



Investigation of the relationship between bioclimatic comfort and land use by using GIS and RS techniques in Trabzon

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Abstract The aim of this study is to investigate the relationship between bioclimatic comfort and land use in Trabzon by using geographical information systems and remote sensing technologies. We aimed to evaluate the relationship between the bioclimatic conditions of the years 1985, 1994, 2005, and 2018 with the use of land in the same years in the province of Trabzon in seasonal and annual periods. Physiological equivalent temperature (PET) index, which takes into consideration the physiological characteristics of humans, was used when determining bioclimatic comfort zones. The meteorological parameters used in the calculation of this index are as follows: daily average temperature values reduced to sea level, daily average relative humidity, and wind speed. The inverse distance weighting (IDW) method was preferred in the calculation of the spatial distribution of the obtained values at sea level. Using DEM data, height-dependent PET values were obtained and bioclimatic comfort maps were generated. According to the years of the bioclimatic comfort maps produced, land use maps were created by using CORINE

land cover data. Then, the relationship between bioclimatic comfort zones and land use was examined.

Keywords Bioclimatic comfort · Geographic information systems · Land use change · Physiological equivalent temperature (PET) · Remote sensing

Introduction

The climate has been effective in guiding the needs of the people from the past to the present day such as settlement, housing, nutrition, and health. For centuries, people attempted to understand the climate better; a concept that substantially affects their daily life routine. It is seen that people feel healthier and more vigorous in certain conditions physiologically and spiritually. Accordingly, the concept of bioclimatic comfort is defined as the conditions in which people adapt to their environment by spending the least amount of energy (Cetin 2015a, 2016a, 2019; Cetin and Zeren 2016; Cetin et al. 2010, 2018a, 2019). In the indices used to determine the bioclimatic comfort state, temperature, humidity, and wind, data were evaluated together (Topay and Parladir 2015; Altunkasa 1990; Kaya et al. 2019; Olgyay 1973; Attia and Herde 2009; Sevik et al. 2017; Cetin et al. 2010; Milne 2013; Cetin 2015a, b, c; Bozdogan Sert et al. 2019; Cetin et al. 2018a, b, c; Cetin 2016a; b, c; Cetin and Zeren 2016; Cakir et al. 2016; Navazi et al. 2017; Salehi and Zabardast 2016;

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Ghanghermeh et al. 2017; Molanezhad 2017; Aricak 2015).

The effect of bioclimatic comfort on humans and other species makes this finding an important input, especially for planning and design processes, because physical planning and design processes—which are mostly carried out in order to create environmentally friendly and sustainable living spaces—focus on providing optimum living conditions for people while preserving environmental and cultural elements. In this context, it is important to evaluate the climatic factors in a way that will lead to a more comfortable life and make it a planning input. Similarly, the impact of existing land use and physical characteristics on climate is extremely important and is among the criteria to be considered in sustainable planning and design. Therefore, the investigation of the effects of climate parameters and physical properties on each other is one of the necessary steps in the creation of sustainable spaces (Altunkasa 1990; Aydin et al. 2019; Cetin 2017; Kocman 1991; Cetin 2015a, b; Dereli et al. 2013; Cetin 2016a, b, c; Cetin and Sevik 2016; Ozturk et al. 2017; Cetin and Zeren 2016; Bozdogan Sert et al. 2019; Cetin et al. 2018a, b, c; Kaya et al. 2019; Cetin et al. 2019; Cetin 2019; Nowak et al. 2005; Kaya 2009; Yucedag et al. 2018; Yucedag and Kaya 2016; Kaya et al. 2018; Sevik et al. 2017).

Literature research has been carried out, and national and international studies have been determined for the calculation of bioclimatic comfort and the effects of meteorological parameters on humans. The main outputs of these studies and the main outputs obtained by the method used in the studies are summarized below: Cetin et al. (2019), Cetin (2015a, b, c), and Cetin et al. (2019); Bursa, Burdur, Aydin, Kutahya, and Kastamonu in the study of the effects of urbanization on the temperature in Kastamonu have concluded that they have comfortable outdoor weather conditions (Cetin 2015a, 2016a, 2019; Cetin and Zeren 2016; Cetin et al. 2010; 2018a, 2019). One of the important results of the study is the frequency of the different stresses experienced depending on the temperature. Svensson et al. (2003) investigated the bioclimatic comfort areas in Gothenburg in Sweden by means of PET index and meteorological data. Both air temperature and wind zone maps are based on land use, altitude, and distance to shore. Based on Svensson's study, specific values for each air temperature and wind station were determined. Land use areas are categorized as dense urban areas, multi-

family buildings, detached house areas, green areas, and industrial zones. Each land use category has different coefficients according to the Sverdrup power law. According to height, land use categories are divided into two main groups, which are below or above 50 m. According to the findings, it is concluded that the main problem affecting comfort in Scandinavia is the wind and the cooling effect. In addition, the highest PET values were found in central settlement areas and the lowest PET values were found in coastal and green areas (Svensson et al. 2003). In the study conducted by Topay (2007), the bioclimatic comfort of Muğla province was evaluated in GIS environment by using mean air temperature, relative humidity, and wind data covering 11 meteorological stations between 1929 and 2000 from June and October. Meteorological data and monthly climate maps were created according to the IDW method. Outcome maps were divided into two classes as comfortable and uncomfortable zones according to Olgyay's (1973) human bioclimatic comfort value. According to the findings, the most comfortable months were in June, August, and September, while the most comfortable areas were the central and northern parts of the province. Similarly, Topay and Parladir (2015) and Topay (2007) determined the bioclimatic comfort areas of Muğla. Meteorological data were collected from 10 meteorological stations whose altitude varies between 3 and 850 m (Topay 2013). Kantor and Unger (2010) proposed a methodology for thermal comfort surveys of resting places in urban areas. They mapped 6775 visitors from 12.00–15.00 at half-hour intervals during the three periods they identified. They calculated the PET with the meteorological data of the field to define the thermal conditions in the measuring ranges. They digitized and processed the data with ArcView to show the relationship between the field usage model and thermal conditions. Air temperature, relative humidity, wind speed, and thermal radiation were taken as parameters affecting climatic comfort and these factors were calculated by PET and OUTSET. In addition, since thermal comfort depends on subjective characteristics, behavioral applications of visitors were also observed. They stated that this information would be useful in the future to calibrate the area model with ENVI-Ray or RayMan software to calculate comfort indices from measured meteorological parameters or to simulate the thermal conditions of the area under investigation (Kantor and Unger 2010). By using weather temperature, relative humidity, and wind speed data between

1975 and 2008, in addition to sunshine time and rainfall data; TCI (Tourism Climate Index), THI (Temperature Humidity Index), and SSI (New Summer Index) were examined. As a result of the study, it has been concluded that the months where climatic comfort conditions are most favorable in terms of coastal tourism are May, June, September, and October, and especially, May was close to the ideal values (Guclu 2010).

In the study conducted by Turkoglu et al. (2012), the spatial and temporal distribution of the bioclimatic comfort areas of Ankara city center were collected from meteorological stations in different terrain textures, temperature, wind speed, global solar radiation, and relative humidity data of 2001–2010. Physiological equivalent temperature (PET) values were calculated by using RayMan software. As a result of the analyses and calculations, it was observed that the high PET value was high during the night and heat islands were formed during the year in areas where high buildings were densely situated in the city center of Ankara. Again in the city center where high-rise buildings are dense, extreme hot measurements were made at the end of July and early August and the PET value was high (Turkoglu et al. 2012). Caliskan and Turkoglu et al. (2012) conducted a similar study using monthly average air temperature, wind speed, global solar radiation, cloudiness, and relative humidity parameters from 69 stations from 1975 to 2008. Turkey's bioclimatic conditions showed the spatial distribution of thermal comfort in the map. They determined the relationship between PET values and latitude, elevation, and marine parameters by multiple linear regressions and the degree of correlation by correlation analysis. The analysis of Turkey's southern and western coastal belt of the valley floor, from other areas of the PET value in low-lying areas such as plains, has identified 5–25 °C higher than that. The highest PET values were observed in the low areas in the southeast between May and September and on the Mediterranean coast between October and April; the lowest PET values in the warm and northern peaks of the sea in the Kaçkar Mountains, in the cold period, the high and high peak of Mount Ararat were stated that they were seen (Caliskan and Turkoglu 2012). Daneshvar et al. (2013) analyzed the bioclimatic comfort conditions in Iran with PET. The meteorological data used are air temperature, relative humidity, and wind speed of 48 stations for 30 years (1976–2005). Monthly PET values were obtained by using these data. As a result of the study, it has been determined that the areas where the comfort is optimum

are heights of 1000–2000 m, the temperature is between 12 and 20 °C and the average rainfall is below 200 mm (Daneshvar et al. 2013). Pawar et al. (2015) have described the procedure that demonstrates that thermal comfort changes in specific regions using GIS and also changes responsive building design strategies. They used a subset of high-resolution interpolated climatic data to illustrate a wide range of climate changes in India. They derived and classified raster data using GIS to calculate the six climate indicators using the Mahoney table method. In 8 groups, the selected building design criteria 62 were overlapped to form a thermal comfortable design zone. Thermal comfort analysis was performed with ArcMap 10 using air temperature, relative humidity, and precipitation data. As a result of the analyses, comfort zones were determined and mapped according to different climates (Pawar et al. 2015). Song and Wu (2018) investigated the heat stress of human beings by means of remote sensing methods through parameters such as land surface temperature (LST) and discomfort index (DI). The study was conducted in Wisconsin, USA. In order to obtain the DI value, experimental models were first established to connect LST, which is considered as dry temperature, to air temperature in this study. Then, dry thermometer temperature and wet air temperature were obtained from relative humidity. To calculate the wet air temperature, relative humidity values were taken from NARR (North America Regional Reanalysis). Then, because DI was calculated from dry and wet air temperature, the spatial distribution was compared with LST. The MODIS image was used to calculate LST, NDVI (normalized difference vegetation index), and NDBI (normalized difference built-up index). Then, LST—NDVI—NDBI and DI were subjected to correlation analysis to compare the spatial distribution of LST and DI and to show the importance of DI in calculating heat stress. The results showed that the air temperature calculated based on the experimental model generated in this study was quite accurate with low RMSE values compared with the current studies. On the other hand, DI has proven to be a more important indicator of human discomfort in a warm environment. However, the accuracy of the calculated DI is related to the accuracy of the LST. In addition, field measurements were not performed to prove the accuracy of DI, and the results were based on a single scale of study (Song and Wu 2018).

The summarized bioclimatic comfort studies have been guided in determining the method and data to be used in Trabzon.

Materials and methods

The material section describes the characteristics of the work area. The software, data, and data sources used are given. Work area of the study is the province of Trabzon in Turkey. It has a surface area of 4664 km² and is located between 41° 00' North latitude and 39° 44' east longitude. Figure 1 shows the boundaries of the work area. Trabzon is a central city in the Eastern Black Sea region. It is located between the Black Sea coast and the Zigana Mountains. Eynesil district of Giresun to the west, Torul district of Gümüşhane to the south and Bayburt to the east, and İkizdere and Kalkandere districts to Rize to the east are the names of the province and provincial center that has been known since the Ancient Age (Municipality 2018).

Behind the coastline, the center of the province, which has a mountainous terrain extending vertically to the sea, was founded on Boztepe (Ancient Minthron hill). The province is composed of 22.4% plateau and 77.6% hills. The climate of Trabzon is normal in summer and warm in winter. In summer, the average temperature is + 32 °C. In the coldest days of the winter, the temperature drops to – 6 degrees. Spring is usually rainy and foggy. Autumn months are quite nice. General climate data of the province: average sunshine duration (ASD), average number of rainy days (ANRD), average monthly total precipitation amount (AMTP), highest temperature (HT), and lowest temperature (LT) values are presented in tables. The average meteorological data of Trabzon, which is one of the cities subject to the study, is given in Table 1.

Trabzon has a humid climate and humidity increases up to 99% from time to time. The average annual rainfall is 800–850 kg/m². As we move towards the inner parts, the rain rate increases. The least rainfall is in July and August and the most snow falls in February. The coldest months are January and February. With these characteristics, it can be said that the climate of Trabzon is warm and soft. As you move from the beach inward, air and water are clearer. The average annual sea water temperature is 16.1 °C and reaches 27.5 °C in August. The lowest value is 6.0 °C in March (Meteorology 2018).

In forest areas within the boundaries of provinces and regions, predators such as hawks, eagles, and animals

such as wolves, jackals, foxes, brown bears, pigs, hooked horned goats, and roe deer are available. In forests, spruce, fir, beech, scotch pine, alder, and chestnut varieties such as trees can be grown. In Trabzon and its surroundings, forests, green areas, plant species, and wildlife are very rich. It is suitable for growing almost all kinds of trees and plants and for sheltering wild animals. The forest cover starts from the seaside and reaches an altitude of 2000 m.

Due to the large area of the city, Trabzon has significant effects on urban space characteristics. Today, Trabzon has become one of the economic and administrative centers which play the role of a mega city among Turkey's big cities. Numerous residential and industrial cores have been formed in the city.

Another material of the study is the software used. While calculating PET index for Trabzon Province, bioclimatic comfort map was created by using ArcGIS 10.6 software and RayMan Pro and comfort zones were determined. Erdas Imagine software was used to create land use maps based on Corine data.

The data and data sources used in the study are as follows: the meteorological data used in the bioclimatic comfort mapping stage of the study and the daily average air temperature, relative humidity, and wind speed data obtained from Meteorology for 1985, 1994, 2005, and 2018 were used. Figure 2 shows the locations of the stations for the relevant years on the map.

At this stage, the data used in the distribution of temperature-dependent height is the ASTER-GDEM digital elevation model. ASTER-GDEM has been produced in 83° north and south parallels with a resolution of 30 m to cover the world. The land use maps of CORINE (Coordination of Information on the Environment) downloaded from the Copernicus Program database coordinated by the Council of Europe for 1985, 1994, 2005, and 2018 were used in the determination of land use. The CORINE project was initiated in 1985 by the European Union. It is produced using 1:100,000 scale and satellite imagery and topographic maps. Information about these images is given in Table 2.

In the “Method” section, the methods of obtaining PET values, comfort maps, land use maps, and the relationship between bioclimatic comfort maps and land use are explained.

In order to obtain PET values, firstly PET calculation was made by using RayMan program using daily average temperature, relative humidity, and wind



Fig. 1 The boundaries of the work area of Trabzon, Turkey

measurement values taken from meteorological stations in Trabzon and its vicinity.

For the PET calculation, firstly the daily temperature, humidity, and wind data of the stations were obtained. The arithmetic average of daily data was taken into four seasons and annual averages and the temperature values were reduced to sea level with the formula given in Eq. (1) (Cetin 2015a, 2016a, 2019; Cetin et al. 2010, 2018a; Thom 1959; Matzarakis et al. 2010; Toroglu et al. 2015).

$$T_d = T_i + (h_i \times 0.005) \tag{1}$$

where T_d is the reduced temperature to sea level; T_i is the average temperature of the station; and h_i is the station height.

The seasonal and annual temperature, wind, and humidity data obtained as a result of these processes and the four seasons and annual PET values for 1985, 1994, 2005, and 2018 were calculated using RayMan Pro software, respectively. Personal physiological information to be used in RayMan Pro software is used for each year, provided that it is fixed.

While creating comfort maps, four seasons and annual comfort maps were produced with ArcGIS software for 1985, 1994, 2005, and 2018 by using PET values produced by RayMan program.

The PET values of the study area were obtained by ArcGIS software for the annual and four seasons PET temperature map for 1985, 1994, 2005, and 2018 and were interpolated by the inverse distance weighted (IDW) method. Accuracy analyses were performed provided that the stations indicated in Fig. 2 are used. Then,

the Dem data was calculated by means of the Raster Calculator and the result map was obtained by calculating the elevated temperature of the map which was obtained by using the reduced temperature before. The maps obtained were classified according to the bioclimatic comfort ranges.

Corine land cover maps were used for 1985, 1994, 2005, and 2018 during the determination of land use and were determined by controlled classification on Landsat 8 satellite images.

The process steps in the creation of the land use maps are given below.

Make mosaicism (or done mosaic) of satellite images of 2018.

To increase the mosaic images with 30-m spatial resolution to 15-m spatial resolution by subjecting image sharpening.

Controlled classification of satellite images with enhanced resolution.

Accuracy analysis of the classified image.

Reclassification of CORINE land cover maps and preparation of printouts based on classified image classes with accuracy above 80%.

Results

As a result of the analysis, it is understood that PET values vary in cool and slightly warm scale when we examine the 1985 bioclimatic comfort map. In the

Table 1 The average meteorological data of Trabzon

	Jan	Feb	Mar	Apr	Jun	Jul	Jun	Aug	Sep	Oct	Nov	Dec	Average
	Last climate period (1929–2017)												
Av T (°C)	7.3	7.2	8.3	11.7	15.9	20.3	23.1	23.4	20.3	16.6	12.8	9.5	14.7
Av HT (°C)	10.7	10.7	11.8	15.5	19.1	23.1	25.8	26.5	23.6	20.0	16.4	12.9	18.0
Av LT (°C)	4.5	4.3	5.3	8.6	12.8	16.9	19.8	20.3	17.3	13.6	9.9	6.6	11.7
ASD (h)	2.7	3.2	3.4	4.2	5.5	7.0	5.9	5.6	4.9	4.5	3.6	2.7	53.2
ANRD	11.5	11.8	12.6	12.4	12.1	10.3	7.5	8.3	10.6	11.9	11.4	12.1	132.5
AMTP (mm)	82.0	63.8	58.1	57.2	51.6	50.4	35.5	45.1	78.5	115.0	99.1	83.3	819.6
HT (°C)	25.9	30.1	35.2	37.6	38.2	36.7	37.0	38.2	36.7	33.8	32.8	26.4	38.2
LW (°C)	-7.0	-7.4	-5.8	-2.0	4.2	9.2	11.0	13.5	7.3	3.4	-1.6	-3.3	-7.4

northern part of the area, comfortable areas are predominant. There are cool areas on the southern sides. In addition, the index values around the center were found to be higher and slightly warmer than the other areas. It is concluded that the index values calculated according

to the point locations of the stations in Trabzon are higher than the other stations and that these regions appear to be comfortable in the annual comfort map. However, since the mountains are perpendicular to the sea due to the geographical structure of the region, it has



Fig. 2 Geographical location of meteorological stations of Trabzon Province

Table 2 Information about the images used for research area

Sensors	Dates	Path/ row	Bands	Resolution meters
Landsat7 ETM	15.07.1985	127/45	742	30
			6	60*30
	15.05.1994		742	6
	15.07.2005		742	6
Landsat 5	14.07.1985	127/45	753	30
			6	120*30
	10.07.1994		753	6
	14.07.2005		753	6
Landsat 8 OLI	13.07.2018	127/45	754	30
			10	100*30
	8.07.2018		764	10
			10	

been concluded that the PET values do not penetrate the inner parts. These results are more clearly seen in the seasonal maps in Fig. 3. As a result, in 1985, PET values were found to be higher in locations with high settlement density and structuring.

In 1994, the PET values in the northern region on the microscale are clearer than the other central settlements of Trabzon. In addition, as in 1985, it is seen that the index values in the region close to the central border of Trabzon are high but cannot reach the inner parts. Likewise, it was concluded that the central area of the railroad was cold compared with other regions (Fig. 4).

When the map of 2005, shown in Fig. 5, is examined, it is understood that there is generally a cooling trend compared with previous years. In the annual bioclimatic comfort map, it was observed that the comfortable areas are located regionally in the vicinity of the airport and it is concluded that the index values are higher in both the annual and seasonal maps compared with the other areas. The highest season in Trabzon in terms of spatial comfort was the summer season.

In the maps shown in Fig. 6, in 2018, while there were comfortable areas in the city center of Trabzon, the other areas, where settlements and urbanization were dense, were seen as slightly cool. In the districts close to Trabzon city center, comfortable areas were found to be predominant. In the same way, it was concluded that

the central and surrounding areas were warmer in the seasonal maps.

Creation of land use maps

Corine land cover maps used in the determination of land use are shown in Fig. 7 by controlled classification on Landsat 8 satellite images for 1985, 1994, 2005, and 2018 and for 2018.

As can be seen in Fig. 8, when the land area usage of Trabzon Province is examined according to years, it is seen that the increase in settlement areas and artificial surfaces decreases the agricultural areas. It has been observed that forest areas and natural and semi-natural areas have changed over the years. The reason for this can be explained as the increase of forest areas and the decrease of natural and semi-natural areas by making afforestation works in some regions after the increase of natural and semi-natural areas.

When we look at land use conditions in areas suitable for bioclimatic comfort in 1985, 57% of the region is composed of agricultural areas, 25% consists of natural and semi-natural areas, and 14% consists of forest areas.

Looking at the land use conditions in areas suitable for bioclimatic comfort in 1994, 57% of the region is composed of agricultural areas, 26% is composed of natural and semi-natural areas, and 13% is composed of forest areas.

Looking at the land use conditions within the areas suitable for bioclimatic comfort in 2005, it is seen that 47% of the region consists of agricultural areas, 18% consists of natural and semi-natural areas, and 18% consists of forest areas.

Looking at the land use conditions within the areas suitable for bioclimatic comfort in 2018, it is seen that 58% of the region consists of agricultural areas, 29% consists of natural and semi-natural areas, and 8% consists of forest areas.

According to the biocomfort map of Trabzon, hot clusters form during the hot seasons and disappear during the cold seasons. In other words, areas marked in green form hot clusters formed or reinforced between the hot and cold seasons in the west and southwest of Trabzon. On the other hand, areas marked in blue represent areas where hot clusters are lost or weakened. According to the map, the city center maintains the main focus of the heat island. In addition, new hot clusters are emerging around the west and southwest.

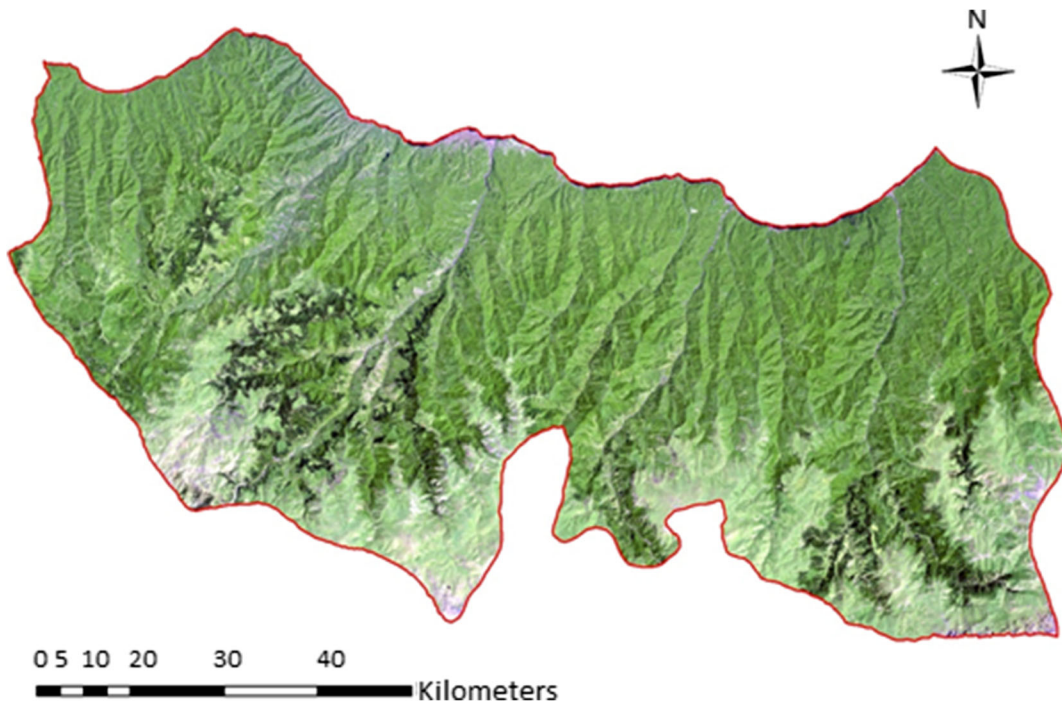


Fig. 3 Annual and seasonal bioclimatic comfort map of 1985

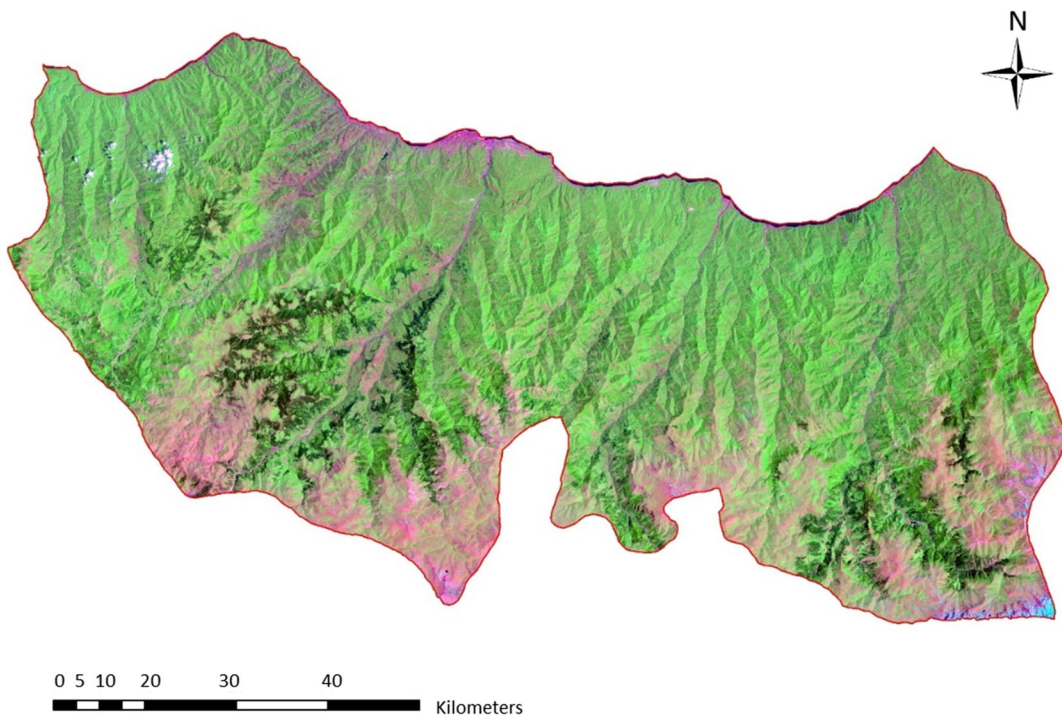


Fig. 4 1994 annual and seasonal bioclimatic comfort map

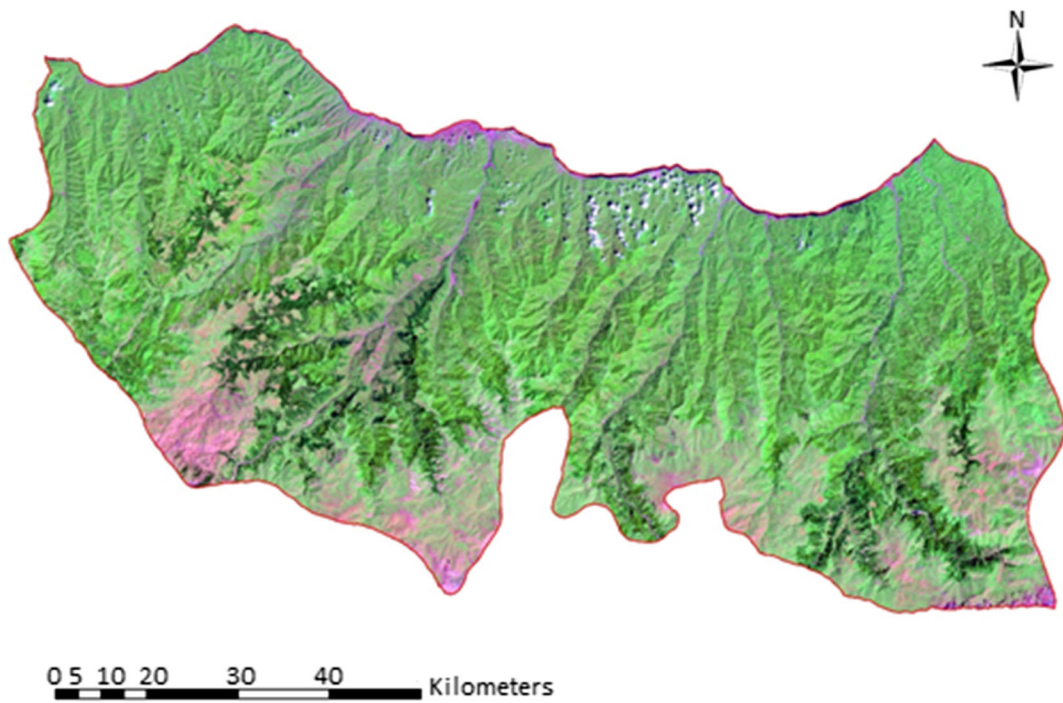


Fig. 5 Annual and seasonal bioclimatic comfort map for 2005

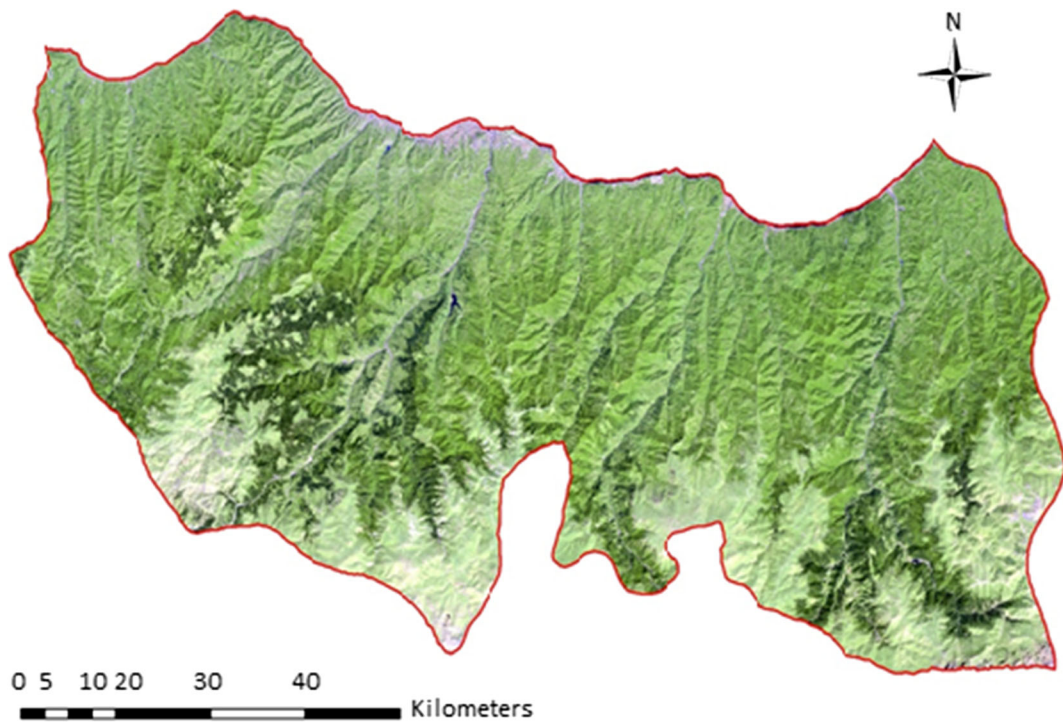


Fig. 6 Annual and seasonal bioclimatic comfort map for 2018

Discussion and conclusion

Bioclimatic comfort maps and land use maps of 1985, 1994, 2005, and 2018 were examined and it was observed that the majority of the comfort zones of Trabzon Province consisted of agricultural and then natural and semi-natural areas, forest areas, and settlements respectively.

The fact that the settlements are located within the bioclimatic comfort area indicates that the temperature increases in the related areas with the construction. The materials used together with the construction increase the reflection (albedo) values in the settlements and cause the formation of heat islands with harmful gases released into the air. The fact that the materials used in the cities or the urban design is not intended to reduce the albedo values causes the heat islands in these clusters to increase further and decrease in the temperature difference between day and night. This causes the temperatures of residential areas to increase over the years. Due to the high amount of moisture in Trabzon Province and the distorted

urbanization observed in the city center, the cooling effect of the wind cannot be used in the city, indicating that this region will overheat from the comfort zone.

Forest areas provide an effect of increasing the night temperatures by decreasing the daytime temperature within the area it occupies. Likewise, it has the effect of decreasing the air temperature in hot seasons and increasing the temperature in winter. The temperature differences in forest areas due to this situation are not much compared with soil areas but they are higher than urban heat islands. In addition, forests are the best climate regulators and can remove most of the harmful gases released into the air.

The fact that agricultural land and natural and semi-natural areas are located within the comfort zone indicates that the albedo value of the soil is higher than the settlement areas. However, it is important to note here that this is not the case in the areas where soil is formed while heat islands are formed in urban areas. Therefore, there is no heat set held in the air and the temperature drops naturally at night. The difference between night

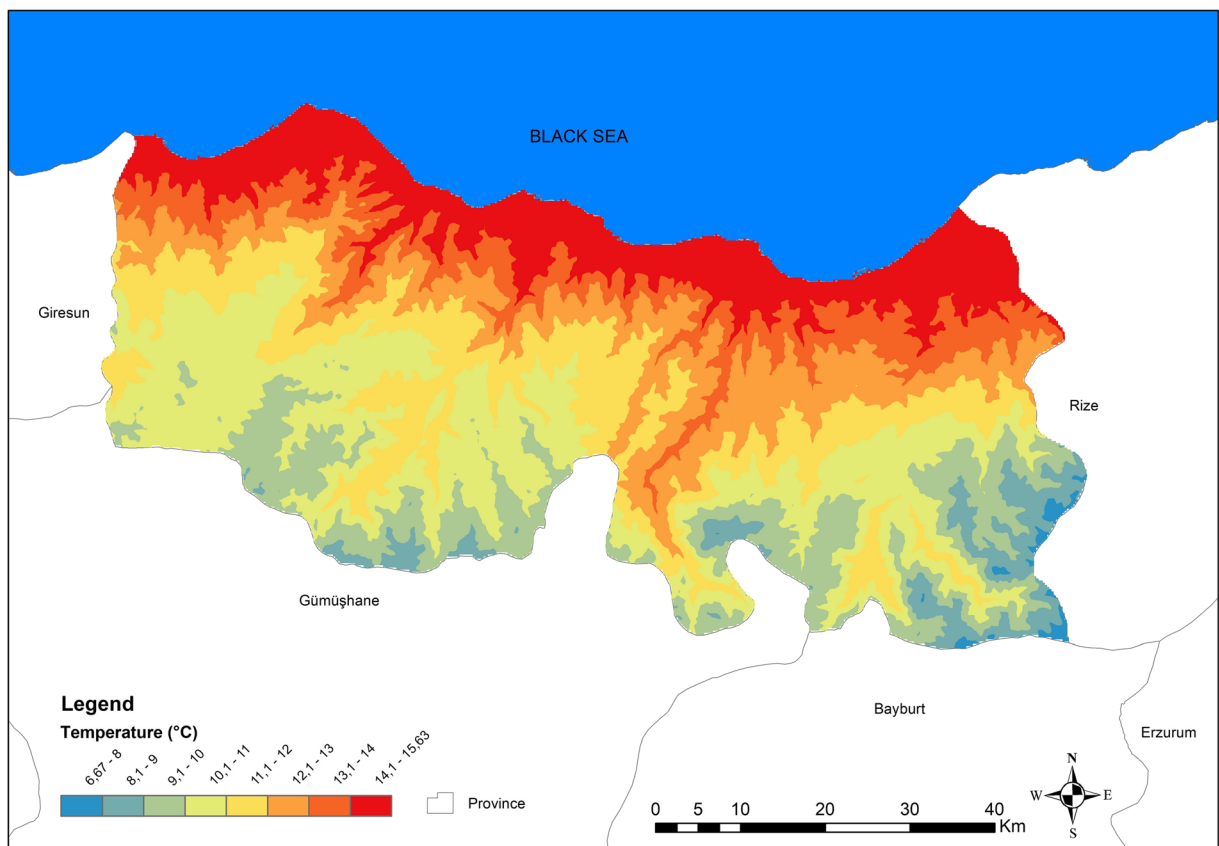


Fig. 7 Land cover map for 2018 satellite images and temperature classes obtained from the ground station

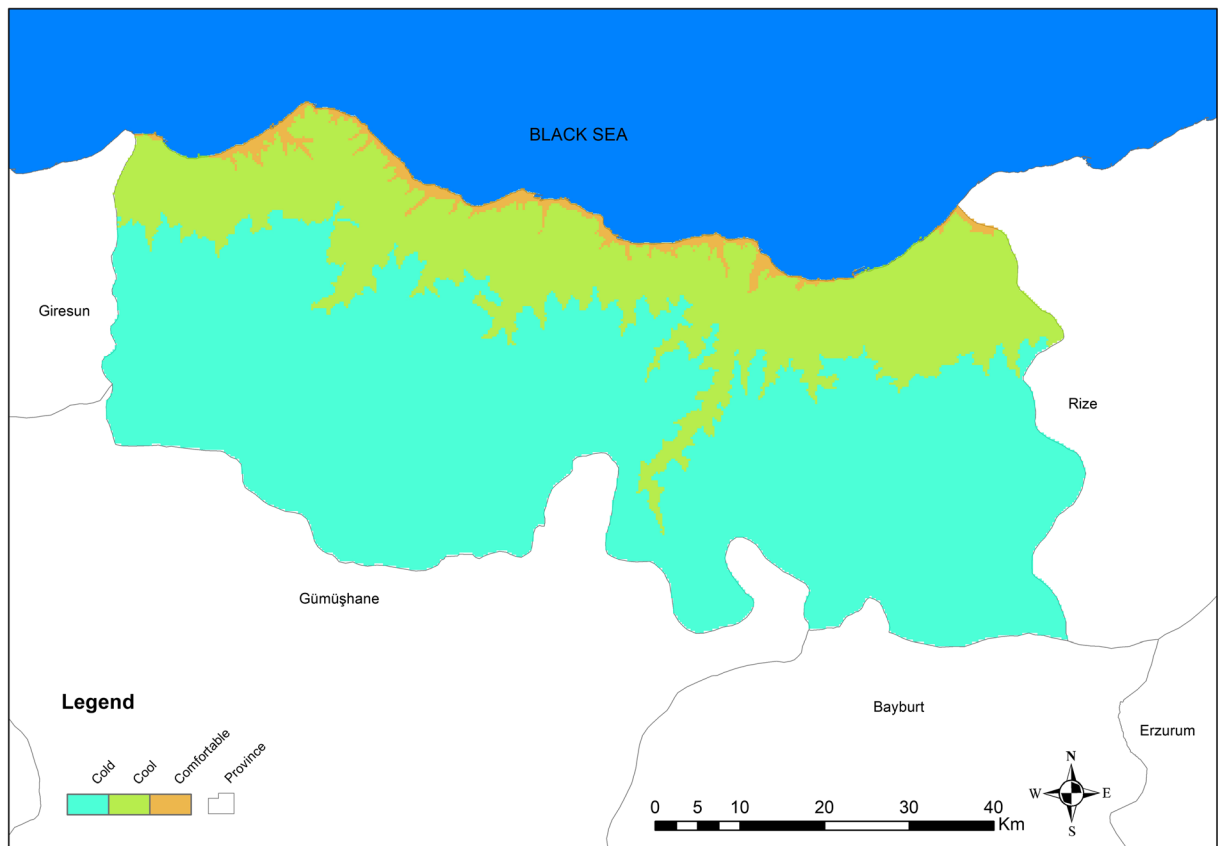


Fig. 8 Bioclimatic comfort map

and day temperatures in the areas where the soil is located is higher than the other area uses did not adversely affect the bioclimatic comfort zones and even removed them more comfortably. The reason for this is that the high humidity seen in Trabzon Province has a negative effect on comfort areas by increasing the sensed temperature value. These temperature differences in soil areas have been identified as a factor that increases the comfort of the city in damp cities such as Trabzon. In order to increase the bioclimatic comfort zones which have been decreasing over the years, first of all, the settlement areas to be built should be preferred according to the climate of the region. For the previously built environment, urban landscaping should be done in a way that minimizes albedo values. It should be aimed to dissipate the heat island and harmful gas clustering in the city by using the wind direction prevailing in the city. Within the control of these heat islands and removal of harmful gases, forest areas within the city and especially on the city wall should be increased. Throughout the province, the topography of the region

should be used and plan decisions should be taken. The disintegration of agricultural areas should be reduced and soil areas should be handled in a more holistic way. Again, forest areas throughout the province should not be distributed in parts and the ecological network should be planned in such a way as to form a green corridor together with the other provinces.

In this study, the data obtained from the meteorological stations of Trabzon and the surrounding provinces and the bioclimatic comfort zones of Trabzon Province were calculated on the basis of PET index depending on the location of these stations. Afterwards, index values calculated based on point locations of meteorological stations were interpolated throughout the province by IDW technique and distributed according to heights. Then, according to 1985, 1994, 2005, and 2018 CORINE data, land use maps were created and controlled classification and land use maps were produced for 2018. As a result, the relationship between land use and bioclimatic comfort zone changes of Trabzon Province in 1985, 1994, 2005, and 2018 has been examined

and solutions and suggestions have been presented for increasing the comfortable areas. In this way, it is aimed to create a base work for designing sustainable urban models in harmony with the environment, human, and nature.

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Compliance with ethical standards

Informed consent Informed consent was obtained from all individual participants in the study.

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