	107.62	102.42	76.9	51.1	27.05	10.0	608.41
ATY	84.0	70.0	67.0	63.0	61.0	44.0	25.0	21.0	31.0	55.0	66.0	95.0	682.0
BSAD	0.0	0.0	0.0	0.0	–	–	– 41.17	0.0	0.0	3.9	38.95	57.15	–
Bir.Su	100.0	100.0	100.0	100.0	89.63	41.17	0.0	0.0	0.0	3.9	42.85	100.0	–
Etr	1.38	6.06	18.8	43.25	71.37	92.46	66.17	21.0	31.0	51.1	27.05	10.0	439.64
Sn	0.0	0.0	0.0	0.0	0.0	0.0	41.45	81.42	45.9	0.0	0.0	0.0	168.77
Sf	82.62	63.94	48.2	19.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.85	242.36
A	55.24	73.28	56.07	33.97	9.88	0.0	0.0	0.0	0.0	0.0	0.0	13.93	242.37
NO	59.87	10.55	2.56	0.46	– 0.15	– 0.52	– 0.77	– 0.79	– 0.6	0.08	1.44	8.5	–

AYT-Total monthly precipitation ASI- Monthly average temperature (°C), ASD—Monthly temperature value, DPE^a- Unadjusted PE, DPE- Adjusted PE, BSAD-Monthly accumulated water change, Bir.Su- Accumulated water-, Etr- Actual Evapotranspiration, Sn—Water shortage. Moderate water shortages are observed in the dairy during the summer season (Fig. 18). High levels of evapotranspiration during the summer may cause oxidative stress in plants, particularly affecting their physiology. The difference observed at the Sutluk station may be attributed to topographic factors, climatic changes, and emissions (Çetin 2020)

$$I_m = \frac{P}{T_{om}} \quad (2)$$

P = Total annual precipitation.

T_{om} = Represents the maximum temperature average value.

The index values of the stations according to the precipitation efficiency category of Erinç (1965) are shown in Table 8. Looking at the table, the climate class and vegetation characteristics of all stations are similar. In terms of climate type, "semi-humid" is seen, and in terms of vegetation characteristics, "dry forest with park location" is seen.

De Martonne climate structure of the study area

Another commonly used method of climate classification is the one developed by De Martonne in 1942 (Stefanovic et al. 2021; Omidipour et al. 2021; Tylkowski et al. 2021; Aghelpour et al. 2021; Keshavarz and Moqadas 2021; Ahmadaali et al. 2021; Michalet et al. 2020; Gönençgil 2020; Partal and Yavuz 2020; Güney and Turoğlu 2020; Bayrakdar et al. 2020). This method is based on temperature and precipitation factors, with temperature being the most important factor (Akman 2011). The classification is based on the principle of considering annual average temperature values, temperatures in the hot and

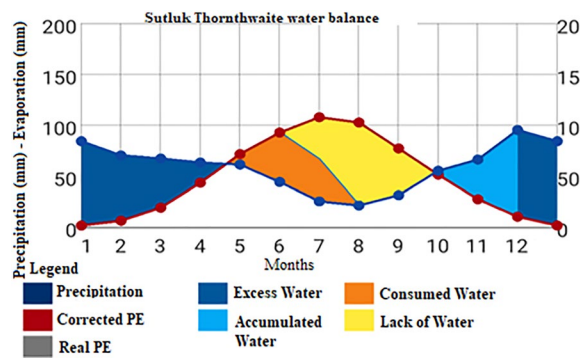


Fig. 18 Sutluk (Pozanti) station Thornthwaite water balance (Çetin 2020)

cold seasons, the differences between these average temperatures, and the duration of the hot and cold periods (Akman 2011). Another climatic element considered in this climate type is precipitation. The total annual precipitation amount is generally used to distinguish between arid and rainy climate types. However, the drought situation depends on changes in evapotranspiration and temperature rather than the amount of precipitation. Average monthly precipitation also helps to study climates with dry periods and contributes to the determination of climatic characteristics such as the duration of cloudiness, air humidity, and rainy days. The calculation of the De Martonne index is shown in formula 3:

De Martonne Drought Index

$$I = \frac{P \text{ (mm)}}{T + 10} \quad (3)$$

I = drought equation.

P (mm) = Annual precipitation.

T (°C) = Annual average of temperature values.

10 = Constant number that makes t positive in regions where the temperature is 0 °C. In the formula, p = the driest month with the least precipitation (mm), and t = the average temperatures of the driest month (°C) are mostly taken into account. De Martonne index results of the stations are given in Table 9.

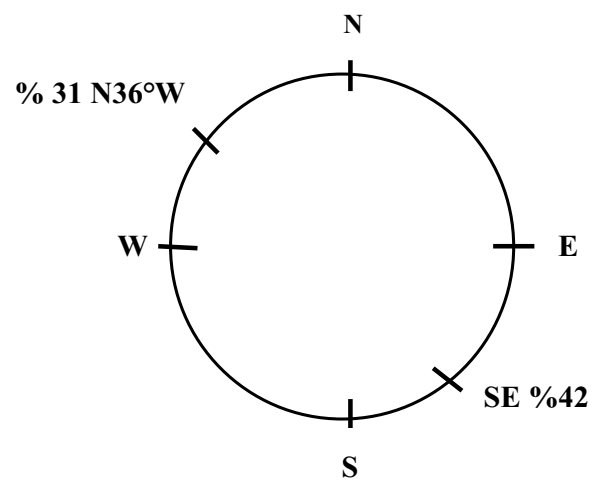


Fig. 19 The prevailing wind direction and frequency of Dagdibi (Pozanti) station according to the Rubinstein formula

Emberger bioclimate development of the study area

Different continents and regions around the world, including countries adjacent to the Mediterranean, a part of Pakistan, California (USA), the Cape region (Africa), Northern Australia, the south of Chile, and the Caspian Sea, are characterized by the Mediterranean climate type, which has hot and dry summers and dry winters, but follows a warm and rainy cycle (Atalay 2012). Many researchers have conducted studies to determine the boundaries of the Mediterranean climate around the world (Gholami et al. 2020). Oceanic, continental, and tropical climates all influence the boundaries of Mediterranean climates in these areas, leading to an interaction between these climates and Mediterranean climates (Aslı Baylan and Ustaoglu 2020).

The Emberger bioclimate formula was used to reveal the bioclimatic characteristics of the stations. The Emberger summer drought index (S value) is calculated using the formula $S = PE/ME$. According to Emberger's result, if the S value is between 5 and 7, it can be interpreted as Semi-Mediterranean, and if it is greater than 7, it is non-Mediterranean. Some researchers also consider plant sociology criteria in addition to plant

Table 8 Index values according to the Erınç index

Station and observation time	Equa	Index mean	Climate type	Vegetation cover
Yazıcık (1980–2018)	502.1/17.3	29.2	low humidity	Park view dry forest
Kamışlı (1980–2018)	539.2/17.9	30.11	low humidity	Park view dry forest
Hamidiye (1980–2018)	513/17.25	29.73	low humidity	Park view dry forest
Dagdibi (1980–2018)	490/16.4	29.87	low humidity	Park view dry forest
Sutluk (1980–2018)	545/15.1	36.9	low humidity	Park view dry forest

Table 9 Climate characteristics based on De Martonne classification

Station	Equation conclusion
Yazıcık (1980–2018)	$la = (502.1)/(11.2 + 10)/2 = 21.2$
Kamışlı (1980–2018)	$la = (539.1)/(11.9 + 10)/2 = 21.9$
Dagdibi (1980–2018)	$la = (490)/(10.4 + 10)/2 = 20.4$
Hamidiye (1980–2018)	$la = (513)/(10.1 + 10)/2 = 21.25$
Sutluk (1980–2018)	$la = (545)/(10.1 + 10)/2 = 20.1$

geography criteria in determining the Mediterranean climate (Akman 2011). The long-term bioclimate results of the stations are given in Table 10. Based on the stations, only the Sutluk station was evaluated in the category of “Temperature with low rainfall but not Mediterranean bioclimate” in terms of bioclimate characteristics. In this evaluation, an interpretation of “non-Mediterranean” was made because the “S” value was greater than 7. Table 10 includes meteorological parameters commonly used in the Emberger bioclimate classification. Within these parameters, researchers and bioclimatologists typically prefer two parameters for determining the bioclimatic layer and belt of an area: “m (°C)” and “Q” (temperature-precipitation equivalent) (Akman 2011).

Wind activity in the study area

Since the prevailing wind directions depend on the relief characteristics of the air currents, they do not vary much. Wind directions are an indicator of the condition of the topography. The winds that bring plenty of precipitation to the E-S and SW-SE slopes of the area during the winter months greatly reduce the hydrological and meteorological droughts that occur in the summer season as they pass through the front view and humid areas. However, winds coming from arid regions and settling in the region, which have drying effects, have negatively impacted the ecological conditions of the region in various ways by

increasing evapotranspiration and transpiration. The dominant wind direction and frequencies at the Dagdibi station were analyzed using the Rubinstein formula and observation data collected in the study area and its surroundings. The frequency range of winds blowing from the Dagdibi (Pozantı) station is 42%, and the frequency of winds blowing from N36°W is 31% (Fig. 19).

Conclusion

In this research, various climatic variables (temperature, precipitation, wind, etc.) and topographical factors affecting the natural environment conditions of Mount Karanfil and its surrounding area (Pozantı-Adana) were analyzed, and the following results were obtained: Mount Karanfil displays ecological integrity in the Mediterranean basin due to its topographic and geomorphological features, which influence the Mediterranean climate and Mediterranean transitional climates. In the climatological observations made in the area and its surroundings, climatic differences were noted at points where elevation changes in short distances and deep valley profiles with steep slopes and narrow bases are observed due to the rugged topographic structure. These differences add value to physical geographical conditions such as temperature, precipitation, and wind in terms of geographical location. When the results obtained from the statistical analysis methods were evaluated, differences in temperature tolerance values were noted with the effect of topographical conditions on the northern and southern slopes, which changed depending on various factors. When the temperature and precipitation distributions in January and July were evaluated, the areas with the highest precipitation were observed between the N-NW and SE-SE slopes. Considering the physical geographical conditions and ecological characteristics of the study area, it is understood that it consists of a complex climatic structure and morphological units of different ages. Therefore, the study area is located in a tectonic

Table 10 Bioclimate dimensions calculated with long-term meteorological data indicators of the locations of the stations according to Emberger bioclimate results

	Altitude (m)	P (mm)	M (°C)	m (°C)	Q	PE (mm)	S	Bioclimate class
Stations								
Yazıcık (1980/2018)	1294	502.1	29	+0.6	74.5	42	4.66	Semi-rainy, warm Mediterranean bioclimate
Kamışlı (1980–2018)	1133	539.1	29.8	+1.3	75.3	42	4.66	Semi-rainy, warm Mediterranean bioclimate
Hamidiye (1980/2018)	1355	513	29.2	+0.5	73.4	42	4.31	Semi-rainy, warm Mediterranean bioclimate
Dagdibi (1980–2018)	1296	490	29.2	+0.4	72.2	41	4.21	Semi-rainy, warm Mediterranean bioclimate
Sutluk (1980–2018)	1300	545	25.1	+0.5	73.4	90	11.8	Semi-rainy warm but non-Mediterranean bioclimatic layer

P (mm)—Annual Precipitation Amount, M (°C)—Warmest Average of the Warmest Month, m (°C)—Average Lowest Temperature of the Coldest Month, Q—Precipitation and Temperature Value, PE—Summer Precipitation Average, S—PE Index Resulting from/M

belt and an orographic-climatic vegetation belt, attracting attention in terms of both human and natural environmental conditions. In terms of suggestions, the study area and its surroundings should be evaluated as a whole, taking into account the human environment characteristics (such as settlement and agricultural activities) based on the natural observations made in the mountain biome and the topo-climatic data sets obtained, as well as the potential for ecotourism, mountain tourism, botanical tourism, cultural geography, and ornithology. The area should also be protected in terms of resources such as water resources.

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Author contributions

M.Ç. conceived the idea, analyzed the data and prepared the article. A.M. contributed conceptually and theoretically to the field studies and the thematic template of the study. All authors are referred to in the statement, reviewed and approved the article.

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Availability of data and materials

Derived data supporting the findings of this study are available upon request from corresponding author (MÇ).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

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Competing interests

The authors declare that there are no conflict of interests.

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