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Determination of the Summer of Bioclimatic Comfort Criteria in the Landscape Planning

Peyzaj Planlaması için Biyoklimatik Konfor Kriterlerinin Yaz Dönemi Belirlenmesi

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DETERMINATION OF THE SUMMER OF BIOCLIMATIC COMFORT CRITERIA IN THE LANDSCAPE PLANNING

ABSTRACT

Bioclimatic comfort, or biocomfort, refers to the state where environmental factors such as temperature, humidity, and wind speed fall within ranges that are comfortable for human activity. This study assesses the summer bioclimatic comfort conditions in Van province, Turkey, using detailed seasonal climate data. The research analyzes the spatial distribution of key parameters, including humidity, wind speed, precipitation, and temperature, across the province during the summer season. Findings indicate that 51.37% of Van province experiences humidity levels between 40-45%, with wind speeds between 1.5-2.5 m/s in 70.12% of the area. Precipitation levels are generally low, with most of the province receiving 10-20 mm of rain. Summer temperatures range between 17-22°C, with the highest temperatures observed in the central regions. The resulting bioclimatic comfort map reveals that 99.18% of the province is suitable for biocomfort during the summer season, while only 0.82% is classified as unsuitable. These results provide valuable insights for landscape planning and urban development, particularly in creating energy-efficient and comfortable living environments.

Keywords: Bioclimatic Comfort, Climate, Landscape Planning, Summer.

PEYZAJ PLANLAMASI İÇİN BİYOKLİMATİK KONFOR KRİTERLERİNİN YAZ DÖNEMİ BELİRLENMESİ

ÖZ

Biyoklimatik konfor, ya da biyokonfor, sıcaklık, nem ve rüzgar hızı gibi çevresel faktörlerin insan etkinliği için konforlu aralıklarda bulunduğu durumu ifade eder. Bu çalışma, Türkiye'nin Van ilindeki yaz biyoklimatik konfor koşullarını detaylı mevsimsel iklim verilerini kullanarak değerlendirmektedir. Araştırma, yaz mevsiminde il genelindeki nem, rüzgar hızı, yağış ve sıcaklık gibi ana parametrelerin mekansal dağılımını analiz etmektedir. Bulgular, Van ilinin %51.37'sinin nem seviyelerinin %40-45 arasında, %70.12'sinin rüzgar hızlarının ise 1.5-2.5 m/s arasında olduğunu göstermektedir. Yağış seviyeleri genellikle düşüktür ve il genelinin çoğu 10-20 mm yağış almaktadır. Yaz sıcaklıkları 17-22°C arasında değişmekte olup, en yüksek sıcaklıklar merkezi bölgelerde gözlemlenmektedir. Elde edilen biyoklimatik konfor haritası, il genelinin %99.18'inin yaz mevsiminde biyokonfor için uygun

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olduğunu, yalnızca %0.82'sinin uygun olmadığı sınıflandırıldığını ortaya koymaktadır. Bu sonuçlar, özellikle enerji verimli ve konforlu yaşam alanları yaratmada peyzaj planlaması ve kentsel gelişim için değerli bilgiler sunmaktadır.

Anahtar Kelimeler: Biyoklimatik Konfor, İklim, Peyzaj Planlaması, Yaz.

1. INTRODUCTION

People feel comfortable in environments that fall within certain ranges of temperature, humidity, and air quality. This range is known as the comfort zone (Kestane & Ülgen, 2013). Thermal comfort is defined as the state in which a person feels satisfied with the surrounding temperature (Kaynaklı & Yiğit, 2003; Zeren Çetin, 2019, 2023; Zeren Cetin et al., 2020, 2023a, 2023b). Bioclimatic comfort, on the other hand, refers to environmental conditions where individuals feel healthy and energetic while expending minimal energy to adapt to their surroundings (Adiguzel et al., 2019; Bulgan & Yılmaz, 2017; Cetin, 2015; Cetin et al., 2018, 2019, 2023).

In addition to temperature, bioclimatic comfort depends on wind speed and humidity being at levels that are suitable for human comfort. When these factors fall outside of the comfort range, people experience discomfort (Zeren Çetin, 2019, 2023; Zeren Cetin et al., 2020). This discomfort can lead to adverse effects such as loss of concentration, reduced work efficiency, irritability, fatigue, burning eyes, respiratory problems, and throat dryness (Zeren Cetin et al., 2023a, 2023b).

Numerous global studies highlight the importance of bioclimatic conditions for urban planning and sustainable tourism. For instance, Attorre et al. (2007) compared interpolation methods for bioclimatic variables, while Mesquita and Sousa (2009) applied geostatistical methods to define ombrotype and thermotype classifications in Portugal. Unger (1999) assessed the bioclimatic conditions of urban and rural areas in Central Europe, noting that urban areas experience greater thermal stress than rural ones due to higher RSI (Relative Strain Index) values. Other notable studies include Emmanuel (2005) worked on thermal comfort in Colombo, Sri Lanka, and Daneshvar et al. (2013), who used the PET method to evaluate bioclimatic comfort in Iran.

In Turkey, many studies have been conducted to identify biocomfortable regions across various cities, including Ankara (Türkoğlu et al., 2012; Çalışkan & Türkoğlu, 2014), Erzurum (Bulgan & Yılmaz, 2017), Muğla (Çınar, 2004), and İzmir (Kestane & Ülgen, 2013), among others. People's comfort levels can vary widely, but most individuals feel comfortable within a temperature range of 20-25.5°C and a relative humidity range of 30-60% (İlten et al., 2017).

Given the growing importance of bioclimatic comfort, this study aimed to determine the seasonal variation of meteorological parameters in Van province and identify regions that are suitable or unsuitable for biocomfort. Specifically, it examined bioclimatic comfort conditions during the summer season, including factors such as temperature, humidity, wind speed, and precipitation. The study found that 99.18% of Van province is suitable for bioclimatic comfort during the summer, with only 0.82% of the area falling outside of comfort ranges. Identifying such regions is crucial for informed urban planning, especially in areas with growing populations and new settlements.

2. MATERIALS AND METHODS

This study was conducted within the borders of Van Province. Van, located in the Southeastern Anatolia Region, is Turkey's sixth largest province by land area, covering a total area of 19,069 km², which accounts for approximately 2.5% of Turkey's total land area (Meteoroloji Genel Müdürlüğü, 2020). The geographic location of Van is shown in Figure 1. The study is based on climate data, which are the most critical data considered. The long-term averages of meteorological data for Van from 1939 to 2018 are presented in Table 1.

Figure 1. Location of Van

Table 1. Average meteorological data of Van province.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Avg. Temp (°C)	-3.1	-2.6	1.6	7.7	13.1	18.2	22.3	22.2	17.8	11.3	4.9	-0.5	9.4
Max. Temp (°C)	1.9	2.6	6.5	12.8	18.5	23.9	28.2	28.5	24.3	17.3	10.2	4.4	14.9
Min. Temp (°C)	-7.6	-7.2	-2.9	2.6	7.0	10.8	14.6	14.6	10.7	5.6	0.3	-4.7	3.6
Sun Hours	4.6	5.4	6.0	7.3	9.3	11.7	12.1	11.4	9.8	7.1	5.5	4.2	94.4
Rainy Days	10.1	9.9	12.2	12.3	11.1	5.2	2.0	1.3	2.4	8.4	9.0	9.8	93.7
Rainfall (mm)	34.6	33.5	46.6	55.7	46.3	18.1	5.3	3.7	13.4	47.1	46.8	36.6	387.7
Max. Temp (°C)	12.6	14.3	22.7	27.2	28.3	33.5	37.5	36.7	34.0	28.8	20.1	15.4	37.5
Min. Temp (°C)	-28	-28	-22	-17	-3.5	-2.6	3.6	5.0	0.9	-14	-20	-21	-28,7

The analysis of Van's long-term meteorological data reveals that the average temperature in January is -3.1°C, with temperatures also below 0°C in December and February. The warmest months are July (22.3°C) and August (22.2°C). The lowest temperature recorded is -28.7°C, while the highest temperature is 37.5°C. The total annual rainfall is only 387.7 mm.

In this study, preliminary base data for the study area were obtained from Google Earth and official institutions. Elevation, aspect, and slope maps for Van province were created. The coordinates and meteorological data of weather stations were processed using ArcGIS software, creating maps of humidity, wind, rainfall, and temperature for each season. These maps were also produced for annual average data.

To produce biocomfort maps—identifying comfortable and uncomfortable zones—climate data and elevation values were interpolated, and regions were classified based on their suitability for biocomfort. During this process, wind speed, temperature, and relative humidity data were digitized. These point-based data were interpolated using the "Physiological Equivalent Temperature Index" with ArcMap 10 software, extending the data spatially from points to areas. This method is widely used in biocomfort research (Adiguzel et al., 2019; Cetin, 2015; Cetin et al., 2018, 2019, 2023; Çalı, 2018; Elhadar, 2020; Zeren Çetin, 2019, 2023; Zeren Cetin & Sevik, 2020; Zeren Cetin et al., 2020, 2023a, 2023b).

In the second stage, the Summer Comfort Index (SSI) for June, July, and August was calculated. The SSI is an advanced version of indices used to determine thermal comfort conditions for summer tourism (Güçlü, 2010). This index allows for the classification of bioclimatic comfort zones during the summer months. The temperature (°F) and relative humidity (%) data obtained from weather stations were processed using ArcGIS 10.5. Then, the "Inverse Distance Weighted (IDW)" interpolation method in ArcMap 10.5 was used to create climate maps.

The Inverse Distance Weighted (IDW) technique is one of the most commonly used methods for producing maps through interpolation. It determines cell values for unsampled points based on known point values, with decreasing influence of distant points (Adiguzel et al., 2019; Cetin, 2015; Cetin et al., 2018, 2019, 2023; Taylan & Damçayırı, 2016; Zeren Çetin, 2019, 2023; Zeren Cetin & Sevik, 2020; Zeren Cetin et al., 2020, 2023a, 2023b).

The temperature and relative humidity maps generated through interpolation were evaluated for bioclimatic comfort using the SSI formula in the Raster Calculator command in ArcMap 10.5.

This study differs from previous biocomfort studies by assessing seasonal climate data, comparing seasonal and annual average biocomfort maps, and generating and evaluating summer comfort index maps for Van Province. Thus, regions in Van with suitable or unsuitable biocomfort conditions were assessed from various perspectives.

3. RESULTS AND DISCUSSION

The study examines the seasonal changes of some climate parameters for the entire province. The map showing the changes in humidity during the summer season is presented in Figure 2.

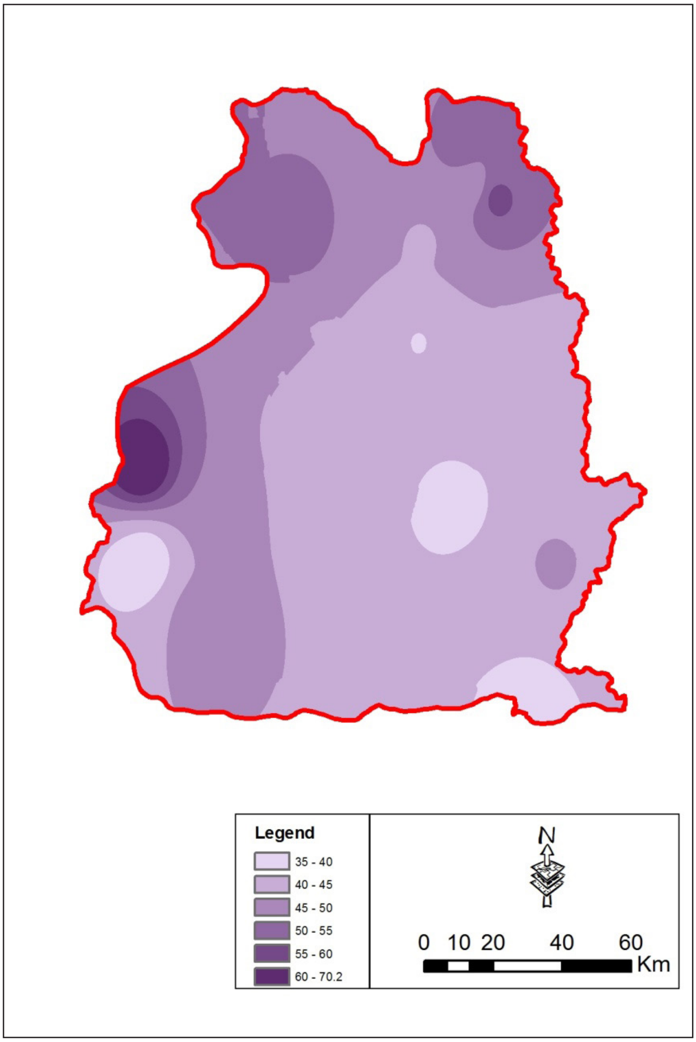

Figure 2. Humidity during the summer season

When analyzing the summer humidity map for Van province, it was found that approximately 5.79% of the province has humidity levels below 40%, 51.37% of the area has humidity levels between 40-45%, 28.06% has levels between 45-50%, 11.98% has levels between 50-55%, 1.49% has levels between 55-60%, and 1.31% of the area has humidity levels above 60%. These results indicate that more than half of the province (51.37%) experiences humidity levels between 40-45% during the summer season. The wind map for summer in Van province is shown in Figure 3.

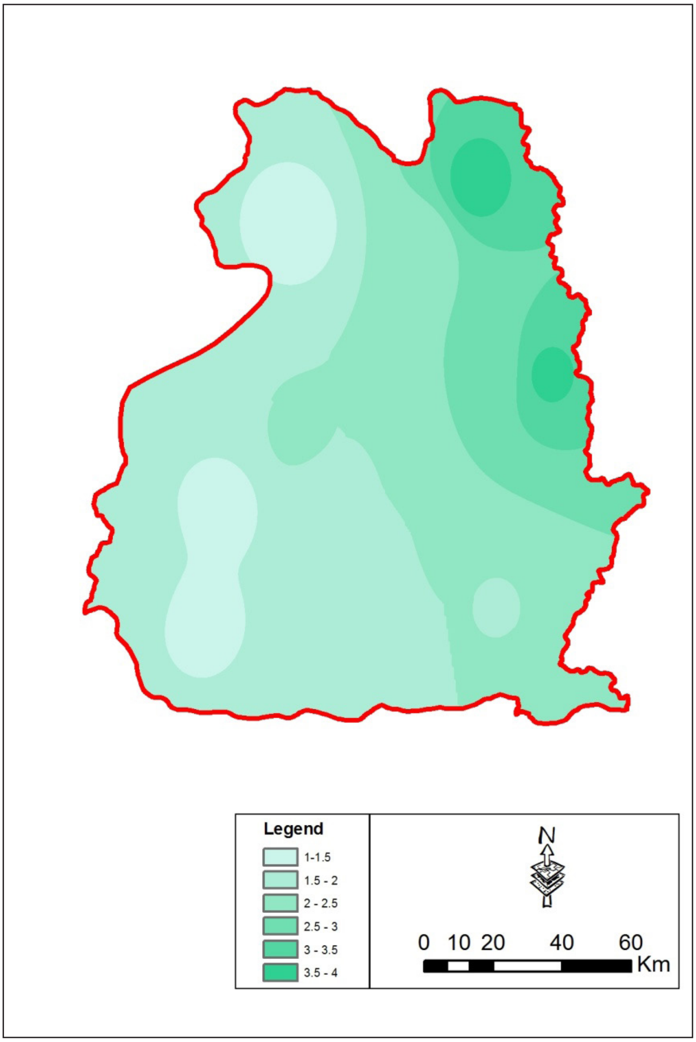

Figure 3. Wind map for summer

In the summer, the wind speeds across Van province are as follows: 9.53% of the area has wind speeds slower than 1.5 m/s, 42.23% has wind speeds of 1.5-2 m/s, 27.89% has wind speeds of 2-2.5 m/s, 10.55% has wind speeds of 2.5-3 m/s, and 7.56% has wind speeds of 3-3.5 m/s. These results indicate that wind speeds are between 1.5-2.5 m/s in 70.12% of the province. The precipitation map for summer is presented in Figure 4.

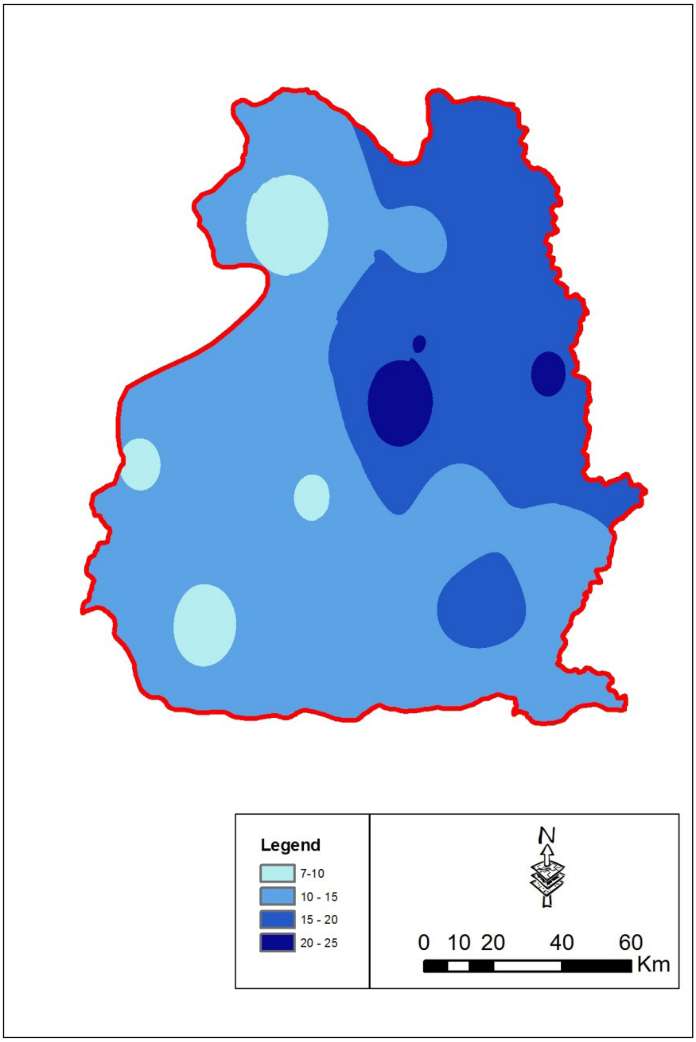

Figure 4. The precipitation map for summer

When examining the precipitation situation during summer, it was found that precipitation levels are relatively low, with even the highest rainfall areas receiving less than 25 mm. Approximately 5.43% of the province receives less than 10 mm of rain, 61.14% receives 10-15 mm, 31.07% receives 15-20 mm, and 2.36% receives 20-25 mm. In general, precipitation levels are higher in the eastern regions. The temperature map for summer is presented in Figure 5.

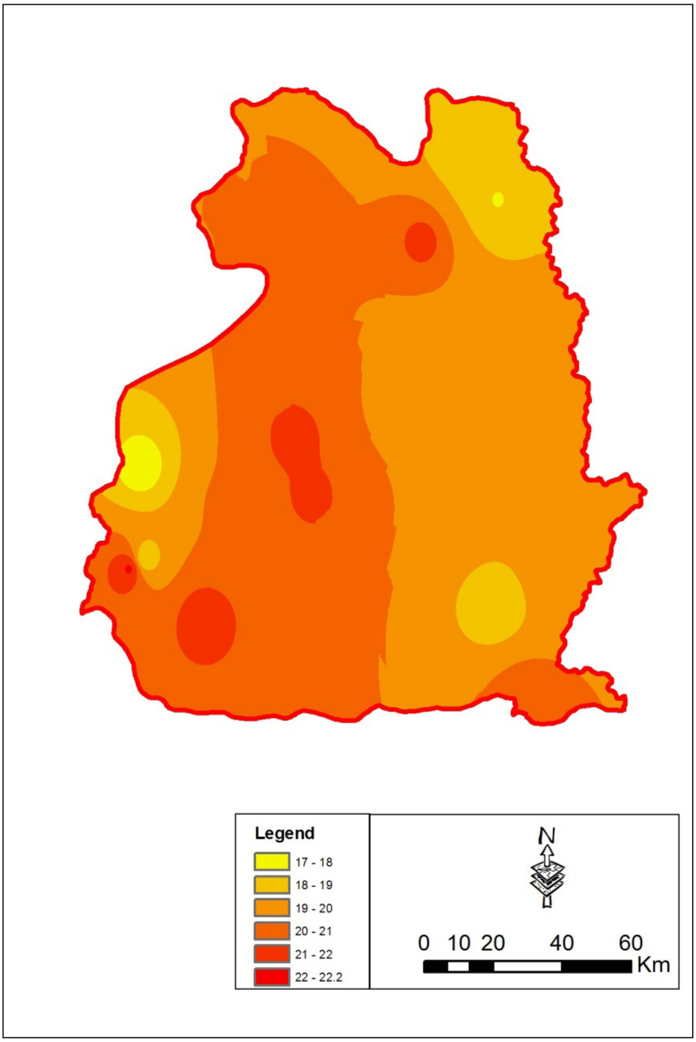

Figure 5. The temperature map for summer

In summer, it was found that approximately 0.82% of the province has temperatures between 17-18°C, 9.72% has temperatures between 18-19°C, 43.49% has temperatures between 19-20°C, 41.89% has temperatures between 20-21°C, 4.06% has temperatures around 21-22°C, and 0.02% has temperatures above 22°C. The hottest areas are located in the central regions. The bioclimatic comfort map for summer is shown in Figure 6.

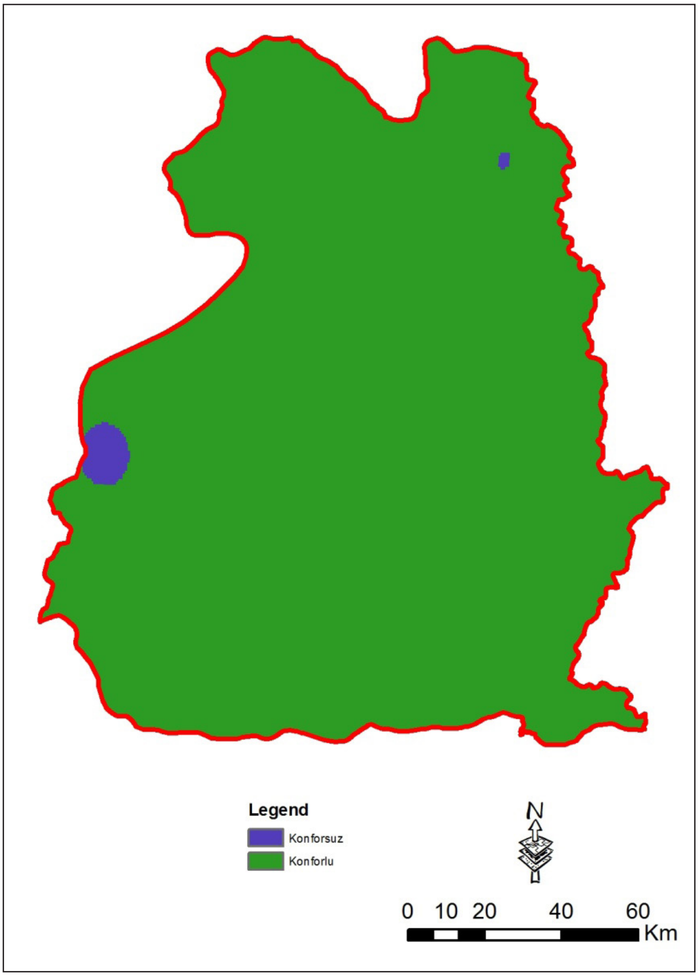

Figure 6. The bioclimatic comfort map for summer

When examining the bioclimatic comfort map for summer, it was found that 99.18% of the province is suitable for bioclimatic comfort, while 0.82% is not.

The study evaluated the bioclimatic comfort of Van province, revealing that the entire province is generally unsuitable for biocomfort based on the biocomfort map created using annual average meteorological data. Seasonal evaluations indicate that the province experiences discomfort in the spring, autumn, and winter seasons. However, during the summer, 99.18% of the province is suitable for biocomfort, while 0.82% remains unsuitable.

This situation is largely influenced by the province's climatic data, particularly temperature. According to the meteorological data for Van province, average temperatures remain below 10°C from November to April, with 13.1°C recorded in May and 11.3°C in October. Thus, for eight months of the year, the temperatures are relatively low, and outside of the summer months (June, July, August, and September), the province tends to experience cooler conditions. Even during the warmest months, the summer index shows that most of the province falls within the first comfort zone, where many people feel comfortable, though some may find it cool (Güçlü, 2010). This suggests that Van province is situated within a relatively cool climate zone.

Biocomfort is directly influenced by climate data, and different results are often observed across various provinces in Turkey, which spans multiple climate zones. For instance, in a similar study conducted by Elhadar (2020) in Gaziantep, it was found that 88.83% of the province is suitable for biocomfort, while 11.17% is unsuitable, based on annual averages. However, when analyzed seasonally, Gaziantep is entirely unsuitable for biocomfort during the winter, while approximately 98.11% is suitable during autumn, 23.02% during summer, and 75.76% during spring.

A comparison between Van and Gaziantep shows distinct differences in temperature patterns. In Gaziantep, average temperatures never drop below zero in any month, and summer temperatures exceed 27°C in July and August. In contrast, summer temperatures in Van range between 17-22.2°C. The higher summer temperatures in Gaziantep lead to significant discomfort during the summer months, whereas Van experiences relatively cooler summer conditions (Elhadar, 2020).

Biocomfort is also affected by altitude, as climate data, especially temperature, varies with changes in elevation. Numerous studies have found a significant relationship between altitude and biocomfort. For example, Daneshvar et al. (2013) evaluated bioclimatic comfort in Iran and found that areas at altitudes of 1,000-2,000 meters offered better comfort, particularly in spring, while the southern coastal regions near the Gulf of Oman and the Persian Gulf were more suitable in winter. In another study, Çalı (2018) noted that in Manisa, bioclimatic comfort reached its highest levels during summer, especially in low-altitude areas. In Trabzon, Zeren Çetin (2019) found that biocomfortable areas were located at sea level, with comfort decreasing as altitude increased.

Biocomfort is highly relevant to climate and plays a crucial role in environmental and tourism planning. Since tourists prefer locations with suitable climatic conditions, mapping bioclimatic comfort can be a valuable tool for city planners and managers (Cetin, 2015). Regional mapping of thermal climate conditions, using statistical indices, forms the basis of many urban, architectural, and tourism-related plans today. Understanding how climate influences tourist satisfaction, for instance, makes bioclimatic comfort maps an essential resource for tourism planning and development.

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4. CONCLUSIONS

Climate has a profound impact on nearly every aspect of the ecosystem, significantly influencing human life, particularly health and comfort. Therefore, identifying regions with suitable comfort conditions is essential, leading to numerous studies on this subject in recent years.

Many of these studies have primarily relied on annual average climate data. However, comfort conditions can vary significantly with seasonal changes, making annual averages potentially misleading. For instance, in a region where winter temperatures drop to -20°C and summer temperatures soar to 45°C, the calculated average may be 25°C, suggesting a comfortable climate. This, however, obscures the reality that the temperatures in both winter and summer fall outside acceptable comfort ranges. Thus, incorporating seasonal data into comfort assessments is crucial.

In urban planning, selecting locations for new settlements is critical. Integrating biocomfort conditions into the planning process can help create energy-efficient and comfortable urban environments. By identifying areas suitable for biocomfort, planners can significantly reduce heating and cooling expenses, leading to energy savings and improved living conditions. Consequently, it is advisable to conduct similar biocomfort studies across all regions.

Moreover, collecting meteorological data through mobile weather stations and comparing it with long-term climate data could enhance the accuracy of these assessments. Evaluating summer bioclimatic comfort is particularly important, as it directly affects residents' quality of life during the warmer months. In conclusion, understanding and addressing biocomfort through comprehensive climate studies can lead to more sustainable and comfortable urban development.

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Authorship Contribution Statement

Amragia H. Mostafa ELAHSADI: (a) Idea, Concept (b) Study Design, Methodology (c) Literature Review (e) Material, Resource Supply (f) Data Collection, Processing (g) Analysis (h) Writing Text

Hafith Mohammed Sulayman ALMANSOURI: (a) Idea, Concept (b) Study Design, Methodology (c) Literature Review (e) Material, Resource Supply (f) Data Collection, Processing (g) Analysis (h) Writing Text

Mohammed Miftah Mohammed BOUZQAYYAH: (a) Idea, Concept (b) Study Design, Methodology (c) Literature Review (e) Material, Resource Supply (f) Data Collection, Processing (g) Analysis (h) Writing Text

Mehmet CETIN: (b) Study Design, Methodology (e) Material, Resource Supply (f) Data Collection, Processing (g) Analysis (h) Writing original draft, (d) Supervision, (i) Critical Review

Ethical Statement

In this study, we affirm that all the necessary rules under the "Regulation on Scientific Research and Publication Ethics in Higher Education Institutions" have been adhered to, and none of the actions mentioned under the title "Actions Contrary to Scientific Research and Publication Ethics" in the said regulation have been conducted.

Conflict of Interest

"The authors declare no conflict of interest."

Author Contribution Rates

Design of Study: AHME(%25), HMSA(%25), MMMB(%25), MÇ(%25)

Data Acquisition: AHME(%25), HMSA(%25), MMMB(%25), MÇ(%25)

Data Analysis:AHME(%25), HMSA(%25), MMMB(%25), MÇ(%25)

Writing Up: AHME(%25), HMSA(%25), MMMB(%25), MÇ(%25)

Submission and Revision: AHME(%25), HMSA(%25), MMMB(%25), MÇ(%25)

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