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Urbanization models suitable for thermal-bioclimatic comfort levels

Aslı Deniz Adıgüzel[a,*], İlknur Zeren Çetin[b]

[a]Bitlis Eren University, Technical Sciences Vocational School, Architecture and City Planning Department, Land Registry and Cadastral Program, Bitlis, Türkiye
[b]Ondokuz Mayis University, Samsun Vocational School, Department of Park and Garden Plants, Program of Landscape and Ornamental Plants Cultivation, Samsun, Türkiye
***Corresponding Author:** adeniz4250@gmail.com

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Abstract: Scientific and technological developments triggered by industrialization started an intense urbanization process, which brought along an increase in population rate and urban structuring. Structural surface materials with low albedo (reflectance) value such as concrete and asphalt, which are used as building materials in urban areas, have trapped the heat inside, causing an increase in the air temperature in the city. The fact that a city is warmer than the surrounding rural areas is described as an urban heat island phenomenon. This phenomenon negatively affects the people living in the city physically and mentally. It is defined as Bioclimatic Comfort when people are not warned against the atmospheric conditions of the city they are in and feel comfortable. According to the PET index chart created by Matzarakis and Höppe, it has been revealed that people feel better between 18.1 - 23.0℃ temperature values. The increase or decrease in these values causes people living in the city to feel more stressed mentally and to feel a decrease in their desire to work, while physical health problems such as eye burns and nosebleeds occur. In this study, the bioclimatic comfort conditions of Kahramanmaraş, where the Mediterranean climate is intensely felt, are discussed. Meteorological measurement data of the study area between 1970 and 2021 were obtained from meteorological stations in the region. In line with these data, temperature, relative humidity, and wind speed maps were created and then correlated with PET index values.

Keywords: Bioclimatic comfort, Urbanizations, Models, Thermal comfort, GIS

Öz: Sanayileşmenin tetiklediği bilimsel ve teknolojik gelişmeler yoğun bir kentleşme sürecini başlatmış, bu ise nüfus hızında ve kentsel yapılaşmada artışı beraberinde getirmiştir. Kentsel alanlarda yapı malzemesi olarak kullanılan, beton ve asfalt gibi albedo (yansıtma) değeri düşük yapısal yüzey malzemeleri ısıyı içerisinde hapsederek kent içerisinde hava sıcaklığında artışa neden olmuştur. Bir kentin çevresindeki kırsal alanlara göre daha sıcak olması kentsel ısı adası olgusu olarak nitelendirilmektedir. Bu olgu kentte yaşayan insanları fiziksel ve ruhsal açıdan olumsuz yönde etkilemektedir. İnsanların bulunduğu kentin atmosferik koşullarına karşı uyarılmadığı ve konforlu hissetmeleri Biyoklimatik Konfor olarak tanımlanır. Matzarakis ve Höppe'in oluşturmuş olduğu PET indeksi çizelgesine göre 18.1–23.0℃ sıcaklık değerleri arasında insanların kendilerini daha iyi hissettiği ortaya koyulmuştur. Bu değerlerin artış ya da düşüş göstermesi kentte yaşayan insanlarda ruhsal açıdan daha stresli, çalışma isteğinde düşüş hissetmelerine neden olurken fiziksel açıdan göz yanması, burun kanaması gibi sağlık problemlerini beraberinde getirir. Ele alınan bu çalışmada Akdeniz ikliminin yoğun bir şekilde hissedildiği Kahramanmaraş ilinin biyoklimatik konfor şartları ele alınmıştır. Çalışma alanına ait 1970 -2021 yılları arasında meteorolojik ölçüm verileri bölgedeki meteoroloji istasyonlarından temin edilmiştir. Bu veriler doğrultusunda sıcaklık, bağıl nem ve rüzgâr hızı haritaları oluşturulmuş sonrasında PET indeksi değerleri ile ilişkilendirilmiştir.

Anahtar Kelimeler: Biyoklimatik konfor, Kentleşmeler, Modeler, Termal rahatlık, CBS

1. Introduction

As it is known, the climate parameter has undoubtedly been an effective factor in the basic needs of people such as shelter, nutrition, and settlement for centuries. The rapid increase in the understanding of urbanization and consumption from the past to the present, the destruction of natural green areas, the increase of impermeable surfaces, the uncontrolled energy consumption used in buildings, the increase in harmful gases caused by the use of automobiles, which follow a parallel course with the population growth, etc. Many factors have caused increases in air temperature and climatic deterioration [1-30]. Especially the temperature increases in the cities lead to the formation of heat islands, which is the most striking indicator of the urbanization phenomenon. In the shortest sense, the heat island effect is the situation in which the average air temperature values in urban areas are higher than those in the surrounding rural areas. Temperature changes in urban areas have caused each city to create a unique morphology, and the decrease in green areas in addition to the increase in impermeable surface with changing urban morphologies has brought various environmental consequences and increased the urban heat island effect. It has been observed that the heat island affects the thermal conditions of people as well as the air quality in the cities [31-51]. When we look at the relationship

between humans and climate, the climate factor, which we can see that even the daily life routine is affected, can have negative consequences on people both physiologically and spiritually [52-93]. Especially big cities that are exposed to climatic change and ecological deterioration, as places that offer unhealthy and equally bad conditions for the people living there, become an important parameter in terms of decreasing their quality of life, decreasing work efficiency, psychological depression, and livability [28, 30-42, 83-104]. With the growth of cities, it is seen that the use of structural surface materials such as concrete and asphalt increases, and due to the decrease in evaporation surfaces such as natural green areas, grass, and soil, increases in air temperatures occur. Because the use of structural surface materials in urban areas, which is unavoidable, converts the radiation absorbed throughout the day into heat and releases it back into the environment, which causes an increase in air temperatures. It is known that people feel healthier and more vigorous between certain temperature values. According to the PET (physiologically Equivalent Temperature) index, people feel better between 18.1–23.0℃ temperature values, and above or below this value range causes conditions such as fatigue, nervousness, tension, and many physical symptoms such as dryness in the throat and burning in the eyes. It has been determined that it causes health problems. Energy use can be reduced by increasing tree and vegetation cover in urban areas, and quality is increased by reducing air pollution. Smart urbanization is one of the important determinants of physical development and socioeconomic development [1, 2, 30-45, 89]. Smart growth practices and the creation of green cool roofs cause a decrease in greenhouse gas emissions while increasing human health and comfort areas and improving their quality of life [27, 35-55]. Various studies are being conducted on the concept of bioclimatic comfort, which can be defined as the conditions in which people can adapt to their environment by spending less energy, especially with the urbanization phenomenon that started with the industrial revolution and continues to increase today [31-61]. Bioclimatology is a multidisciplinary science that studies the relationship and interaction between living things and climate. In addition to human, plant, and animal bioclimatology, urban areas also have their climate and bioclimatology, which are different from the surrounding rural areas. The phenomenon of bioclimatic comfort, in which climate parameters such as temperature, humidity, and wind play a role, has become an important issue in the planning and landscape design processes of urban areas with increasing temperature values due to the effect on humans and all other living things, and it has become necessary to create sustainable spaces where people feel more comfortable. [33-68].

In this study, the bioclimatic comfort conditions of Kahramanmaraş, where the Mediterranean climate is intensely felt, are discussed. Meteorological measurement data of the study area between 1970 and 2021 were obtained from meteorological stations in the region. In line with these data, temperature, relative humidity, and wind speed maps were created and then correlated with PET index values.

2. Material and Method

Material

Kahramanmaraş province, which is the study area, is located in the Mediterranean region. The city center has a rough structure because it was established on the skirts of Ahir Mountain. It is surrounded by Sivas in the north, Gaziantep in the south, Adana in the east, and Adıyaman in the west, and the altitude value starts from 123 meters and ends at 3076 meters (Figure 1). This study, it is aimed to examine the bioclimatic comfort conditions of Kahramanmaraş Province, which is under the influence of the Mediterranean climate, which is hot and dry in summer and warm and rainy in winter. As you go from south to north and from west to east, the Kahramanmaraş plain located in the center and especially in the southern part of the province, which shows terrestrial climate characteristics, has provided the opportunity to grow various agricultural products in these areas.

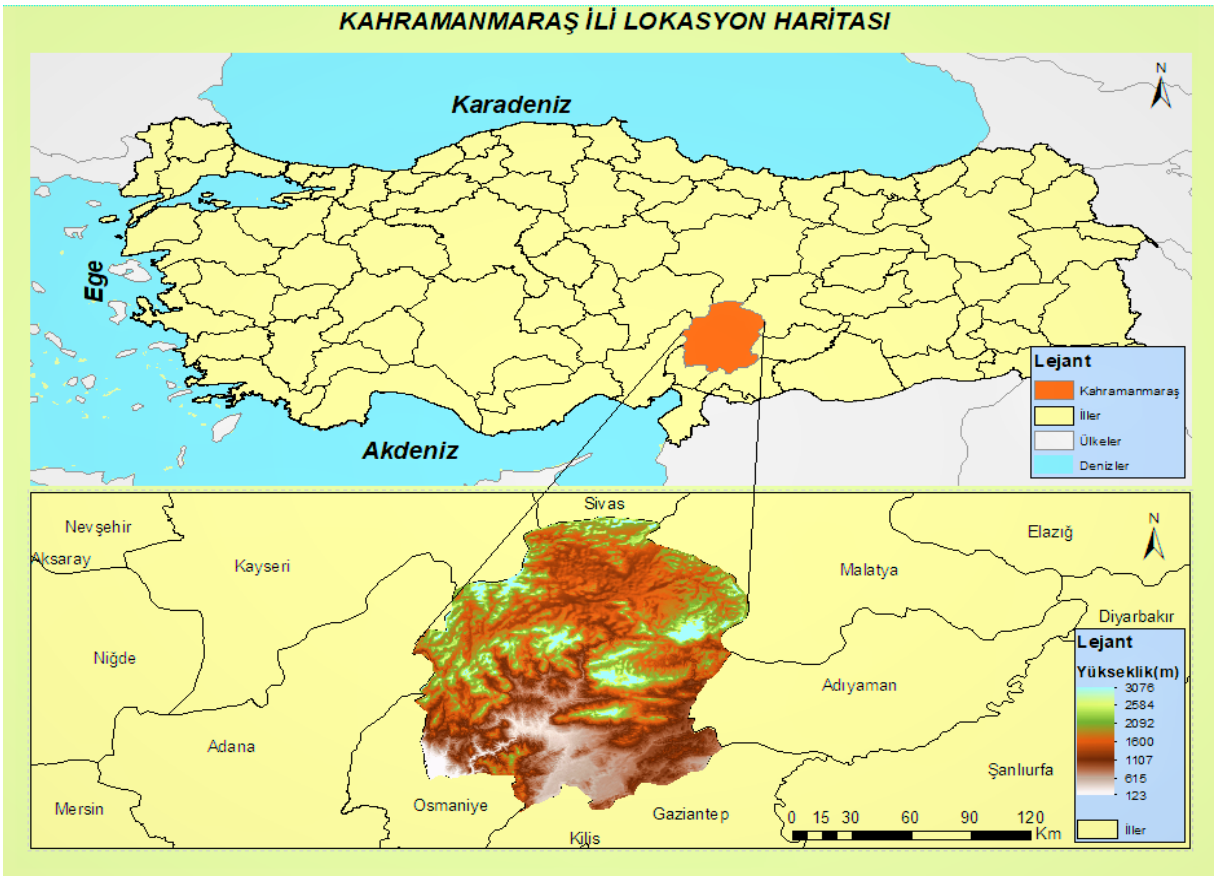

Figure 1. Study area location map

Method

Meteorological climate data of Kahramanmaraş province for the years 1970-2021 were obtained from MGM. Afterward, these data were transferred to ArcGIS 10.8.1 program, and temperature, PET, humidity, and wind maps were created using co-kriging and IDW methods from interpolation methods. The results obtained are correlated with the PET index data in Table 1 above. The 12-month minimum and maximum temperature differences of the bioclimatic comfort conditions of Kahramanmaraş Province were determined. As a result of the examination, the lowest and highest climatic comfort levels were reached, and with the result obtained, suggestions were made on what kind of measures can be taken to provide bioclimatic comfort conditions and suitable thermal conditions for people in the planning processes in the coming years.

Table 1. Pet index thermal stress levels

Human feeling	PET(°C)	thermal stress level
Very cold	<4	extreme cold stress
Cold	4.1 - 8.0	strong cold stress
Cool	8.1- 13.0	moderate cold stress
slightly cool	13.1 - 18.0	mild cold stress
Comfortable	18.1 - 23.0	no thermal stress
mild temperate	23.1 - 29.0	mild heat stress
mild	29.1 - 35.0	moderate heat stress
Hot	35.1 - 41.0	Strong heat stress
Very hot	>41.0	extreme heat stress

3. Result

The water vapor suspended in the air is called humidity. From this point of view, humidity also means wetness and precipitation. When we look at the monthly humidity data of the study area according to the 12-month humidity data of Maraş Province in Figure 2 above, it is seen that the months with the highest humidity rate belong to the winter months, and the lowest humidity rate is in the summer months. Especially in December, January, and February, the air mass reaches its maximum level quickly because it becomes saturated faster.

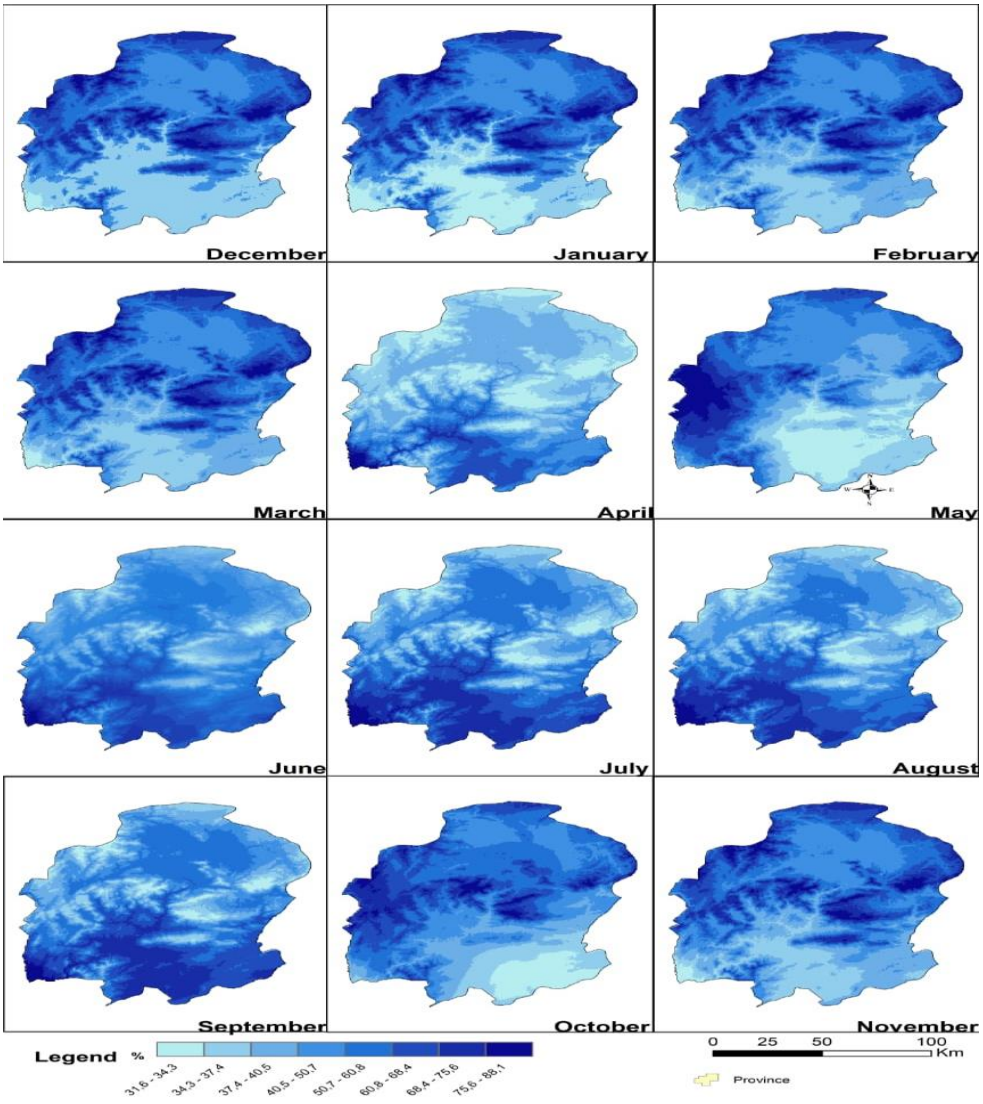

Figure 2. Kahramanmaraş province humidity map

In the summer months, due to the high-temperature level, the saturation gap in the air mass increases, which causes a decrease in the amount of humidity in April, May, and June. When evaluated in terms of bioclimatic comfort, it can be observed that the suffocating air is dominant between July and September, and August is more suffocating than July and September. It is seen that there is no sweltering air in February when the humidity is low, and bioclimatic comfort is more suitable.

When the Pet Index Thermal Stress Levels in Table 1 of the Kahramanmaraş Pet Index analysis in Figure 3 are taken into consideration, the thermal stress level of the central region, which is dominated by red colors, is high in the summer months, and the thermal stress level of the central area, which is blue, is lower in the winter months, depending on the temperature conditions. observed to be lower. It is understood that the temperature level, which is also effective with urbanization, reaches the highest levels, especially in June and July, and the thermal comfort level decreases, and with this decrease, there are periods when suffocating and unbearable.

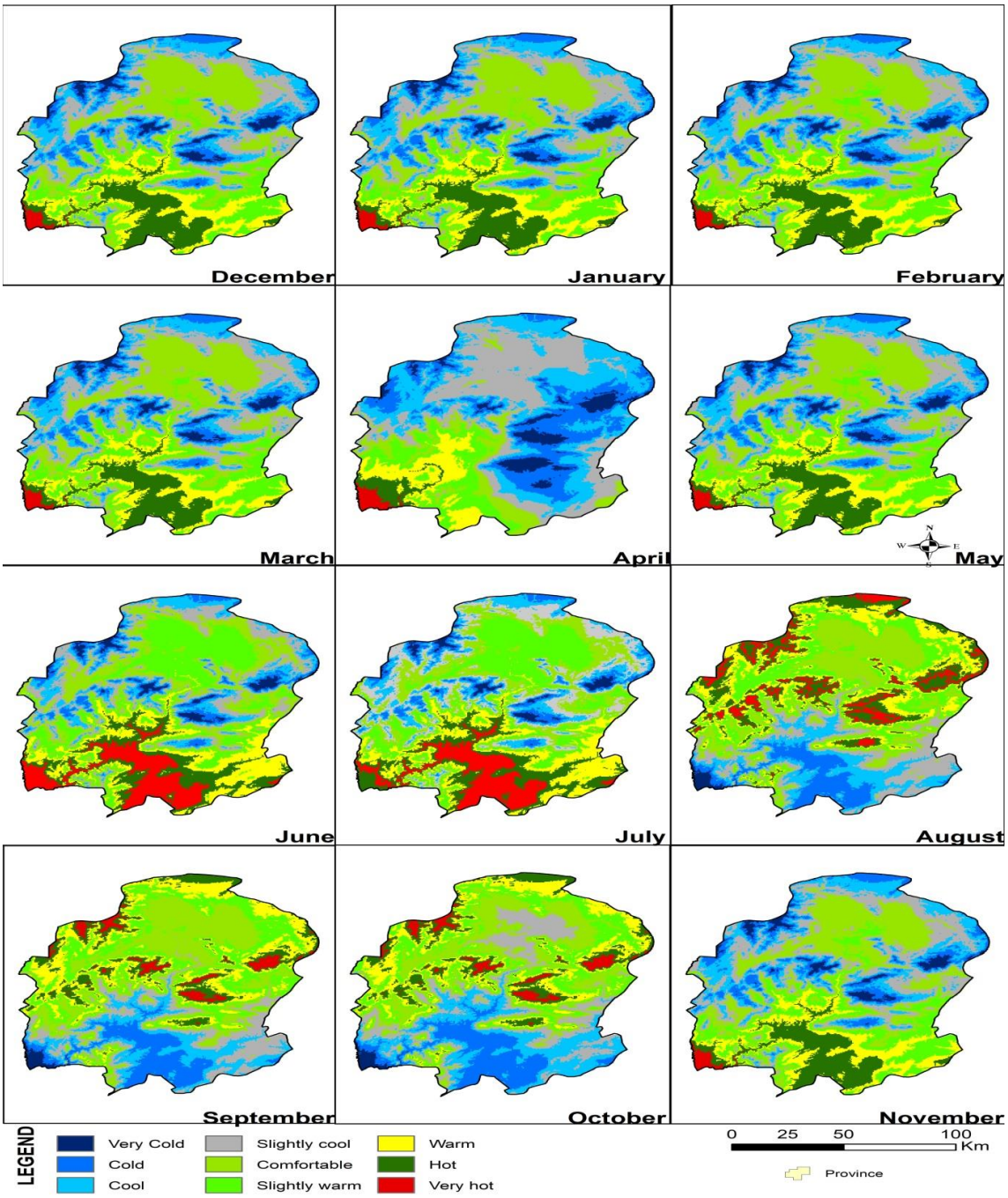

Figure 3. Kahramanmaraş province pet index map

The wind is when the air mass moves horizontally. The wind is one of the factors that determine the climatic condition of a region. Wind speed in Kahramanmaraş shows slight seasonal variations throughout the year. When we look at the monthly wind speed data of the study area according to the 12-month wind speed data of Kahramanmaraş province in Figure 4 above, it is seen that the months with the highest wind speed rate belong to the winter and spring months, and the lowest wind speed is in the summer months. Especially in the summer months, with the warming of the weather, the wind condenses and rises and moves from high-pressure areas to low-pressure areas, as a result of which there is a decrease in wind speed. In the spring and winter, the cooled air begins to descend and moves from the low-pressure area to the high-pressure areas, increasing wind speed.

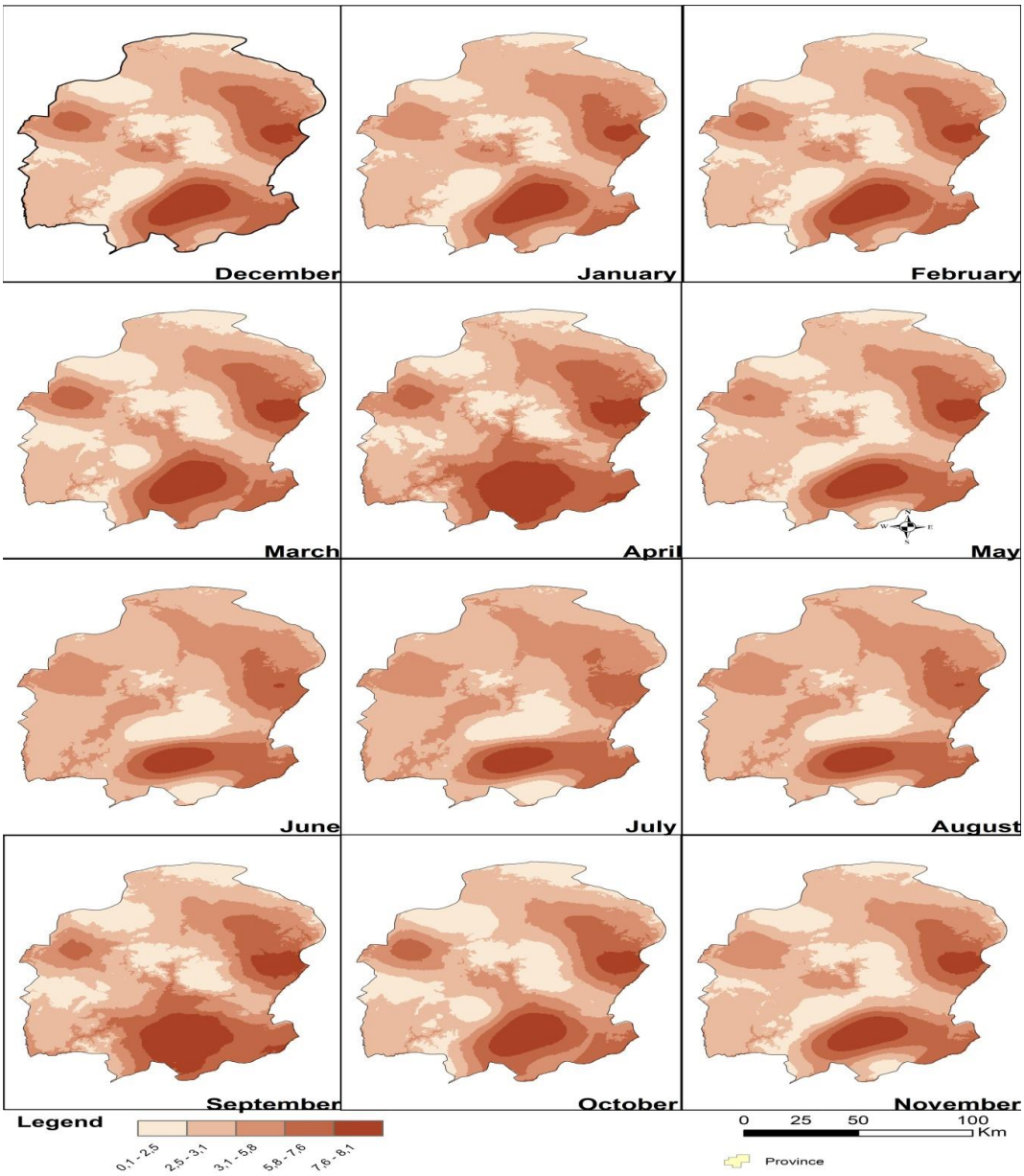

Figure 4. Kahramanmaraş wind analysis map

Urban temperature is the amount of heat the city retains. Temperature is one of the factors that determine the climatic condition of a region. In determining the temperature of a region, the movement of the earth, hot water currents, winds, vegetation, urban structure, etc. factors play a decisive role. Kahramanmaraş province generally shows Mediterranean climate characteristics and there are regions with continental climate characteristics. When we look at the monthly temperature data of the study area according to the 12-month temperature data of Kahramanmaraş province in Figure 5 above, it is seen that the months with the highest temperature rate belong to the summer months, and the lowest temperature is in the winter months. In the central district of Kahramanmaraş, it is around 5.6-7.7 °C in December, January, and February. With the increasing temperatures since May and the effect of the urban heat island, the temperature increased to 25.3-31.2 °C in August. The temperature value required to provide bioclimatic comfort is 18. 1 – 23.0℃. Since the temperature in the central district rises above this value in summer, people living in the city are exposed to heat stress. The temperature values of Göksun, Afşin, Elbistan, and Nurhak districts are lower during the year compared to the Central district and its surroundings due to the terrestrial climate effect and the lack of urbanization.

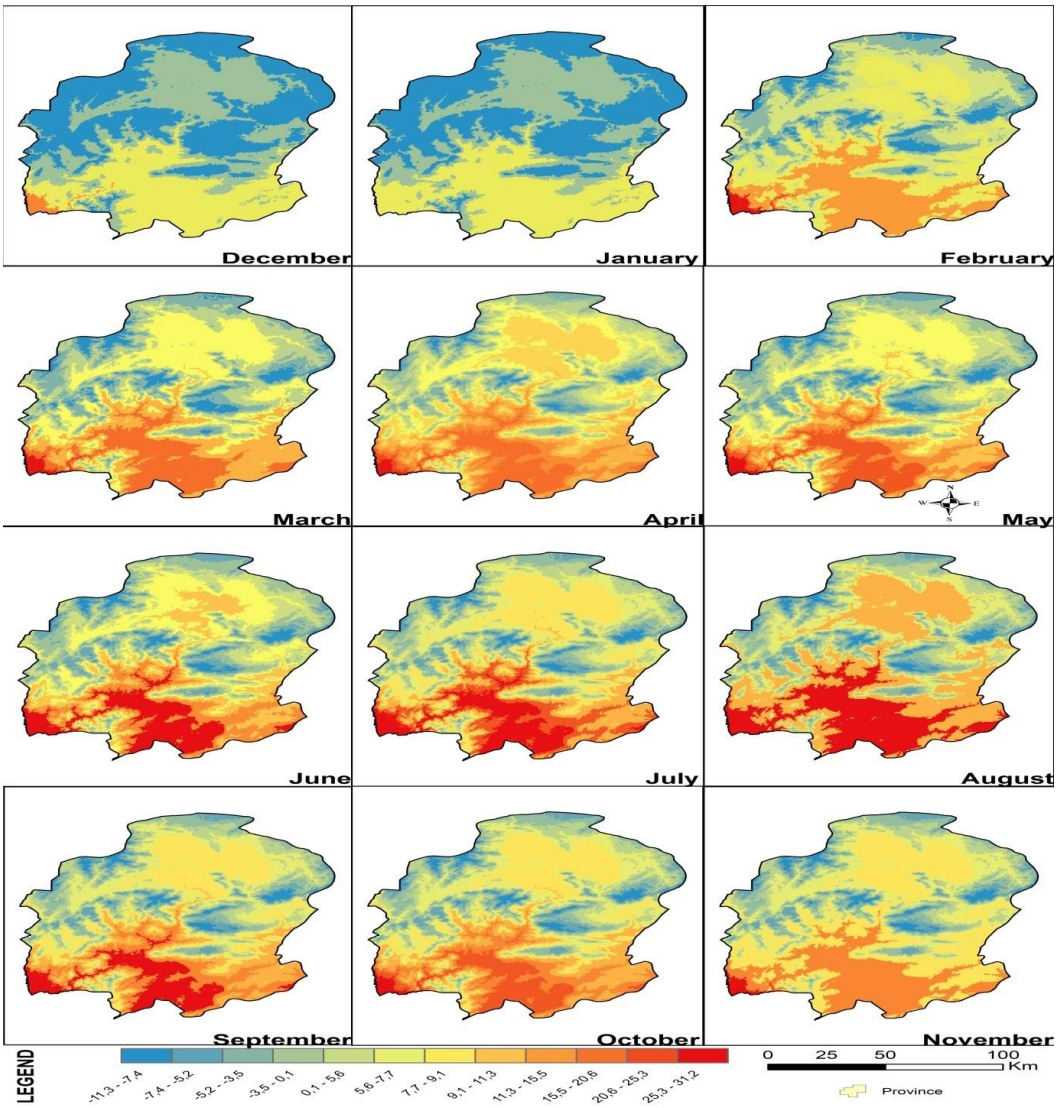

Figure 5. Kahramanmaraş temperature analysis map

4. Discussion

Many international studies have been carried out on the determination of bioclimatic comfort zones in Turkey in recent years. To determine the bioclimatic comfort conditions of many different cities in Turkey for certain years; Zeren Cetin and Sevik [5], Kilicoglu et al. [54] have used the PET index [3, 55, 62, 70]; Cetin [45] have relied on PET and DI index methods; while Cetin et al. [8], Adıguzel et al. [60]; Zeren Cetin et al. [4] have adopted the method of environmental climatic parameters [35-40, 46, 47, 60, 62, 70, 71]. This study is the first study on the bioclimatic comfort areas of Bartin for determining the effect of land use a land cover change on sustainable forest areas. The most important fundamental difference of the study from the related studies is that more than one parameter and indices are used in determining the suitable areas in terms of bioclimatic comfort, and therefore it can reveal the differences in approach between the indices. The second important difference is that the climatically comfortable zones change annually in 3 different 30-year periods (1990, 2000, 2020) according to each parameter/index. The third important difference is that the climatically comfortable zones in the reference years and the land cover of the province are evaluated together.

5. Conclusions

The climate, which has been in constant change since the formation of the world, has started to show a more significant change, especially with the industrial revolution and industrialization. Urbanization on the one hand and the increase in the use of fossil fuels on the other, mostly due to anthropogenic reasons, accelerated this change and affected the entire ecosystem, especially fauna and flora on earth. With the increasing climate change in our country, the decrease in precipitation and the increase in temperature levels have caused many researchers to conduct research studies on the subject. The climate changes that occur are effective in all areas such as agriculture, industry, energy, transportation, and settlement, especially the natural environment, and it is thought that they will continue to be effective.

In this study, humidity, wind, temperature, and pet index analysis were carried out to determine the bioclimatic comfort conditions of Kahramanmaraş Province. According to the analysis results of these parameters; It has been observed that the average minimum and maximum values of the temperature conditions increase, and the center and its surroundings reach the highest temperature level, especially in summer. When we look at the wind speed analysis, it is concluded that while the speed rate is high in the winter months, this rate decreases in the summer months. It has been understood that the temperature conditions are effective in the condensation of the wind and the decrease in the speed ratio while moving from high pressure to low pressure.

When we look at the humidity analysis of the area, it has been observed that in July, August, and September, when the suffocating air is dominant, in December, January, and February, when the humidity is low, there is no sweltering air and there are more suitable times for the bioclimatic comfort level. In all analyzes for the study area, when evaluated according to the Pet index values, it was seen that the most significant differences were experienced in the summer months. It has been understood that the bioclimatic comfort conditions are gradually decreasing in the central district where the population is dense in Kahramanmaraş. The negativities experienced in bioclimatic comfort areas have become a situation that directly affects the thermal comfort of people. In the study area, where the Mediterranean climate is dominant, urban planning should be made with a more sustainable, environmentalist understanding and geographical perspective for people who are exposed to temperature values that may threaten their mental and physical health in summer due to urbanization, and models suitable for thermal and bioclimatic comfort levels should be developed.

Competing Interest / Conflict of Interest

The authors declare that they have no competing interests

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