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Determination of appropriate areas in terms of bio comfort by using summer temperature index with the help of GIS throughout Ordu province

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Abstract

Threshold values for climate elements have been determined and some indices have been developed, especially with studies on human comfort. It is a fact that the feeling of comfort is subjective and there are different psychological and physical factors affecting this feeling. However, the presentation of threshold values and indices is very interesting in determining the current state of the climate conditions of the environment in terms of average and optimal values and the extent of deviation from the most appropriate values. The values of the climate elements that need to be looked at in order to provide bioclimatic comfort; it as a combination of 21-27.5 °C temperature, 30-65% relative humidity and wind speed up to 5 m/s in open area. These values have been used in many bioclimatic assessments. In addition to being an effective factor in almost every aspect of people's lives, bio comfort is also important in the periods when tourism activities are carried out. Thus, it is extremely important to determine the regions that are not suitable for bio comfort in the season of tourism in the regions that tourism activities are carried out. The aim of this research is to determine the suitable and unsuitable areas in terms of bio comfort in summer by using New Summer Index throughout Ordu province via GIS. As a conclusion, it has been determined that the area covering approximately 57.62% of the southern part of the province is cold, and the most comfortable part of the province is the part covering approximately 11.12% of the province and located by the sea in the north of the province.

Keywords: summer temperature index, bio comfort, tourism, Ordu.

1. Introduction

Climate is an important factor that directly or indirectly affects the life of all living things on earth (Cesur et al. 2021; Varol et al. 2022). For human to feel comfortable, the environment may be in a wind range, humidity, and temperature, which is called “bioclimatic comfort” or simply “bio comfort” (Kilicoglu et al., 2020). In addition to factors such as people's workforce and productivity, activities in daily life, tourism activities, bio comfort is effective in many areas from the performance of the employees to the choice of the region where people will live and even energy efficiency (Feray et al., 2010; Gungor et al., 2021; Adiguzel et al., 2022; Kong et al 2019; Salata et al 2017; Sancar and Güngör 2020; Sevik et al. 2020a,b).

In order to determine the bioclimatic comfort situation in a space, first of all, it is necessary to determine and evaluate the radiation, relative humidity, wind conditions and temperature. Besides these basic factors, the number of hot days, precipitation, diseases and pests due to weather events, air pollution and the amount of oxygen in the atmosphere also affect human comfort.

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Bioclimatic comfort status can be determined by considering all of these effects. Bioclimatic comfort is the climatic conditions in which a person feels the healthiest and most dynamic. In other words, it is the conditions in which a person can adapt to his environment by spending the least amount of energy. The climate components that are important in providing bioclimatic comfort can be listed as temperature, relative humidity, radiation and wind. People feel more vigorous and comfortable in locations where climatic factors are more suitable for maintaining vital activities. The fact that these climatic factors are in suitable ranges for individuals is called bioclimatic comfort (Adiguzel et al., 2020).

There are many studies on the calculation of bioclimatic comfort for humans. Various formulas and indices have been created since the beginning of the last century, and human bioclimatic comfort conditions have been tried to be calculated by considering the factors that are thought to be effective on human bioclimatic comfort and the human characteristics. In this regard, Wetbulb temperature (Tw) index (Haldane's, 1905), designed to determine the thermal stress of miners in England, and is considered the first study. Epstein and Moran (2006), in their compilation study, stated that approximately 40 different and leading thermal comfort indices have been developed since 1905.

There are various indices used to determine suitable areas in terms of bio comfort and one or more of these indices are used following the purpose of the research. In this study, it was aimed to find the suitable and unsuitable areas in terms of bio comfort in summer by using the SSI (=New Summer Index) throughout Ordu province with the aim of GIS.

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find the suitable and unsuitable areas in terms of bio comfort in summer by using the SSI (=New Summer Index) throughout Ordu province with the aim of GIS.

2. Material and Method

The research was carried out throughout the city of Ordu. Ordu, one of Turkey's major cities, is located in the Black Sea region (Figure 1).

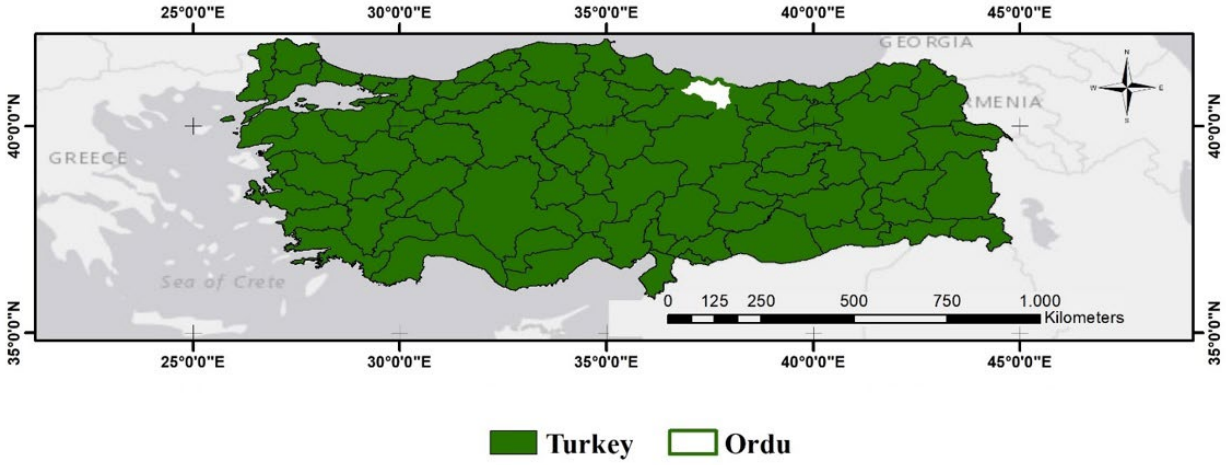

Figure 1 Ordu Location Map (Alrabiti 2023)

The situation of thermal comfort throughout the city was calculated using the SSI. In many studies, this index is preferred for determining bioclimatic comfort conditions for the summer months. Within the scope of the research, first of all, locations of meteorology stations and long-term climate parameters were obtained from relative humidity (%), temperature, meteorology stations, data were processed on the software of ArcGIS (Aricak, 2020). Arc map software was used to make climate maps with the "Inverse Distance Weighted (IDW)". IDW technique is the techniques among the methods of map generation by interpolation. It is an interpolation technique used to find the values of cell un-sampled points with the help of the values of known sample points. The formula used in this method is as follows:

$$z(x_o) = \frac{\sum_{i=1}^{n} z(x_i).\, d_{i0}^{-r}}{\sum_{i=1}^{n} d_{i0}^{-r}}$$

The location X0 from which the estimations are made is a function of neighbor measurements n (z(X0i) and i=1,2,…,n); r is the exponent determining the assigned range of each of the observations, and d is the distance separating the observation location Xi from the prediction location X0 (Kilicoglu et al., 2020; Adiguzel et al. 2022).

The maps of relative humidity and temperature produced by the interpolation method were created and evaluated by applying the SSI formula using the "Raster Calculator" command in the Arc map 10.5 scripts. The formula used in this step is given below.

SSI=1.98 * (Ta– ((0.55 - 0.0055 * RH) * (Ta-58))) - 56.83

3. Results

Maps showing the percentage of humidity throughout Ordu province in June, July, August, and September are given in Figure 2.

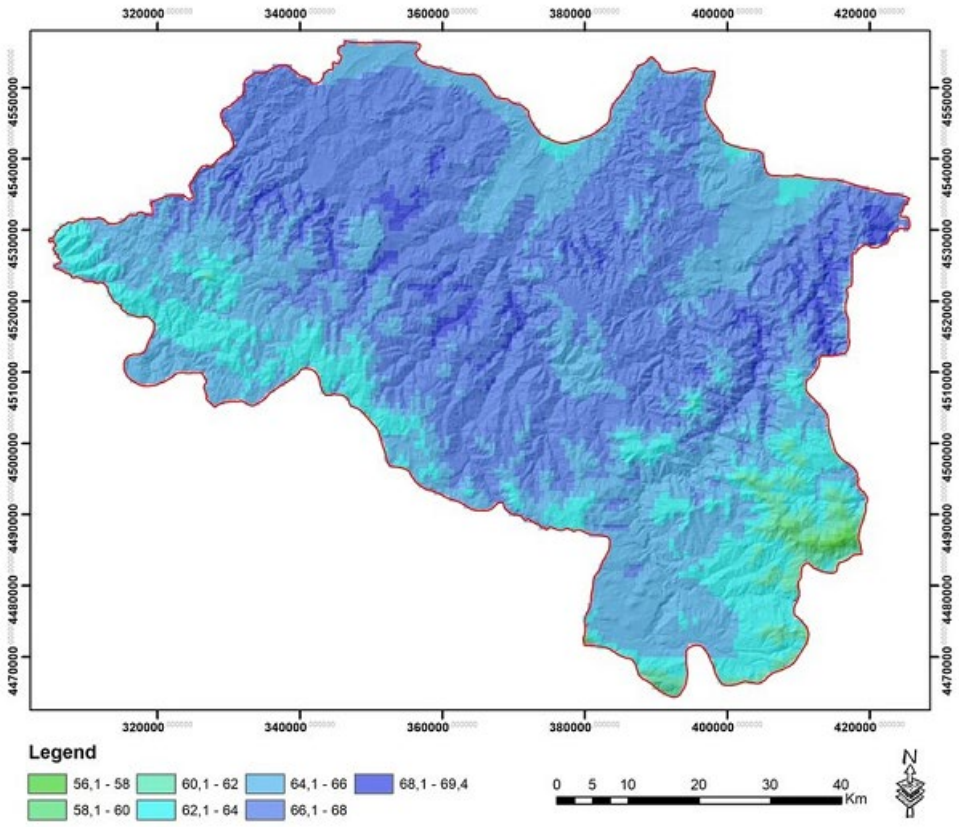

Figure 2 Percentage of Humidity in Ordu Province in Summer (Alrabiti 2023)

When Figure 2 is examined, it is seen that the humidity is between 56.1% and 69.4% in the four months in general, the parts with the lowest humidity are in the southeast of the province, and the parts with the highest level are in the middle part. As a result of the calculations, it has been calculated that the humidity percentage, which is below 58% in approximately 0.12% of the province, is above 68% in approximately 3.67% of the province. Apart from this, the percentage of humidity is in the range of 66-68% in approximately 45.75% of the province, in the range of 64-66% in 34.41%, between 62-64% in 13%, 60-62% in 2.59% of the province. It was calculated that it was in the range of 58-60% in the range of 0.46% and the range of 0.46%. The map showing the average temperature throughout the province during the summer months in the study area is given in Figure 3.

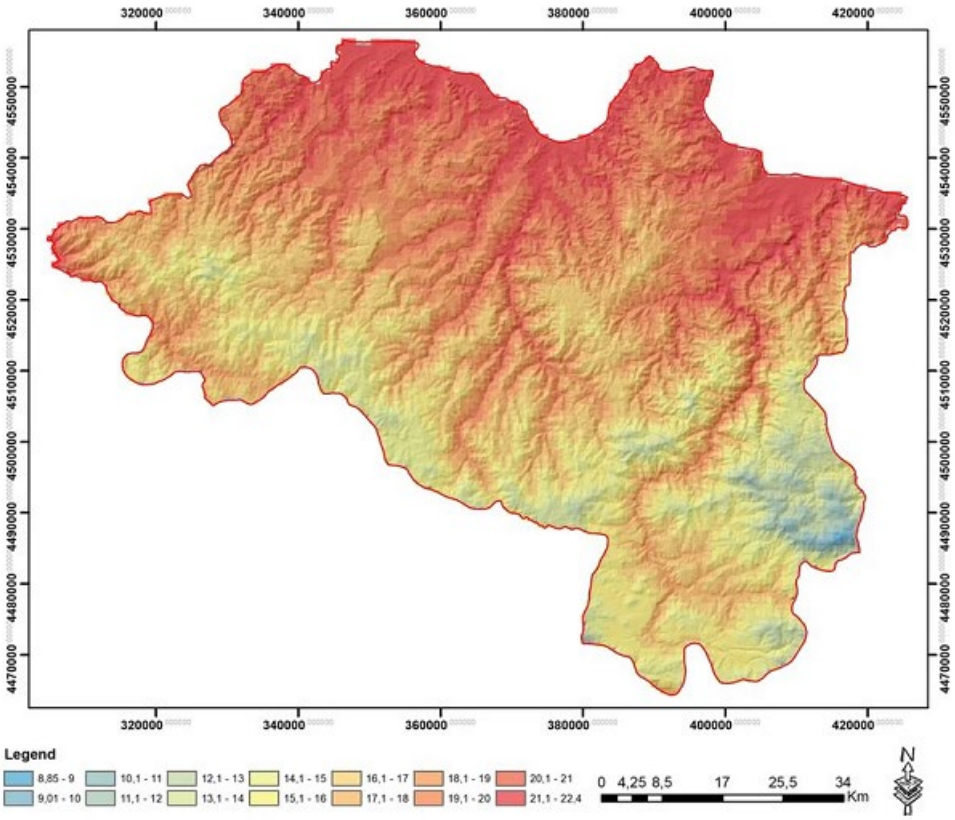

Figure 3 Average Temperature in Ordu Province in Summer (Alrabiti 2023)

When the map showing the average temperature in the summer months is examined, it is seen that the warmest parts of the province are generally the northern parts, the average temperature decreases from the north to the south, and the coolest parts of the province are the southwest. According to the calculations, the average temperature in summer is below 13 °C in approximately 2.88% of the province and above 20 °C in 24.91% of the province. In approximately 14.31% of the province, the temperature is between 16-17 °C. By using the values of humidity and temperature, the values of SSI and belts were evaluated throughout the city, and the comfort status for the summer months is given in Figure 4.

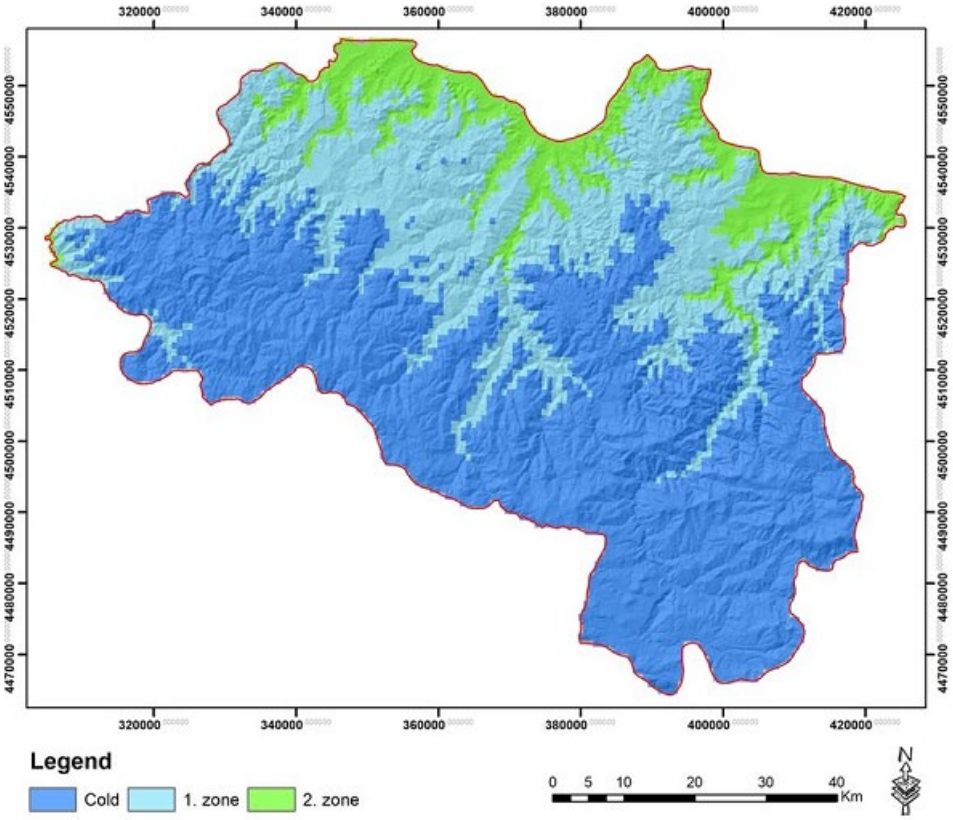

Figure 4 Comfort in Ordu Province in Summer (Alrabiti 2023)

According to the results of the research, it was found that there were three generations in Ordu during the summer months. When the map is found, it is shown that the area covering approximately 57.62% of the southern part of the province is cold. The 2nd Zone, which is located in the north of the province and where most people feel comfortable, covers approximately 11.12% of the province in general. The area between the two regions and covering approximately 31.26% of the province is in Zone 1, where is comfortable and cold.

4. Discussions

People are warm-blooded creatures and therefore they feel uncomfortable in that environment when the outdoor conditions are not within certain intervals (Zeren Cetin and Sevik, 2020; Zhao 2020; Kilicoglu, 2022). People's comfort is affected by factors for example: air pollution, particulate matter, CO2 concentration, which are not easily perceived by the five senses, as well as factors such as noise, smell, and light.

Cetin (2015) derived and evaluated temperature values with a resolution of 1x1 km in his study named “Determining the bioclimatic comfort in Kastamonu City”. By overlapping the derived temperature values with the humidity values, the felt temperature values were derived and mapped these values.

However, the most important parameters affecting all vital activities of living things are temperature and precipitation (Yucedag et al., 2018; Zhu et al. 2019; Koç, 2021a,b; Kong et al 2019; Salata et al 2017; Sancar and Güngör 2020; Sevik et al. 2020a,b; Zeren Cetin et al. 2020; Zeren Cetin et al., 2022). Similarly, temperature and humidity, which are the basic climatic parameters, are at the forefront of the conditions affecting human comfort (Kilicoglu et al., 2020; Kong et al 2019; Salata et al 2017; Sancar and Güngör 2020). In terms of the continuity of human life, especially the temperature value must be within certain ranges. The temperature values within certain ranges with both various clothes and heating or cooling equipment (Kilicoglu et al., 2021; Kong et al 2019;

Salata et al 2017; Sancar and Güngör 2020). Some of these research used the climate data of annual average, while others used monthly or seasonal average data (Kaya et al., 2019; Kong et al 2019; Salata et al 2017; Sancar and Güngör 2020).

Cetin, M., Topay, M., Kaya, L. G., & Yılmaz, B.'s 2010 study titled " Efficiency of bioclimatic comfort in landscape planning process: case of Kutahya" examined the bioclimatic conditions in areas of the city center with different land textures. In the study, the Physiological Equivalent Temperature (FES), is in its calculations in addition to the meteorological parameters, was used. The hourly thermal sensing values of 6 meteorological stations in the period 2001-2010 were evaluated.

In the study conducted by Adiguzel et al. (2020), five areas with different characteristics were determined in Hatay city center, which is a high altitude and crowded city in the Mediterranean Region of Turkey. In order to calculate the bioclimatic comfort values in these areas, meteorological data covering the hours of 00:00, 03:00, 06:00, 09:00, 12:00, 15:00, 18:00 and 21:00 daily parameters are taken. These parameters were obtained from meteorological measuring devices installed in five urban areas and from station, which was taken as a reference. In the study, FES index and RayMan 2.1 model were used to calculate bioclimatic comfort conditions. Because of the research, it has been revealed that there are "very cold stress" and "very hot stress intervals" in Hatay during the summer months.

Cetin et al. (2019), in his study in the city center of Burdur, obtained climatic data of the study area through a portable meteorology station and calculated bioclimatic comfort using these data. The study used the Physiological Equivalent Temperature (FES)-Physiological Equivalent Temperature (PET)-index and the RayMan 2.1 program to calculate the bioclimatic comfort conditions.

Cetin (2020), in his study, took temperature, humidity and wind data from stations belonging to Kahramanmaras province and its surroundings, evaluated these data with the IDW technique and created climate maps. Then, with the overlay analysis, he revealed the comfort areas in terms of bioclimatic.

5. Conclusions

It has been compared with the same dated ground station measurements obtained from the General Directorate of Meteorology. It was observed that the difference between the temperature measurements obtained from the meteorology station located within the provincial borders and the temperature values calculated with the satellite data was 0.2 degrees Celsius (absolute) at the lowest station and 4.1 degrees Celsius (absolute) at the highest station. It has been determined that the temperature values obtained from the Ground Surface Temperature (LST) algorithm applied in the study are within the limits of sufficient accuracy.

The research, suitable areas to bio comfort were determined with the aim of the summer temperature index by using temperature values and humidity in the summer months throughout Ordu. As a conclude of the calculations, it has been determined that most of the city, in general, is in the cold zone, the most comfortable areas in the province are located in the coastal part of the north of the province and it covers approximately 11.12% of the province.

Evaluating of the bioclimatic comfort structure within the borders of the province, the annual climatic values required should be averaged and overlapped. According to the results obtained from this superposition, the areas where the settlement area located in the province and its borders have suitable climatic values in terms of human comfort are determined. Thus, it will help to plan suitable urban open green spaces for this study.

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Resume

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