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Determining Bioclimatic Comfort Areas in Summer with The Heat Index Method

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ABSTRACT

From past to present, human beings are striving to live following climatic conditions. With the increase in urbanization, these conditions have become more difficult, and especially in the summer months, some settlements have become unbearable. One of these settlements is the Adana-Çukurova district. This study aims to determine the temperature areas felt by the Heat Index method in the Adana-Çukurova district and its surroundings. Bioclimatic comfort zones of the summer months were determined with the climate data obtained from the General Directorate of Meteorology, and these comfort zones and thermal stress levels were classified according to PET.

Anahtar Kelimeler:
Biyoklimatik Konfor,
CBS,
Heat Index,
Çukurova,
Yaz Mevsimi.

ÖZ

Geçmişten günümüze kadar insanoğlu iklim şartlarına uygun yaşama çabasındadır. Şehirleşmenin artmasıyla birlikte bu şartlar daha zorlaşmış ve özellikle yaz aylarında bazı yerleşmelerde çekilmez duruma gelmiştir. Bu yerleşmelerden biri de Adana-Çukurova ilçesidir.

Bu çalışmanın amacı da Adana-Çukurova ilçesi ve çevresinde Heat Indexsi metoduyla hissedilen sıcaklık alanlarını belirlemektir. Meteorloji Genel Müdürlüğünden alınan iklim verileri ile yaz aylarının biyoklimatik konfor alanları belirlenmiştir ve bu konfor alanları ve termal stres seviyeleri PET'e göre sınıflandırılmıştır.

1. Introduction

Human beings have made many scientific developments to improve their living conditions in the historical process. In this context, especially individuals want to have a comfortable life in every sense. Comfort is a dynamic cultural and social structure that has different meanings related to many different areas (work, entertainment, home, school, etc.) in daily life [1-10]. Geographical conditions and especially climate are known to have a multidimensional effect on people's comfort standards. However, when we evaluate it in terms of climate, it has psychological and physiological effects on the individual, as well as economic and social effects. It is a fact that climate is among the main factors controlling the daily life of the individual, clothing and food styles, behaviors and lifestyles, and even health conditions [8-23]. Another situation is that the factors affecting or controlling the climate should not be forgotten in this process. When the climate is considered as a whole, there is the control of mechanisms of various scales and dimensions on similar climatic elements such as pressure, wind, precipitation, humidity, or temperature [11-29]. Today, most people live in cities. In this process,

urbanization has increased more rapidly, especially with the progress of the industrial field in the world. However, with this rapid urbanization, various problems have arisen, especially in terms of planning, cities have developed negatively [23-29]. In the world, more people live in urban areas than rural areas, 55% of the world's population live in urban areas in 2018, while this situation was 30% in 1950, but it is estimated that 68% will live in urban areas in 2050 depending United Nations (UN, 2019) [30]. Since there are very deep and complex relationships in unplanned developing cities, it has left many negative effects on human comfort. As cities change the environmental structure and topography of nature in their location, they have effects on many other natural parameters that have an effect in that area with the increasing population [1-10,23-29, 31-35]. For this reason, it has a great effect on the climate as well as on many natural elements in cities. Thus, the comfort of people living in cities is directly affected. When looking at many studies on human comfort, the climate affects a large part of the life of the individual, and thus, humidity, wind, and temperature must be at certain intervals for the individual to be comfortable in his / her environment [31-41]. In other words, people's stress levels increase considerably when they are above or below these desired values. In this context, in cases where stress increases, firstly its effect is observed on psychology, while it affects daily life negatively. However, it is possible to see these problems on the physical glaze, and this includes a process that goes up to the death of a person. For many such reasons, academic studies in this field have increased gradually. It is increasing with studies on various subjects, especially global warming, urban heat island, and bioclimatic comfort areas.

This study aims to determine and map the bioclimatic comfort areas of Çukurova and its surrounding region. Also to evaluate the human settlement activities in terms of bioclimatic comfort and to determine the stress conditions of the individuals living in the region depending on the temperature. The study took place at various stages in line with such purposes. In this context, climate data such as temperature and relative humidity from 18 meteorology stations covering the study area were obtained by request from the General Directorate of Meteorology. With these data taken in 12 months, it was prepared as general average and monthly average. With these data obtained from a total of 18 meteorology stations, the relative humidity and temperature were transferred to the Geographical Information Systems environment, and the model was created with the co-kriking method, and pixel-based humidity and temperature maps were created. The scale was produced by using the temperature values felt with these produced maps over the "Heat Index" standard. Thus, the temperature values felt on the map were classified.

2. Material and Method

The study area covers the province of Adana, Çukurova district, and its wider environment. It is located between the districts of Pozantı and Çamlıyayla in the northwest and Mersin province in the west and İmamoğlu in the northeast (Figure 1). The altitude of the study area starts from 4 meters and goes up to 2848 meters.

Graphs were prepared for various purposes with the help of climate data obtained from the MGM excel program. Subsequently, with the ArcGIS 10.8.1 program, humidity and temperature maps of the study area and its surroundings were created with the co-kriging method included in the interpolation methods. "Heat index" calculation has been made with the help of the ArcGIS Pro program.

HI = -42.379 + 2.04901523*T + 10.14333127*RH - .22475541*T*RH - .00683783*T*T - .05481717*RH*RH + .00122874*T*T*RH + .00085282*T*RH*RH - .00000199*T*T*RH*RH [42]

Classification of thermal sensation and stress levels of the PET index was used to show the bioclimatic comfort conditions of the study area and its environment (PET Table). However, the heat index map of the district created as a result of mobile measurements and modeling was not subjected to PET index classification, and the felt temperature values were shown (Table 1).

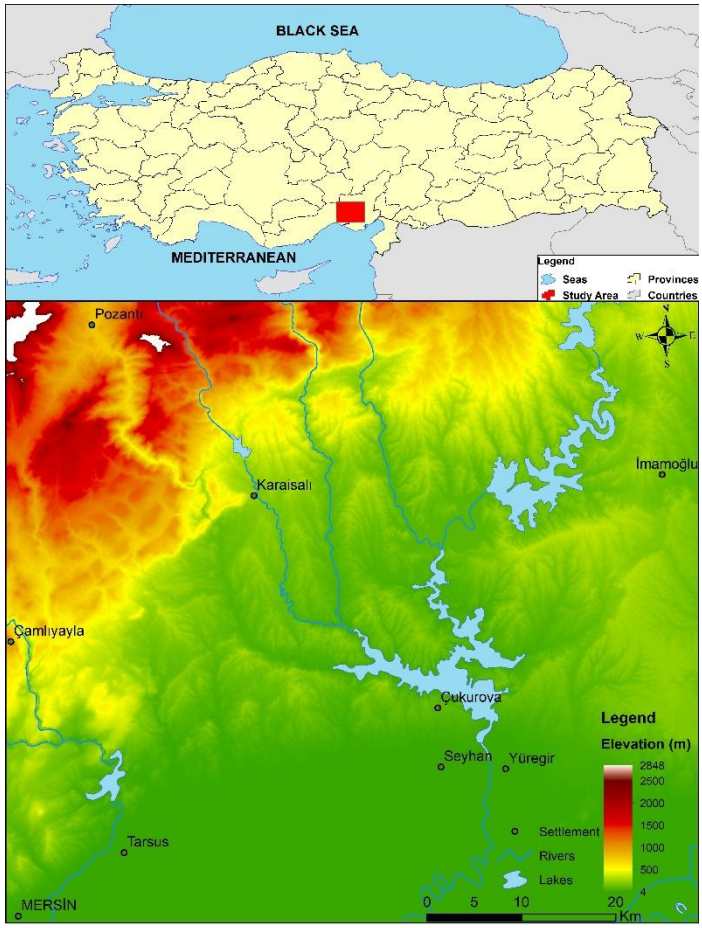

Figure 1. Study Area Location Map

Table 1. The values of PET [43]

PET (°C)	The feeling of warmth	Thermal stress level
< 4	Very cold	Extreme cold stress
4,1 – 8,0	Cold	Strong cold stress
8,1 – 13,0	Cool	Moderate cold stress
13,1 – 18,0	Light cool	Mild cold stress
18,1 – 23,0	Comfortable	No thermal stress
23,1 – 29,0	Slightly warm	Mild heat stress
29,1 – 35,0	Marrow	Medium temperature stress
35,1 – 41,0	Hot	Strong heat stress
> 41,0	Very hot	Extreme temperature stress

3. Result and Discussion

3.1.Spatial Distribution of Temperature and Bioclimatic Comfort Conditions

Temperature (average, maximum and minimum) and bioclimatic comfort conditions of the working area and its environment; The monthly average temperature, the monthly average of the daily maximum temperatures, and the monthly average of the daily minimum temperatures were obtained, and the distribution of temperature and bioclimatic comfort values were made monthly.

In this study, Heat Index was used in index calculations, but PET values were used in thermal detection classes.

3.1.1.June

When the average temperature properties of the study area and its surroundings are examined, it is seen that the lowest temperature is 19 ° C and the highest temperature is 26.83 ° C. The places where the lowest temperatures (19 ° C-22 ° C) are observed are in the north and northwest of the area. The highest temperatures (26 ° C-26.83 ° C) are found in the south of the study area. When looking at the work area, the average temperature is between 24.5 ° C-25 ° C (Figure 2).

For many years, according to the daily maximum temperature monthly averages, the temperatures in the study area and its surroundings hover between 25.88 ° C -33.08 ºC. The areas where the temperatures are the lowest are the Pozantı district and its surroundings located in the northeast of the region. When the study area is examined, it is seen that the maximum temperatures are between 30 ° C-31 ° C, while the values located further south are 33 ° C.

For many years, the daily minimum temperature monthly averages hover between 13.83 ° C-16 ° C in Pozantı, Çamlıyayla, and its vicinity, while the temperature in the study area is around 18 ° C, and in the southern areas, it is 21 ° C and above.

When examining the spatial distributions of bioclimatic comfort conditions according to the June Heat Index values, the average, maximum and minimum temperatures of the work area and its surroundings indicate that "Cool", "Slightly Cool", "Comfortable", "Slightly Cool", "Warm", "Warm" and "Very Hot "thermal detections are seen.

Average temperature values are between 19ºC and 26.83ºC. According to the heat index, these values are between 18.5 ° C-29.45 ° C and indicate the perceived temperature values. The working area is around 20 ° C and in the "Comfortable" range. The north and west of the study area are between 24.8 ° C-25.2 ° C, "Slightly Warm", the south is 29 ° C and above and is in the "Slightly Warm" range.

Maximum temperature values are between 25.88 º C and 33.08 º C. According to the heat index, these values are between 26.03 °-42.58 ° and are in the range of "Comfortable", "Slightly Warm", "Warm", "Warm" and "Very Hot". is located. The working area and its surroundings are around 36 º C and in the "Hot" range. The south of the study area is between 38 ° C-42.58 ° C and is in the "Very Hot" range. The temperature values of Pozantı and Çamlıyayla districts are between 25.88 ° C-30 ° C and are between "Slightly Warm" and "Warm".

Minimum temperature values are between 13.83 ° C and 21.18 ° C. According to the heat index, these values are between 12.81 ° C-21.47 ° C and are in the range of "Cool", "Slightly Cool" and "Comfortable". The area around the work area is "Slightly Cool" and "Comfortable", the north and northwest are generally "Slightly Cool", but a narrow area with high altitude is in the "Cool" range.

The participants' profile has been determined according to gender, age, education, employment and their origin (from Perşembe or come from another city). According to survey data the gender of respondents is % 35,90 female and %64,10 male. The ages of the respondents are % 4,3 (0-18 age), % 25,3 (19-30 age), % 30,3 (31-40), % 36,5 (41-65) and % 3,6 (>65).

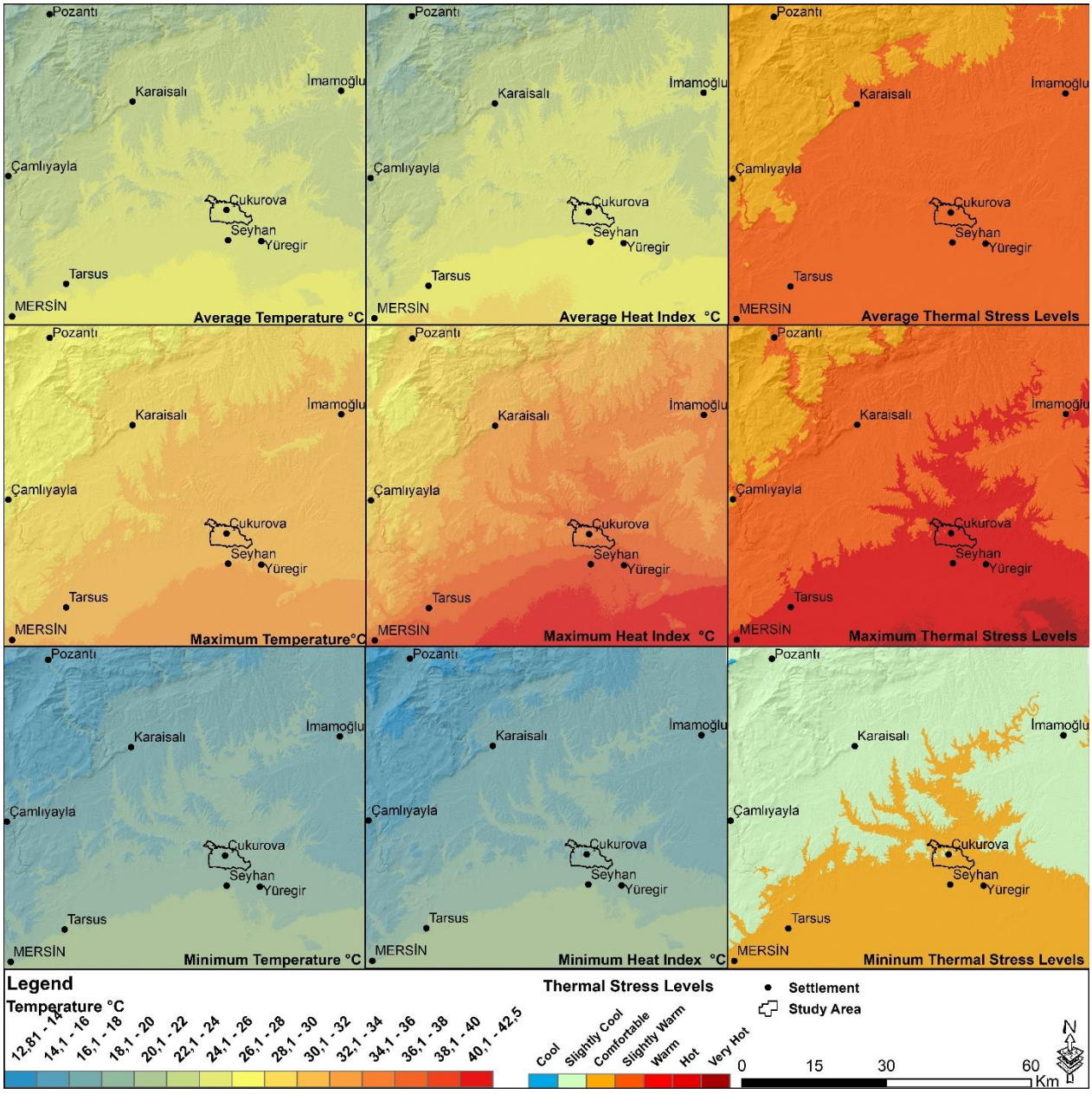

Figure 2: Bioclimatic Comfort Maps of June

3.1.2.July

When the average temperature characteristics of the study area and its surroundings are examined, it is seen that the lowest temperature is 24.79 ° C and the highest temperature is 28.82 ° C. The places where the lowest temperatures (24.79 ° C-26.5 ° C) are observed are located in the north and northwest of the area. The highest temperatures (28 ° C-28.82 ° C) are found in the south of the study area. In terms of the working area, the average temperature is around 27 ° C (Figure 3)

For many years, according to the daily maximum temperature monthly averages, the temperatures in the working area and its surroundings range between 30.35 ° C -34.95 ° C. The areas where the temperatures are the lowest are the Pozantı

district and its surroundings located in the northeast of the region. When the study area is examined, it is seen that the maximum temperatures are around 33 ° C, while the values in the further south are 34 ° C and above.

For many years, the daily minimum temperature monthly averages are between 17.28 ° C-19.4 ° C in Pozantı, Çamlıyayla, and its vicinity, while the temperature in the study area is between 21.5 ° C-22.5 ° C, and in the southern areas it is 24 ° C and above.

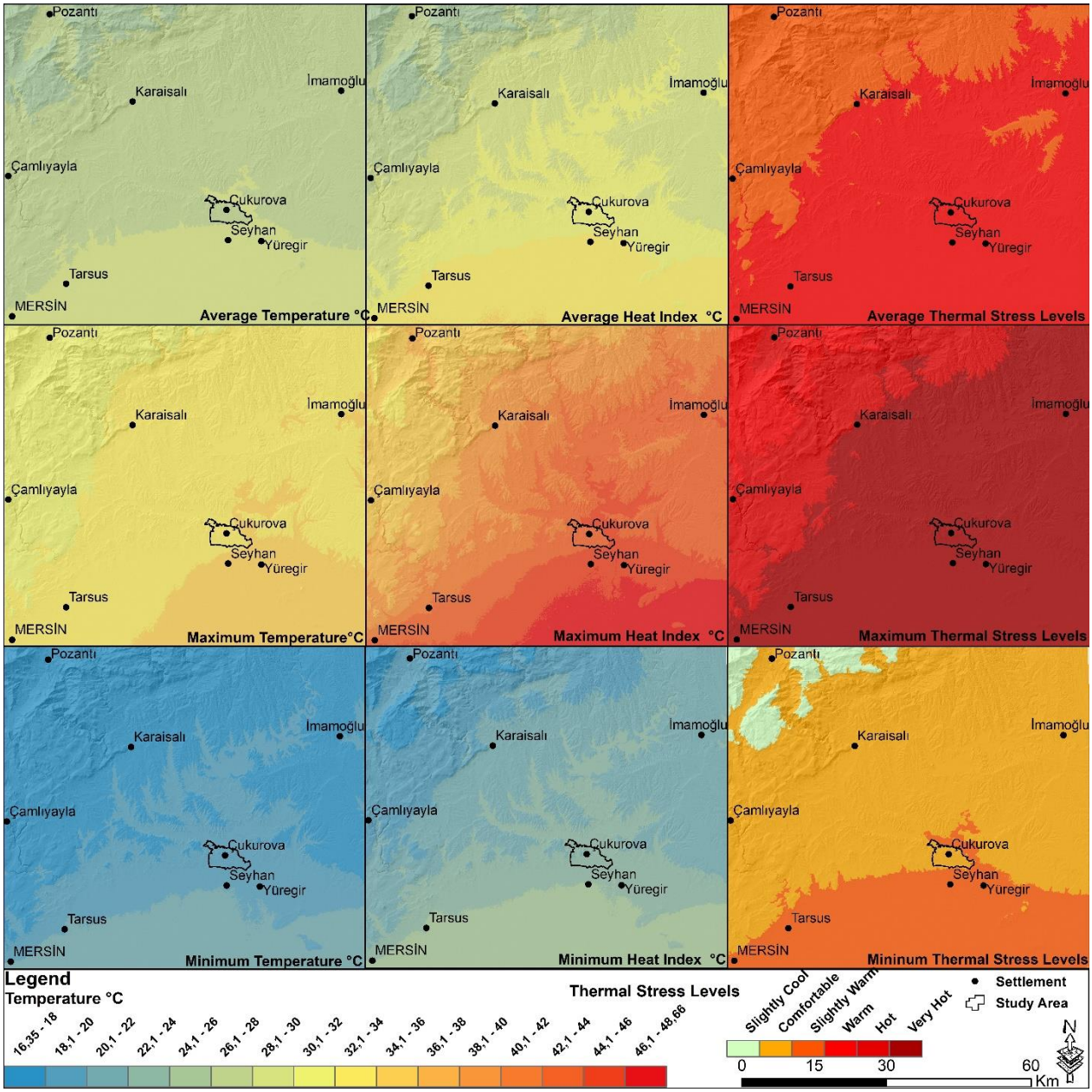

Figure 3: Bioclimatic Comfort Maps of July

When examining the spatial distributions of bioclimatic comfort conditions according to the average, maximum and minimum temperatures of the workplace and its environment, according to the July Heat Index values, "Slightly Cool", "Comfortable", "Slightly Warm", "Warm", "Hot" and "Very Hot" thermal perceptions is seen.

Average temperature values are between 24.79 º C and 28.82 º C. According to the heat index, these values are between 24.6 ° C-34.72 ° C and indicate the perceived temperature values. The working area is around 31 ° C and in the "Warm" range. The north and west of the study area are between 24.6 ° C-26.5 ° C, "Slightly Warm", the south is 33 ° C and above, and is in the "Slightly Warm" range.

Maximum temperature values are between 30.35 ° C and 34.95 ° C. According to the heat index, these values are between 333.04 °C-48.66 ° C and are in the range of "Warm", "Hot" and "Very Hot". The working area and its surroundings are around 43 and in the "Very Hot" range. The south of the study area is between 40 ° C-48.66 ° C and is in the "Very Hot" range. The temperature values of Pozantı and Çamlıyayla districts are between 31.46 ° C-36 ° C and are between "Warm" and "Hot".

Minimum temperature values are between 17.28 ° C and 24.95 ° C. According to the heat index, these values are between 16.15 ° C-25.64 ° C and are in the range of "Slightly Cool", "Comfortable" and "Light Warm". The study area and the west and north of the "Comfortable" study area, in general, are "Slightly Warm" but a narrow area with high elevation is in the "Slightly Cool" range.

3.1.3.August

When the average temperature characteristics of the study area and its surroundings are examined, it is seen that the lowest temperature is 23.92 ° C and the highest temperature is 29.59 ° C. The places where the lowest temperatures (23.92 ° C-26 ° C) are observed are located in the north and northwest of the area. The highest temperatures (28.5 ° C-29.59 ° C) are found in the south of the study area. When looking at the work area, the average temperature is between 27.5 ° C-28 ° C (Figure 4).

For many years, according to the daily maximum temperature monthly averages, the temperatures in the working area and its surroundings range between 30.65 ° C -35.92 ° C. The areas where the temperatures are the lowest are the Pozantı district and its surroundings located in the northeast of the region. When the study area is examined, it is seen that the maximum temperatures are around 34 ° C, while the values in the further south are 35 ° C and above.

For many years, the daily minimum temperature monthly averages hover between 17.36 ° C-19.5 ° C in Pozantı, Çamlıyayla, and its surroundings, while the temperature is around 22.5 ° C in the study area, and 25 ° C and above in the southern areas.

When examining the spatial distributions of bioclimatic comfort conditions according to the average, maximum and minimum temperatures of the work area and its environment according to the August Heat Index values, "Slightly Cool", "Comfortable", "Slightly Warm", "Warm", "Hot" and "Very Hot" thermal perceptions is seen.

Average temperature values are between 23.92 º C and 29.59 º C. According to the heat index, these values are between 23.63 ° -36.98 ° C and indicate the perceived temperature values. The working area is between 30 ° C-31.5 ° C and in the "Warm" range. The north and west of the study area are between 23.63 ° C-26 ° C, "Slightly Warm", the south is 35 ° C and above, and is in the "Hot" range.

Maximum temperature values are between 30.65 º C and 35.92 º C. According to the heat index, these values are between 31.74 ° C-52.12 ° C and are in the range of "Warm", "Hot" and "Very Hot". The working area and its surroundings are between 45 º C-48 ° C and in the "Very Hot" range. The south of the study area rises above 50 ° C and is in the "Very Hot" range. The temperature values of Pozantı and Çamlıyayla districts are between 31.74 ° C-37 ° C and are between "Warm" and "Hot". Minimum temperature values are between 17.34 ° C and 25.49 ° C. According to the heat index, these values are between 16.41 ° C-26.23 ° C and are in the range of "Slightly Cool", "Comfortable" and "Light Warm". The study area and the west and north of the "Comfortable" study area, in general, are "Slightly Warm" but a narrow area with high elevation is in the "Slightly Cool" range.

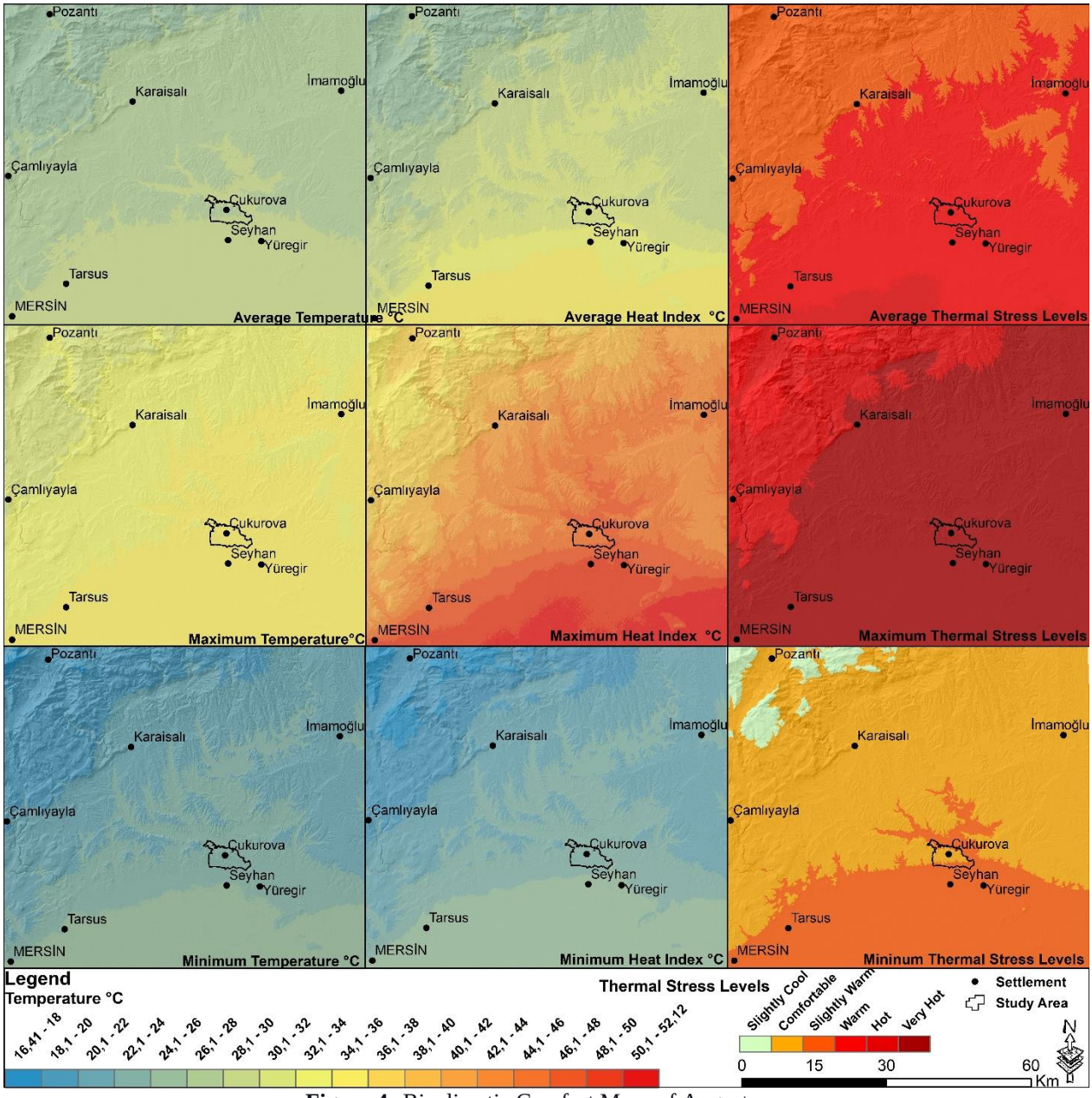

Figure 4: Bioclimatic Comfort Maps of August

4. Conclusion and Recommendation

In this study, the bioclimatic comfort areas of the Çukurova district and its surroundings calculated according to the heat index in the summer months were examined.

Temperature and relative humidity maps were created by interpolating the climate data obtained from MGM and heat index values of these data were revealed through ArcGIS Pro software.

It is observed that the temperatures felt in Çukurova district during the summer months are extremely high according to the maximum heat index and according to the thermal stress level, it is in the hot and very hot class in June and in the very hot class in July and August. This makes the city uninhabitable and causes people to use air conditioners excessively.

According to the minimum heat index calculation, Çukurova district is generally classified as comfortable in the summer months. However, it is classified as warm according to the average heat index.

Since the study area is a hot and humid place, and the urbanization is intense, the urban heat island effect is more common. For this reason, it is necessary to increase the green areas and to carry out activities that will increase the effectiveness of natural ventilation.

Competing Interest / Conflict of Interest

The authors declare that they no conflict of interest. None of the authors have any competing interest in the manuscript

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