

Mapping of thermal comfort for outdoor recreation planning using GIS: the case of Isparta Province (Turkey)

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Abstract: This study presents a model for the physical planning process of thermal comfort (TC), which is very important for outdoor recreation planning, using thermal perception maps (TPMs). For this purpose, a TPM of Isparta Province was produced according to the physiologically equivalent temperature (PET) index from climatic data of the province. To determine the TC structure of the province, climatic data were collected from 16 meteorology stations. The RayMan 1.2 program was used to obtain the monthly PET values of the stations, and the inverse distance weighted interpolation technique in geographic information system (GIS) software was used to produce monthly PET maps and a TPM of the province. The most comfortable months and regions for outdoor recreation activities were identified by TPM according to the PET values. These months and regions are listed in order, beginning with the most comfortable, as follows: the entire province, with the exception of the towns of Eğirdir, Keçiborlu, Barla, and Kumdanlı-Hoyran in May; the towns of Keçiborlu, Eğirdir, Uluborlu, Yalvaç, Kumdanlı-Hoyran, and Şarkikaraağaç in September; Barla and Keçiborlu in June; and October for the town of Kasımlar. The contributions that TPMs offer for planning the most appropriate areas and periods for outdoor recreation are described.

Key words: Isparta, physiological equivalent temperature, recreational planning, thermal comfort, thermal perception map

1. Introduction

The thermal comfort (TC) of a region is one of the most important factors affecting human life because climate shapes our lives, preferences, and choices. Recreation is very important for physical and spiritual renewal, and the suitability of the climate is of great significance wherever recreational activities are conducted (ASHRAE 1966; Fanger 1973; Olgay 1973; Brown and Gillespie 1995; Höppe 1997; Suminski et al. 2008; Alcoforado et al. 2009; Gourbi 2010). Areas that offer TC make it physically and psychologically possible for people to concentrate on their activities; thus, these areas provide greater satisfaction (Fukuoka 1997; de Freitas 2003). For this reason, considering TC factors when selecting locations for recreation will contribute significantly to the achievement of satisfaction (Liddle 1997; Eliasson 2000; Kliskey 2000; Bell 2001; Schiller 2001; Morillón-Gálvez et al. 2004; Nikolopoulou and Lykoudis 2006; Lin and Matzarakis 2008; Topay and Çınar 2008).

During the recreational planning process on national, regional, or local scales, criteria such as transportation, physical possibilities, cultural values, topographical structure, political concerns, visual values, originality,

naturalness, and carrying capacity are usually considered (Baud-Bovy and Lawson 1998; Braun et al. 1999; Eliasson 2000; de Freitas 2003; Gül et al. 2006). In some countries, human TC parameters do not usually receive sufficient attention (Svensson et al. 2003; Zauli Sajani et al. 2008). The reasons for this omission are as follows: scientific determination of a region's TC structure (Gómez et al. 2001; Nikolopoulou and Lykoudis 2006) and the associated mapping processes have been developed only recently, communication and information sharing between climatologists and planners have been lacking (Eliasson et al. 2007), and the use of TC to construct regional and temporal distribution maps has not occurred because TC has not been available or the use of TC for this purpose has not been coordinated. The consideration of TC has not been included as a planning stage within the planning period (Topay 2007; Wong et al. 2011).

The TC criterion is not currently given sufficient attention in the recreational planning process. The aims of this study were to map the most suitable areas and periods for outdoor recreation in Isparta Province using geographic information system (GIS) applications and to present a model for the production of supporting maps

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reflecting TC for use as a stage in the planning process. These investigations were conducted using information regarding TC.

“Development of potential of the alternative tourism regions and thus increase in the country’s tourism shares” was determined as a national tourism policy target for 2023 (KTB 2012). Isparta is one of Turkey’s important centers for outdoor recreation activity (e.g., river tourism, hunting, botanic tourism, air sports, religious tourism, winter sports tourism, bird watching, cave tourism, and plateau tourism). Because it has rich opportunities for outdoor recreation, Isparta Province was selected as the study area to provide an example of the use of this method. The province’s environmental plan, mapped at a scale of 1/25,000, follows a development model that uses only transportation, economic value, physical facilities, income, and preferences as criteria for the selection of recreation areas. Defining TC, mapping this structure, and incorporating the information in the planning process in light of scientific standards has not been sufficiently studied in Turkey despite the importance of the subject. This research is unique to the Turkish experience. The methods produced by this study will use GIS technology and will be designed from the point of view of TC. They will address the need to identify suitable areas and periods for recreation and to map and implement recreational plans according to a TC structure defined in space and time.

2. Materials and methods

The study area is defined by the administrative borders of Isparta. The province is located between 37°18’N and 38°30’N and between 30°20’E and 31°33’E (Figure 1). It

has an acreage of 8933 km², a mean altitude of 1050 m (IÇDR 2009), and a population of 411,245 (TÜİK 2012). High mountains of up to 3000 m are located within the province’s borders.

2.1. Meteorological characteristics

Isparta Province is influenced by the warmed air of the Iceland low-pressure system. This air mass extends from the Balkans to the middle of the eastern Mediterranean during the winter. The Siberian high-pressure system produces a dry cold and sometimes reaches the region during the winter. Tropical air masses come to the region from North Africa as winter approaches. The Basra low-pressure system and the Asor high-pressure system influence the region during the summer. Climatological analysis using long-term observations made in Isparta Province show that the province is located in the transitional area between the Mediterranean and Middle Anatolian continental climates. Aspects of the Mediterranean climate are observed in the southern part of the province, and aspects of the continental climate are observed in the northern part (IÇDR 2009).

Meteorological data from 1975 through 2006 are available from 16 stations located within the Isparta Province borders. The long-term averages of monthly mean temperature, wind speed, and humidity were used in this study. The data were supplied by the Turkish State Meteorological Service (DMİ). In studies by climate scientists it is emphasized that a 30-year data set is the minimum required to elucidate the overall structure of an area’s climate; a 30-year data set was thus used in this research. The geographical coordinates and altitudes of the

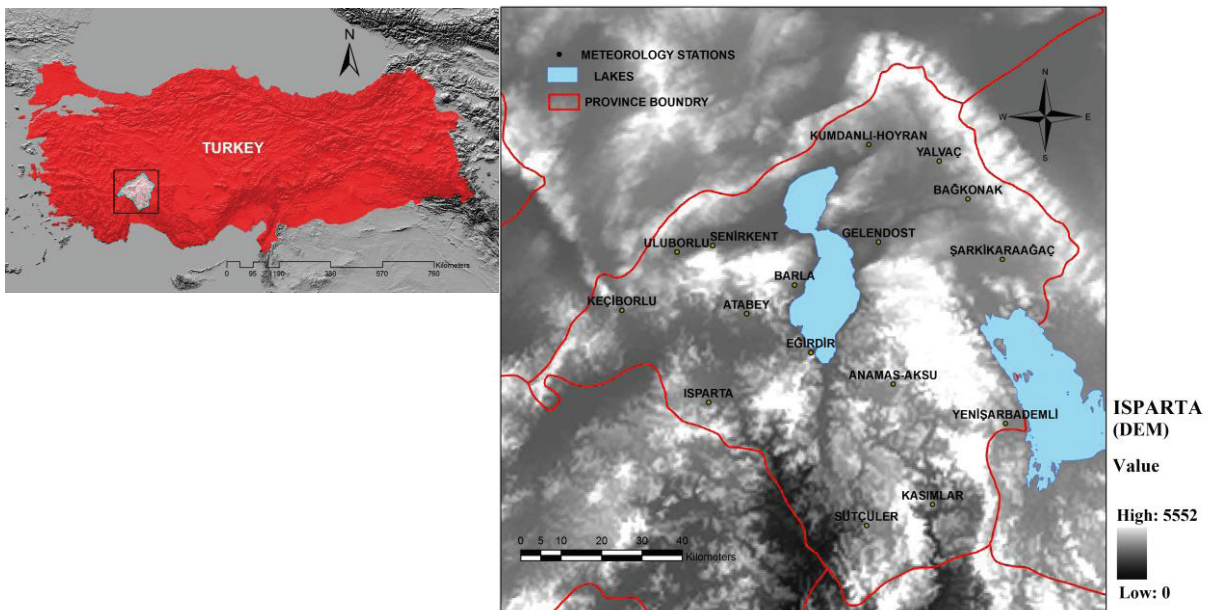


Figure 1. The location of Isparta Province and the meteorology stations in Turkey.

stations and the years for which observations are available are shown in Table 1.

Meteorological aspects of different areas of the province could reflect the microclimatic structure resulting from the province's generally undulating topography. For this reason, data from meteorological stations at different locations were used to indicate the detailed climatic structure. Distribution of the stations within the provincial borders is shown in Figure 1. A digital elevation model (DEM) of Isparta Province was used to visualize the topographic structure.

2.2. Creation of thermal perception map

Thermal perception maps (TPMs) showing suitable regions and times for recreation in Isparta Province were obtained from the climatic data. These regions and times reflect the TC for Isparta Province. The study gathered sufficient data to identify regions and periods and to map them in a spatial format that was suitable to determine TC. The values of the physiologically equivalent temperature (PET) index were used to determine the TC. PET is one of the most important indexes available for developing TC for a region and is predicated on the concept of energy balance. This index considers aspects of climate (temperature,

humidity, radiation, and wind speed) and allows them to be reflected in the results of analyses based on the index by incorporating human physical characteristics as well as the climate parameters themselves (Höppe 1993; Höppe 1999; Matzarakis et al. 1999). Calculation of the mean radiant temperature, an index, makes it easier to evaluate the thermal components of the climate in connection with TC (Matzarakis and Rutz 2005). Table 2 shows the PET index values obtained by considering these aspects of human physiology.

The mean monthly PET values obtained from station data using the RayMan 1.2 program were transferred to a numeric platform using ArcGIS 10 software. TPMs based on PET maps and physiological stress values were made to show the distribution of monthly mean PET values for the entire province. This information was used to determine suitable regions and times for outdoor recreation according to the TC calculated for the province. April, May, June, July, August, September, and October are the months during which most outdoor recreation occurs. These months may include suitable values according to the TC in this location. PET data and TPMs were only produced for these months. The maps obtained show the

Table 1. Coordinates, altitudes (A), and years of observation (YO) of stations (DMİ 2010).

Meteorology stations	Coordinates	A (m)	YO
Isparta (Is)	37°45"N, 30°33"E	997	1975–2006
Yalvaç (Ya)	38°18"N, 31°11"E	1096	1975–2006
Eğirdir (Eğ)	37°52"N, 30°50"E	920	1975–2006
Senirkent (Se)	38°06"N, 30°33"E	959	1975–2006
Atabey (At)	37°57"N, 30°39"E	1000	1975–2006
Anamas-Aksu (An)	37°48"N, 31°04"E	1200	1983–2003
Barla (Ba)	38°01"N, 30°47"E	1100	1987–1992
Bağkonak (Bğ)	38°13"N, 31°16"E	1146	1987–1996
Gelendost (Ge)	38°07"N, 31°01"E	850	1983–1988
Kumdanlı-Hoyran (Ku)	38°20"N, 30°59"E	1050	1984–1995
Kasımlar (Ka)	37°32"N, 31°11"E	1100	1987–1993
Keçiborlu (Ke)	37°57"N, 30°18"E	990	1975–1990
Sütçüler (Sü)	37°29"N, 31°00"E	1000	1975–1993
Şarkikaraağaç (Şa)	38°05"N, 31°22"E	1180	1976–1995
Uluborlu (Ul)	38°05"N, 30°27"E	1160	1975–2006
Yenişarbademli (Ye)	37°43"N, 31°23"E	1150	1983–1994

Table 2. Distribution of PET index values, thermal perception, and physiological stress relating to these values (Matzarakis and Mayer 1996; Matzarakis et al. 1999).

PET (°C)	Thermal perception	Grade of physiological stress
4	Very cold	Extreme cold stress
8	Cold	Strong cold stress
13	Cool	Moderate cold stress
18	Slightly cool	Slight cold stress
23	Comfortable	No thermal stress
29	Slightly warm	Slight heat stress
35	Warm	Moderate heat stress
41	Hot	Wrong heat stress
	Very hot	Extreme heat stress

level of comfort for different locations in the province and for different periods.

In this study, the RayMan 1.2 program was used to obtain the monthly mean PET values from meteorological stations. The RayMan 1.2 program contains a model developed to calculate short- and long-wave radiation flow affecting the human body in simple and complex environments. The program calculates radiation flux densities, sunshine duration, shadow spaces, and thermophysiological relevant assessment indices using only a limited number of meteorological and other input data and presents the results in the form of graphics or charts (Matzarakis et al. 2007; Matzarakis et al. 2010).

Some studies conducted in Isparta Province showed that 1200 hours and the hours immediately following were preferred for outdoor recreation activities (Akten 2009; Nayir 2009). For this reason, the PET values obtained from the stations at 1400 hours were used to produce the TPMs, and these values were interpolated over the surface of the entire province using ArcMap 10 software. Therefore, the inverse distance weighted (IDW) method, generally used as a simple local interpolation technique (Lo et al. 2002), was used. The IDW creates an interpolated surface by calculating the values of unknown locations as the weighted sum of the known values within a certain neighborhood of the unknown point. The weights of known points are inversely proportional to their distance to the unknown point. Hence, known points that are close to the unknown point have a greater influence on the precision value than the points that are farther apart.

Eq. (1) is used to calculate the output cell value for the IDW method.

$$\sum_{i=1}^n m_i / d_i^2 / \sum_{i=1}^n 1 / d_i^2 \quad (1)$$

Here, m_i is the point value and d_i is the distance between points (de By 2001).

3. Results

The following results were obtained from the analysis of the yearly mean humidity values for Isparta Province. The town of Eğirdir was the most humid area (64% humidity), and the town of Gelendost had the minimum humidity value (51.4%). The yearly mean humidity value for Isparta Province was 56.7%. An examination of the monthly mean humidity values for Isparta Province shows that the most humid month was December (71.6%) (Table 3). The results from the examination of the wind speed data for the province show that Eğirdir exhibited the maximum mean annual wind speed (3.4 m s^{-1}). The lowest mean annual wind speed was found in Gelendost (1.2 m s^{-1}). The yearly mean wind speed for the province was 2.2 m s^{-1} . An examination of the monthly mean wind speed values for Isparta Province reveals that the months with the maximum wind speed were February, March, and July (2.4 m s^{-1}) (Table 3).

The analysis of the annual mean temperature data for the province showed that Sütçüler was the hottest town (13.1°C). The town having the lowest annual mean temperature was Şarkikaraağaç (10.2°C). The yearly mean temperature for the province was 11.8°C . Examination of the monthly mean temperatures shows that the month with the highest temperatures was July (23.1°C) (Table 3).

The monthly mean humidity, wind speed, and temperature data for the stations included in the study were entered into the RayMan 1.2 program. The resulting monthly mean PET values are shown in Table 4. A classification was made according to the values of the PET index. Slightly cool ($13\text{--}18^\circ\text{C}$) areas and months are

Table 3. Mean monthly wind speed (ws, m s⁻¹), mean monthly humidity (h, %), and mean monthly temperature (t, °C) values of stations.

		Meteorology stations															
		Is	Ya	Eğ	Se	At	An	Ba	Bğ	Ge	Ku	Ka	Ke	Sü	Şa	Ul	Ye
1	ws	2	2.1	3.5	1.8	1.8	1.4	3.4	1.5	1.4	3.3	1.3	3.1	2.1	1.9	2.6	1.4
	h	72	74	76	69	69	76	69	72	66	68	59	69	65	67	70	78
	t	1.8	3	2.1	1.4	1.8	0.5	0.7	-0.6	3	1.8	2.5	2	3.3	-1.0	1.1	0.2
2	ws	2.4	2.4	3.9	2.0	2.1	1.7	4	1.5	1	3.4	1.6	3.8	2.2	2.1	3	1.7
	h	68	72	72	65	66	73	65	69	60	66	63	65	65	66	66	75
	t	2.6	1	2.8	2.4	2.6	0.7	1.7	0.7	2.9	2.2	3.2	2.8	3.6	0	2	0.1
3	ws	2.5	2.4	3.8	2	2.1	1.6	3.5	1.5	0.9	3.4	1.5	3.4	2.1	2.2	3.1	1.7
	h	65	66	67	60	59	68	61	60	55	59	59	59	60	62	61	62
	t	5.9	4.9	6.3	6.3	6.1	4.5	5.4	4.4	5.3	6.1	6.2	6.3	6.9	4.7	5.7	4.8
4	ws	2.6	2.3	3.8	2	2.2	1.6	2.5	1.3	1.2	3.3	1.8	3.5	2	2.2	2.9	2.1
	h	62	63	64	56	55	60	51	52	53	53	56	54	58	55	57	51
	t	10.6	9.9	11	11.3	10.7	9.6	10.9	10	10.9	11.4	11.4	11	11.3	9.8	10.6	10.5
5	ws	2	2.1	3.2	1.7	1.8	1.4	2.5	1.5	1.2	3	1.6	3.1	1.8	1.9	2.3	1.9
	h	58	59	61	52	51	58	46	51	47	47	53	49	55	55	55	50
	t	15.5	14.7	15.9	16.3	15.7	13.9	15	14.1	15.6	15.9	15.4	15.5	15.6	13.8	15.2	14.3
6	ws	2	2.3	3.3	1.8	2	1.4	3	1.5	1.3	3.1	1.6	3.4	2	1.8	2.3	1.9
	h	52	53	54	46	43	55	46	50	47	42	49	43	50	51	50	45
	t	20.2	19.1	20.6	20.9	20.5	18.3	19.5	18.3	19.3	20.4	20.2	19.9	20.3	18.0	19.5	19.0
7	ws	2	2.8	3.5	1.9	2.1	1.5	4.1	1.9	1.7	3	1.6	3.8	2.3	1.9	2.3	1.8
	h	47	46	51	41	37	52	41	50	39	36	41	35	44	45	46	40
	t	23.5	22.7	23.8	24.3	24.2	21.7	23.4	21.7	23	23.6	24.1	23.5	23.7	21	22.6	22.2
8	ws	1.8	2.6	3.2	1.8	2	1.4	3.3	1.8	1.7	2.9	1.5	3.6	1.9	1.8	2.1	1.8
	h	49	47	53	42	36	52	35	47	40	33	39	35	43	42	46	38
	t	23	22.6	23.3	24	24	21.4	23.4	22	22.8	23.7	24.1	23.4	23.7	21.2	22.4	22.1
9	ws	1.8	2.2	3	1.5	1.8	1.3	2.7	1.6	1.2	2.9	1.4	3.2	1.7	1.8	2.1	1.8
	h	54	52	57	47	41	56	58	49	40	34	38	37	44	43	49	41
	t	18.4	17.9	19	19.2	19.4	17.1	19.9	18	19.5	20.1	20.5	19.7	20.3	17.4	18.1	18.3
10	ws	1.8	2	2.9	1.4	1.7	1.4	3.1	1.5	1.3	2.8	1.5	3	1.8	1.7	2.3	1.6
	h	62	62	65	57	51	63	52	58	46	48	51	49	51	55	59	50
	t	12.8	11.9	13.6	13.1	13.9	11.7	13.4	12	12.5	14	14.6	13.5	14.7	11.6	12.6	12.4
11	ws	2.1	2	3.4	1.5	1.3	1.4	3	1.4	1.2	2.9	1.5	2.8	1.9	2	2.7	1.5
	h	68	71	72	65	62	73	64	69	61	64	63	61	61	65	66	68
	t	7	5.5	7.5	6.8	7.7	6.1	7.4	4.9	7.3	7.1	8.2	7.5	8.8	5.3	6.7	6.2
12	ws	2.3	2	3.4	1.7	1.5	1.5	3.6	1.4	0.8	3	1.4	2.8	1.8	1.8	2.7	1.3
	h	73	75	76	70	71	77	72	75	63	70	69	70	66	69	71	79
	t	3.1	1.9	3.8	3	3.3	2	3.1	1.1	3.1	2.6	3.8	3.3	4.8	0.8	2.8	1.4

Table 4. Mean monthly PET values of stations.

	PET (°C)											
	1	2	3	4	5	6	7	8	9	10	11	12
Is	1.1	2.5	7.2	12.9	19.9	27.1	31.3	31.1	23.9	15.4	6.8	1.5
Ya	-0.9	0.7	6.3	12.8	18.7	24.5	27.9	28.1	21.7	13.8	5.3	0.6
Eğ	-0.7	0.7	5.6	11.3	17.7	24.1	28.3	28.0	21.3	14.1	5.5	0.8
Se	1.0	3.1	8.8	15.1	22.0	28.6	32.6	32.3	26.1	16.9	7.9	2.4
At	1.4	3.1	8.3	13.8	20.7	27.2	31.7	31.4	24.9	16.7	9.5	3.3
An	1.2	2.1	8.1	14.5	20.3	27.0	30.8	30.6	24.4	15.5	7.6	1.9
Ba	-2.3	-0.8	4.9	13.2	17.8	22.9	26.3	27.3	23.3	13.3	5.7	-0.2
Bğ	-0.5	2.6	8.2	16.1	19.9	26.4	29.2	29.6	24.0	15.3	6.1	1.1
Ge	3.7	7.1	12.3	17.8	23.6	28.9	31.6	31.1	27.7	16.4	9.4	5.5
Ku	-1.0	0.4	5.8	12.3	17.8	23.9	28.5	28.6	22.4	14.3	5.4	-0.2
Ka	3.5	5.0	10.3	15.8	21.2	28.5	33.3	33.4	27.9	18.1	9.5	4.1
Ke	0.0	0.7	5.9	11.6	17.3	22.5	26.8	26.9	21.4	13.5	6.0	0.9
Sü	2.4	4.0	9.2	15.1	20.6	27.2	30.6	31.6	26.7	17.4	9.1	4.2
Şa	-1.9	0.2	6.4	12.8	18.2	24.7	28.1	28.4	22.1	14.2	5.0	-0.3
Ul	0.9	0.7	5.8	12.1	18.6	24.9	29.0	29.1	22.2	13.9	5.3	0.4
Ye	0.5	1.5	8.0	13.7	18.7	25.5	29.9	29.5	23.4	15.3	7.3	1.9
13–18 °C: Slightly cool												
18–23 °C: Comfortable												
23–29 °C: Slightly warm												

shown in gray, comfortable (18–23 °C) areas and months are shown in dark gray, and slightly warm (23–29 °C) areas and months are shown in light gray.

Province-wide PET values varied from 11 to 18 °C during April. The physiological stress classification placed the towns of Keçiborlu, Uluborlu, Isparta Center, Eğirdir, Kumdanlı-Hoyran, Yalvaç, and Şarkikaraağaç in the cool category. The rest of the province was classified as slightly cool (Figures 2a and 2b).

Province-wide PET values varied from 17 to 24 °C during May. The towns of Keçiborlu, Eğirdir, Barla, and Kumdanlı-Hoyran were slightly cool; Gelendost was slightly warm; and the rest of the province was comfortable (Figures 3a and 3b).

Province-wide PET values varied between 22 and 29 °C during June. Keçiborlu and Barla were comfortable. The rest of the province was slightly warm (Figures 4a and 4b).

Province-wide PET values varied between 26 and 33 °C during July. Keçiborlu, Barla, Eğirdir, Şarkikaraağaç, Bağkonak, Yalvaç, and Kumdanlı-Hoyran were slightly warm, and the rest of the province was warm (Figures 5a and 5b).

Province-wide PET values varied between 27 and 33 °C during August. Keçiborlu, Barla, Eğirdir, Şarkikaraağaç, Yalvaç, and Kumdanlı-Hoyran were slightly warm, and the rest of the province was warm (Figures 6a and 6b).

Province-wide PET values varied between 21 and 28 °C during August. Keçiborlu, Uluborlu, Eğirdir, Şarkikaraağaç, Yalvaç, and Kumdanlı-Hoyran were comfortable, and the rest of the province was slightly warm (Figures 7a and 7b).

Province-wide PET values varied between 13 and 18 °C in October. According to the physiological stress classification, the town of Kasımlar was comfortable. The rest of the province was slightly cool (Figures 8a and 8b).

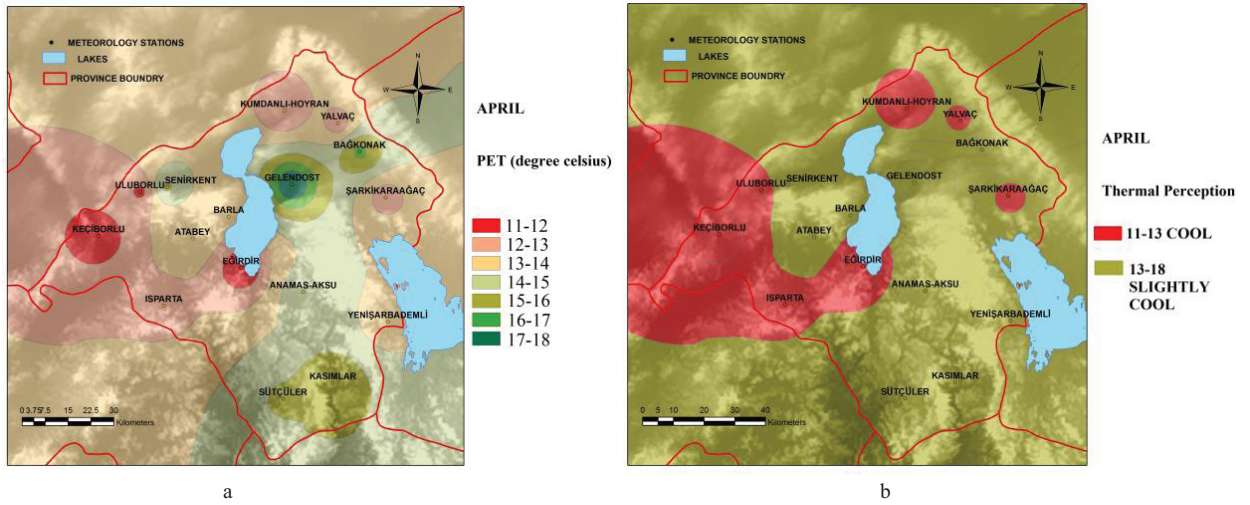


Figure 2. PET (a) and TPM (b) of Isparta Province in April.

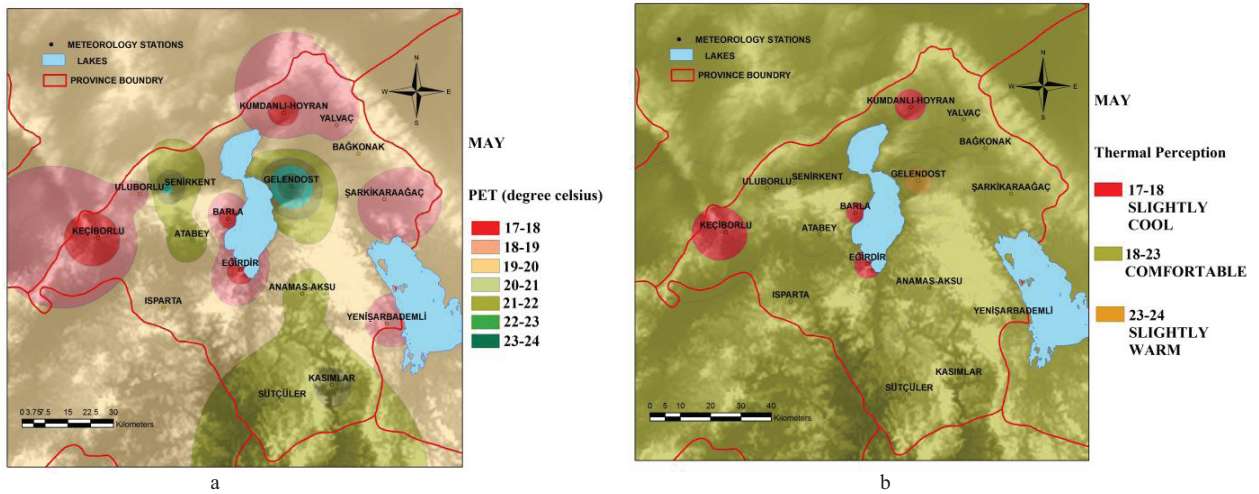


Figure 3. PET (a) and TPM (b) of Isparta Province in May.

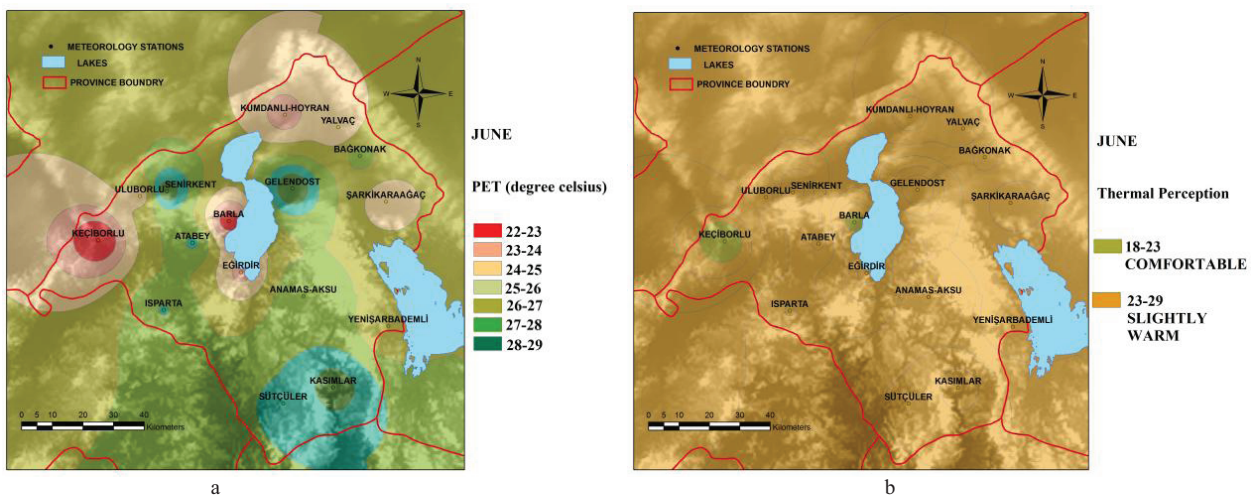


Figure 4. PET (a) and TPM (b) of Isparta Province in June.

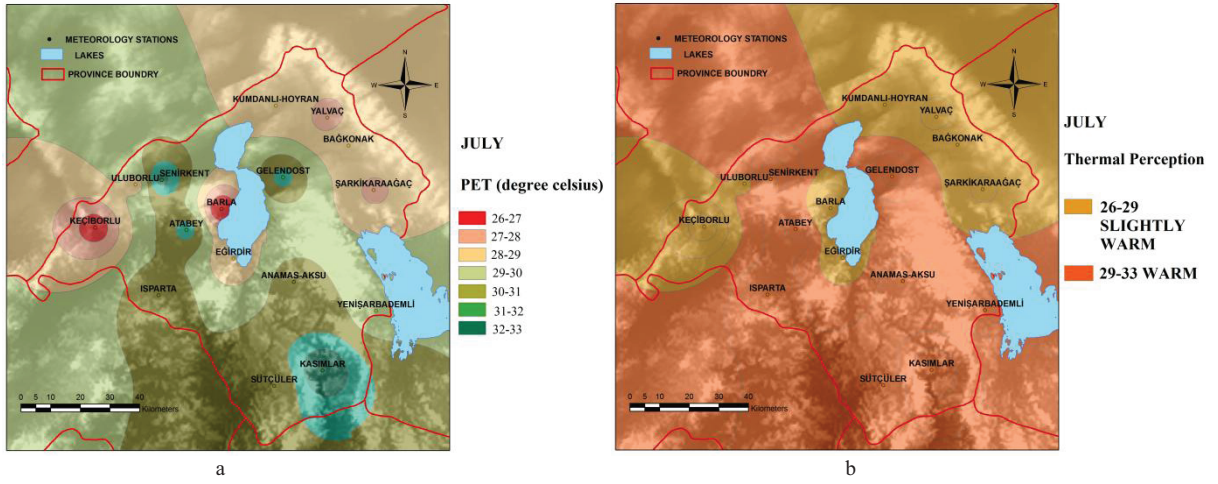


Figure 5. PET (a) and TPM (b) of Isparta Province in July.

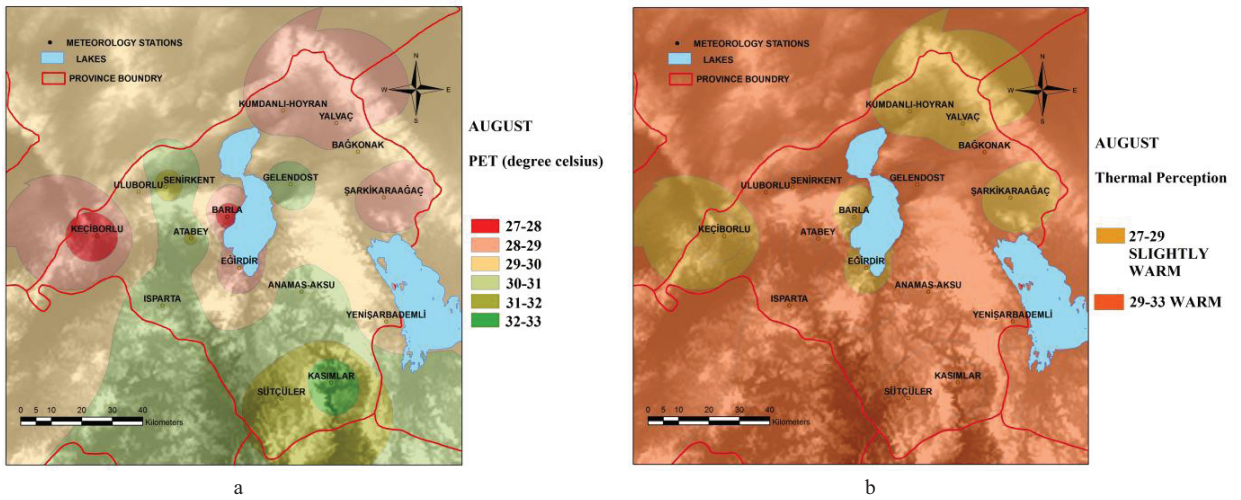


Figure 6. PET (a) and TPM (b) of Isparta Province in August.

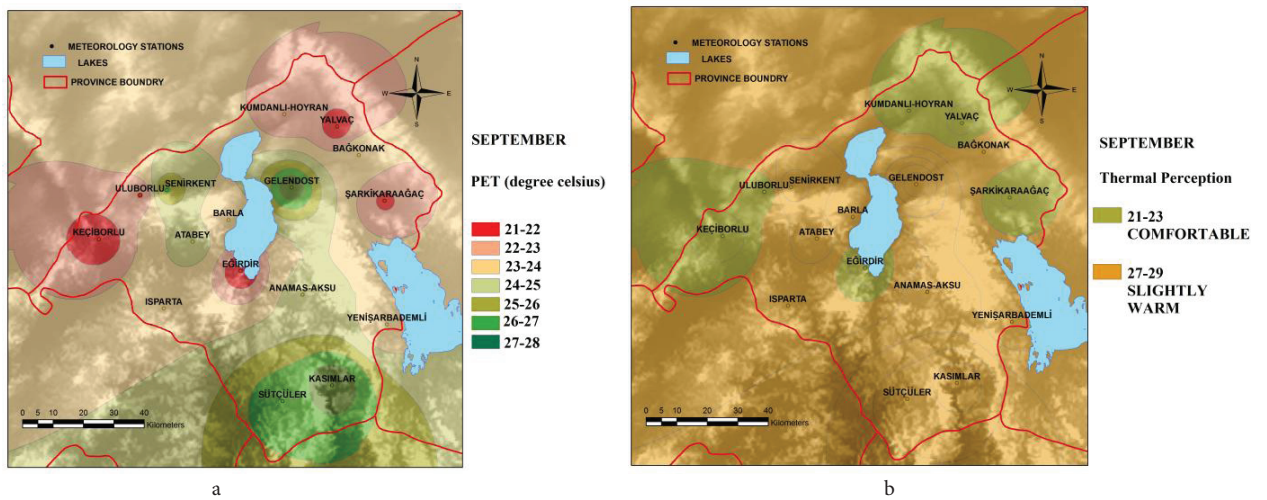


Figure 7. PET (a) and TPM (b) of Isparta Province in September.

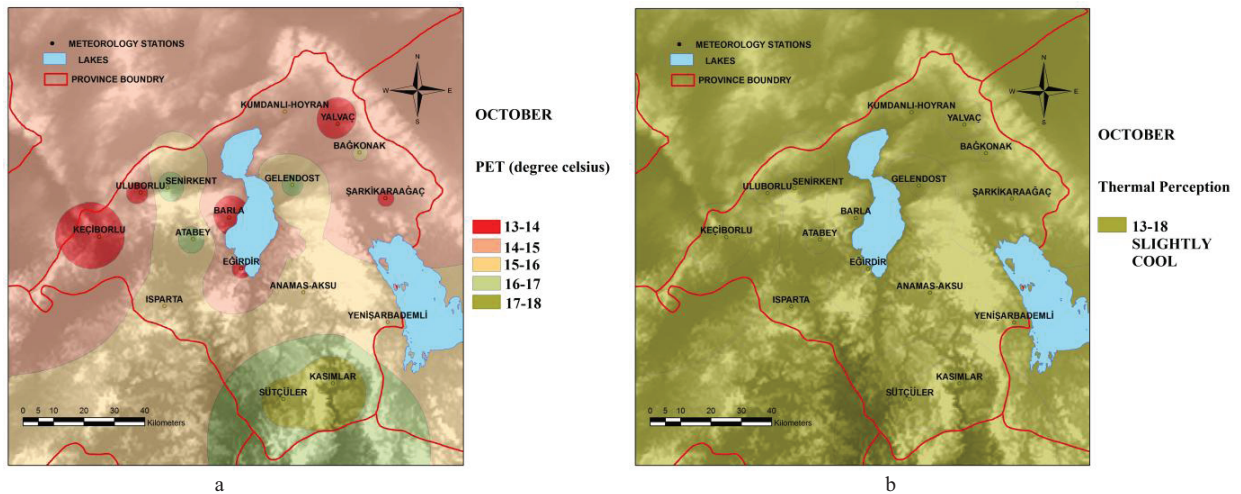


Figure 8. PET (a) and TPM (b) of Isparta Province in October.

4. Discussion

The TPMs used in this study were each prepared for a specific month. Some previous studies addressing shorter periods have presented daily or weekly results. However, planning decisions involve longer time periods. For this reason, the data that will be used to support plans should contribute to developing the sufficiency of planning decisions. For recreational planning that includes all of Isparta Province, a monthly TPM corresponds to an appropriate period due to the topographic structure of the province, geographic location, and extensive area involved. Mapping of the comfort structure for longer periods (e.g., seasonal and annual) will not produce sufficient detail. Accordingly, these longer-period maps would not be sufficiently meaningful to produce correct planning decisions. The desirability of using a monthly basis for TPMs used in planning is confirmed by many studies (Eliasson 2000; Morillón-Gálvez et al. 2004; Alcoforado et al. 2009). The use of longer time scales for mapping topographically complex regions like Isparta Province would not allow the climatic structure to be presented in full detail.

In some studies conducted to define a comfort structure, the data have been presented by using graphics rather than maps (Gómez et al. 2001; Schiller 2001). However, maps that present a comfort structure are better for illustrating the planning studies and give more effective results. The reason maps are effective is that it is very helpful to specify the most comfortable periods and regions for the benefit of planners and tourists. The selection of regions for recreation can be aided by maps that specify comfortable regions and periods. In addition, it is possible to identify relevant interactions by matching these maps with data on other characteristics such as topography, plant cover, or lakes. In this study, the comfort structure and comfortable

periods are revealed by maps. This approach highlights ways in which TC interacts with other data.

Currently in Turkey, no applications that include consideration of the TC criterion for recreational planning studies exist. This factor is emerging as an important subject to consider in rational planning studies. Many previous studies have emphasized the important role of TC in spatial planning studies, the need to use data on climate and conduct studies at a microclimatic scale, the importance of communication and knowledge sharing between planning disciplines and climatologists, and the development of planning instruments (Eliasson 2000; Branderburg and Arnberger 2001; de Freitas 2003). The current study defines the comfortable areas and periods in detail on a monthly basis for Isparta Province and provides important data for further recreational planning.

GIS instruments make an important contribution to the planning process. They also provide the possibility to perform different analyses through repeated matching with other parameters (Svensson et al. 2003; Morillón-Gálvez et al. 2004; Alcoforado et al. 2009; Kántor and Unger 2010; Wong et al. 2011). In this study, detailed TPMs were created using GIS instruments and produced on a medium that was 50% transparent. In this manner, TC and topographic structure could be examined together by matching them repeatedly. This approach is informative because the climatic structure is affected mostly by topographic structure. The interaction of climatic structure with topography should certainly be defined for the purpose of recreational planning. Furthermore, some previous studies used a GIS platform to repeatedly match data from different areas (Svensson et al. 2003; Morillón-Gálvez et al. 2004; Alcoforado et al. 2009; Kántor and Unger 2010; Zengin et al. 2010; Wong et al. 2011). Some important analyses could be performed in this manner.

Isparta Province has a continental and mild climate corresponding to its geographical location. Its varied topographic structure produces variation in the climatic structure of the province. The following results are evident if they are evaluated in light of the combined data on annual meteorological mean values, topographic structure, plant cover, geographic coordinates, and lakes. The winds that come from the south are influenced by the flat topographical structure of Eğirdir, Keçiborlu, and Barla. The flat topographical structure of the area naturally results in high wind speeds. The lowest annual mean wind speed was found for Gelendost. The mountains to the south of that town shelter it from the wind. In the spring (e.g., February and March) the wind speeds are high because of the air flow resulting from temperature differences. Eğirdir Lake affects the humidity. The central regions close to the lake have relatively high humidity values. The humidity could reach nearby areas and interior regions where the topographic structure is flat. The town with the lowest humidity in the province is Gelendost. Although that town is near Eğirdir Lake, its low altitude results in higher temperatures and decreased humidity.

The examination of the monthly mean PET values shows that the comfortable regions of the province are located in its central and northern portions. The most suitable months, listed in decreasing order of suitability, were May, September, June, and October. According to the physiological stress classification, Keçiborlu, Uluborlu, Isparta Center, Eğirdir, Kumdanlı-Hoyran, Yalvaç, and Şarkikaraağaç are cool in April. The wind speeds are higher in these regions during this period. Some of these towns are located in the north and are therefore closer to locations having a continental climate. Throughout the province, a greater number of comfortable areas appear in May because the humidity is decreasing. The decrease in humidity is associated with lower rainfall, an increase in temperature, and decreased wind speed. Some southern regions, low-altitude areas, and humid locations near the lake could

be considered uncomfortable in terms of TC. In June, the most comfortable regions are Keçiborlu and Barla due to the combination of temperature, humidity, and wind speed. The decrease in wind results from the topographic structure and produces more comfortable conditions, although the temperature is rising. Comfort also results from the humidity produced by the lake. During July, the southern portion of the province is more uncomfortable due to geographic location. Some regions in the north and near the lake have a more comfortable structure due to their geographic locations and proximity to the lake. During August, uncomfortable conditions are common province-wide. Some locations near the lake, some northern areas, and some regions with high wind speeds are relatively more comfortable. During September, the regions with high wind speeds, some locations near the lake, and some northern parts of the province are comfortable, whereas the southern regions have a less comfortable structure. During October, a slightly warm structure is present throughout the province. During this period, wind speed, humidity, and temperature combine with topographic structure and geographic position to affect the TC.

For outdoor recreation activities, the most comfortable regions are as follows: all locations in the province with the exception of the towns of Eğirdir, Keçiborlu, Barla, and Kumdanlı-Hoyran in May; Keçiborlu, Eğirdir, Uluborlu, Yalvaç, Kumdanlı-Hoyran, and Şarkikaraağaç in September; Barla and Keçiborlu in June; and Kasımlar, located in the southern part of the province, in October. Slightly cool, comfortable, and slightly warm conditions are present at Barla for a continuous 7-month period.

This study defined the comfort structure by region and by period for use in planning disciplines. A method was proposed for producing comfort maps. These maps could easily be included in the planning process and would furnish significant assistance in making correct planning decisions. The study offers meaningful guidance for future recreation planning studies.

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