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Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Dergisi 2024; 10 (3): 231-242 Araştırma Makalesi/Research Article

Biyoklimatik Konfor Kriterilerinin Peyzaj Planlama Sürecindeki Etkinliği: Van İli

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Öz

İnsanlar, çevresel koşullar belirli aralıklar içinde olduğunda kendilerini rahat hissederler. Bu aralık "konfor bölgesi" olarak tanımlanır. Sıcaklık, rüzgar hızı ve nem gibi iklimle ilgili parametrelerin insanlar için uygun aralıklar içinde olduğu durum "biyoklimatik konfor" veya kısaca "biyokonfor" olarak adlandırılır. İnsanlar yaşamları boyunca, giysi, ısıtma veya soğutma sistemleri gibi yardımcı unsurları kullanarak çevrelerindeki biyokonfor değerlerini ayarlamak için çaba gösterirler, böylece uygun aralıklar içinde kendilerini rahat hissederler. Bu nedenle, insanların yaşadığı bölgelerde iklim parametrelerinin konfor aralıkları içinde olması, insanların refahı, sağlığı, performansı, mutluluğu ve enerji kullanımı için çok önemlidir. Sonuç olarak, biyokonfor açısından uygun aralıkların bölgesel ve zamansal varyasyonu birçok açıdan önemli bir konudur. Bu çalışmanın amacı, Türkiye'nin büyük şehirlerinden biri olan Van ilinde bazı meteorolojik parametrelerin mevsimsel varyasyonunu belirlemek ve bunlara dayanarak biyokonfor için uygun veya uygun olmayan alanları tanımlamaktır. 1939'dan 2018'e kadar Van'a ait meteorolojik verilerin uzun dönem ortalamaları incelenmiştir. Yıllık ortalama meteorolojik verileri kullanılarak oluşturulan biyokonfor haritasına göre, Van ilinin hiçbiri biyokonfor için uygun değildir. Mevsimsel değerlendirmeler, tüm ilin ilkbahar, sonbahar ve kış mevsimlerinde rahatsız edici olduğunu, yaz mevsiminde ise il topraklarının %99.18'inin biyokonfor için uygun, %0.82'sinin ise uygun olmadığını ortaya koymuştur. Ayrıca, yaz indeks değerlerine dayalı değerlendirmeler yapılmıştır. Yaz indeks değerlerine göre, en yüksek sıcaklıkların olduğu Haziran, Temmuz ve Ağustos aylarında bile Van ilindeki çoğu insanın konfor bölgesinde kaldığı, ancak bazı insanların serin hissettiği bulunmuştur. Bu durum, Van ilinin nispeten serin bir iklim bölgesinde yer aldığını göstermektedir.

Research on the Effectiveness of Bioclimatic Comfort Criteria in the Landscape Planning Process: A Case Study of Van Province

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Abstract

People feel comfortable when environmental conditions fall within certain ranges. This range is defined as the comfort zone. The condition where the climate-related parameters such as temperature, wind speed, and humidity are within suitable ranges for humans is called “bioclimatic comfort” or simply “biocomfort.” Throughout their lives, people make efforts to adjust biocomfort values in their surroundings, using aids such as clothing, heating, or cooling systems, to feel comfortable within the appropriate ranges. Therefore, having the climate parameters in the regions where people live fall within comfort ranges is crucial for people's well-being, health, performance, happiness, and energy use. Consequently, the regional and temporal variation of suitable ranges in terms of biocomfort is of significant importance in many aspects. In this study, the aim was to determine the seasonal variation of some meteorological parameters and, based on these, to identify areas that are suitable or unsuitable for biocomfort in the province of Van, one of Turkey’s major cities. The long-term averages of meteorological data for Van from 1939 to 2018. According to the biocomfort map created using annual average meteorological data, it was determined that none of Van province is suitable for biocomfort. Seasonal assessments revealed that the entire province is uncomfortable in spring, autumn, and winter, while in summer, 99.18% of the province is suitable for biocomfort, and 0.82% is unsuitable. Additionally, evaluations were made based on summer index values. According to the summer index values, it was found that even in June, July, and August—when temperatures are highest—most people

in Van province remain in a comfort zone, although some people feel cool. This indicates that Van province lies in a relatively cool climate zone.

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INTRODUCTION

People feel comfortable in environments with specific ranges of temperature and humidity and clean air. This range is defined as the comfort zone (Kestane and Ülgen, 2013). Thermal comfort refers to a person feeling thermally satisfied with their surroundings or being pleased with the thermal environment (Kaynaklı et al., 2003; Zeren Çetin 2019; Zeren Çetin 2023; Zeren Cetin et al 2020; Zeren Cetin et al 2023a,b;). Bioclimatic comfort, on the other hand, is generally defined as climatic conditions in which a person feels extremely healthy and dynamic, while expending the least amount of energy to adapt to their environment (Bulgan and Yılmaz, 2017).

In addition to temperature, the condition where wind speed and humidity are at suitable levels for humans is called "bioclimatic comfort" or "biocomfort." When biocomfort values do not fall within appropriate ranges, people tend to feel discomfort in those areas (Cetin, 2016; Zeren Çetin 2019; Zeren Çetin 2023; Zeren Cetin et al 2020; Zeren Cetin et al 2023a,b). When these values are not within suitable ranges, people may experience discomfort, leading to negative consequences such as concentration loss, decreased work efficiency, irritability, fatigue, burning eyes, circulation and respiratory problems, and throat dryness (Boz, 2017; Alaud, 2019; Zeren Çetin 2019; Zeren Çetin 2023; Zeren Cetin et al 2020; Zeren Cetin et al 2023a,b;).

Throughout their lives, people try to adjust biocomfort values in their environments to comfortable ranges using clothing, heating, cooling systems, etc. However, bringing outdoor climate conditions to suitable ranges requires a significant amount of energy (Başer, 2015; Alaud, 2019). It is stated that approximately 40% of fossil resources worldwide are used to meet the heating, cooling, or lighting needs of buildings (Yılmaz and Oral, 2018).

The energy used to make living environments more comfortable places a significant economic burden, and the cost of energy consumed is a major strain on both individual and national economies. This issue becomes even more significant for countries like Turkey, which rely heavily on external sources for energy (Dağıdır and Bolattürk, 2011).

Studies suggest that global energy consumption will be approximately 60% higher in 2030 compared to today, and in Turkey, energy consumption in 2030 is expected to be nearly double the current amount (Başer, 2015). This will place considerable pressure on limited natural resources (Güner and Turan, 2017; Bulut, 2018). Therefore, by establishing new settlements in biocomfortable areas, substantial energy savings can be achieved in the process of making non-comfortable areas comfortable. Additionally, living in comfortable areas where people feel relaxed can bring significant psychological, social, and health benefits (Alpay et al., 2013; Çalı, 2018; Alaud, 2019).

Globally, research is being conducted on bioclimatic conditions considering the importance of climate conditions in human life, urban planning, and sustainable tourism development. Attorre et al. (2007) compared various interpolation methods for regional and climatic bioclimatic variables. Mesquita and Sousa (2009) defined ombrotype and thermotype geostatistical methods for the Portuguese region based on climate data. Unger (1999) compared the bioclimatic conditions of some urban and rural areas in Central Europe, identifying bioclimatic conditions in urban and rural areas based on THI (Temperature-Humidity Index) and RSI (Relative Strain Index). Due to the high temperature stress, the RSI value is lower in urban areas.

Emmanuel (2005) examined thermal comfort in cities in the hot and humid metropolitan area of Colombo, Sri Lanka, using THI and RSI. The findings indicated that climate sensitivity should be considered in urban design for tropical regions.

Daneshvar et al. (2013) evaluated bioclimatic comfort conditions in Iran using the PET method. Roshan et al. (2017) examined thermal comfort limits for estimating heating and cooling demand in Iran's urban areas, while Semahi et al. (2019) conducted studies on comparative bioclimatic approaches for comfort and passive heating and cooling strategies in Algeria.

Mazhar et al. (2015) studied outdoor thermal comfort in Lahore, Pakistan. Salata et al. (2016) and Salata et al. (2017) conducted research in Italy, Daemei et al. (2019) in Rasht (Iran), Durban (South Africa), Tokyo (Japan), Kutaisi (Georgia), Houston (USA), Buenos Aires (Argentina), Brisbane (Queensland, Australia), and Trieste (Italy), and Lamarca et al. (2018) in Chile on identifying areas suitable for biocomfort.

Turkey is one of the countries where most studies on biocomfort have been conducted. Numerous studies have been carried out to identify biocomfortable areas in various cities in Turkey. These include studies in Ankara (Türkoğlu et al., 2012; Çalışkan and Türkoğlu, 2014), Erzurum (Bulgan and Yılmaz, 2017), Muğla (Çınar, 2004), Izmir (Kestane and Ülgen, 2013), Kastamonu and its districts (Cetin, 2016; Cetin and Zeren, 2016; Cetin et al., 2017), Aydın and its districts (Cetin et al., 2018a; Cetin et al., 2018c), Kütahya (Cetin et al., 2010; Cetin, 2015b), Karabük (Cetin, 2018a), Elazığ (Cetin et al., 2018b), Manisa (Çalı, 2018), Bursa (Cetin, 2019), Burdur (Cetin et al., 2019), Trabzon (Zeren Çetin, 2019; Zeren Cetin and Sevik, 2020), Çankırı (Alaud, 2019), Gaziantep (Elhadar, 2020), Şanlıurfa (Kolbüken, 2018), and Tekirdağ (Boz, 2017).

People feel more comfortable under various conditions, and the conditions in which people feel comfortable vary from person to person. While most people feel comfortable in a temperature range of 20-25.5°C and a relative humidity range of 30-60% (İlten et al., 2017; Alaud, 2019), some people have reported feeling comfortable at extreme temperatures as low as 10°C or as high as 35°C (Nicol and Roaf, 2017).

Therefore, in order to determine biocomfortable areas in a region, it is necessary to first identify which environmental conditions are within acceptable ranges. Numerous studies have been conducted on the importance of biocomfort, its impact on human health, its historical development, its economic aspects, thermal comfort, and modeling, most of which are reviews (Rupp et al., 2015; Arif et al., 2016; Zomorodian et al., 2016; Lodi et al., 2017; Van Craenendonck et al., 2018; Potchter et al., 2018; Xiong et al., 2019; (Adiguzel et al 2019; Ahmadi and Ahmadi 2017; Cole et al 2010; Çetin et al 2018; Orimoloye et al 2019; Perkins and Debbage 2016; Zeren Cetin and Sevik 2020; Zeren Çetin 2019; Zeren Çetin 2023; Zeren Cetin et al 2020; Zeren Cetin et al 2023a,b; Cetin et al 2023a,b).

Hence, identifying regions that fall within suitable biocomfort ranges is of great importance, especially in cities where population growth and new settlement areas are expected. This study aimed to determine the seasonal variation of some meteorological parameters in the province of Van and identify regions suitable or unsuitable for biocomfort.

MATERIAL AND METHOD

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 (URL1, 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.

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 (from the weather station coordinates) 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 (Cetin 2015a; Cetin et al., 2010; Çalı, 2018; Zeren Çetin, 2019; Alaud, 2019; Elhadar, 2020; Zeren Cetin and Sevik, 2020; Zeren Çetin 2019; Zeren Çetin 2023; Zeren Cetin et al 2020; Zeren Cetin et al 2023a,b;).

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 (Taylan and Damçayırı, 2016; Cetin et al., 2018a; Zeren Çetin 2019; Zeren Çetin 2023; Zeren Cetin et al 2020; Zeren Cetin et al 2023a,b;).

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.

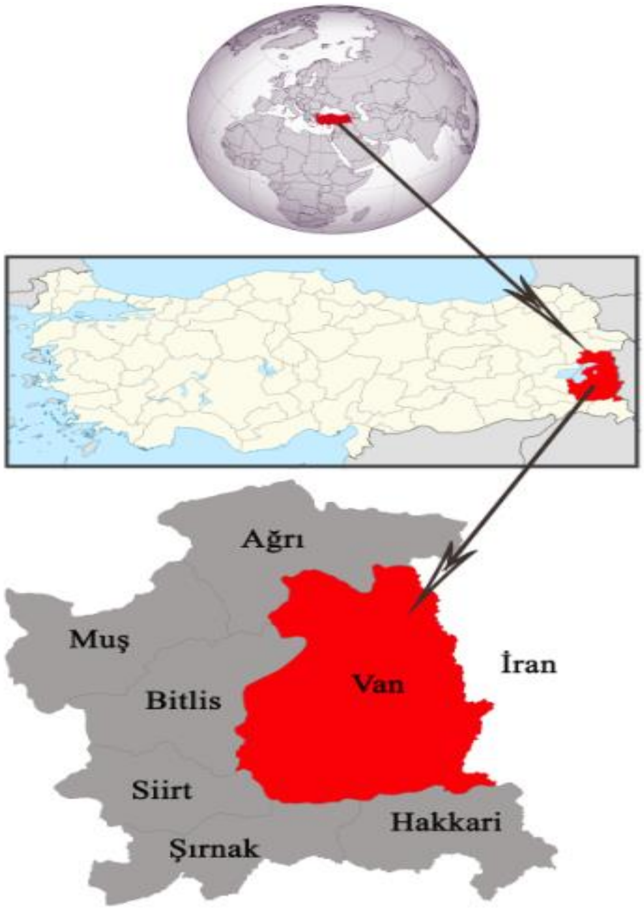


Figure 1. Location of Van

RESULTS

The primary objective of this study is to determine the areas suitable for biocomfort within Van Province. The annual average humidity variation map for Van Province, based on meteorological data, is presented in Figure 2.

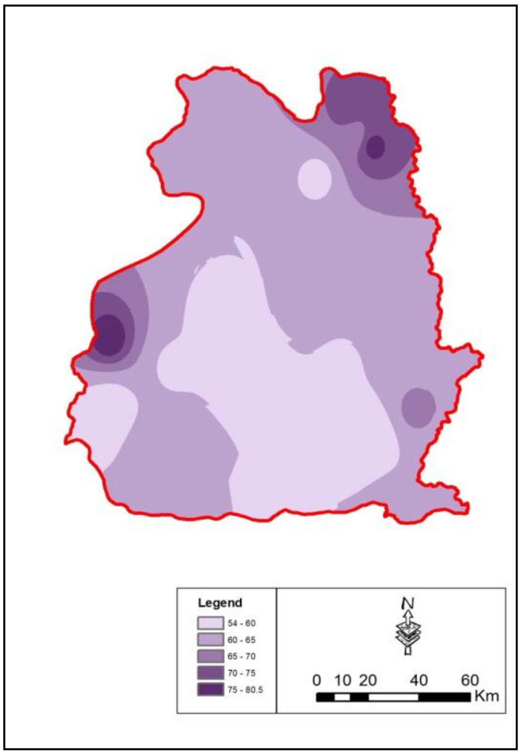


Figure 2. Map of the annual average humidity

Across Van province, it was calculated that the annual average humidity was in the range of 54-60% for approximately 30.99% of the province, 60-65% for 56.06%, 65-70% for 6.7%, 70-75% for 5.17%, and 75-80.5% for 1.08%. Based on these figures, it can be stated that the average humidity in a large part of the province (87.05%) is below 65%. The annual average wind condition in Van province is presented in Figure 3.

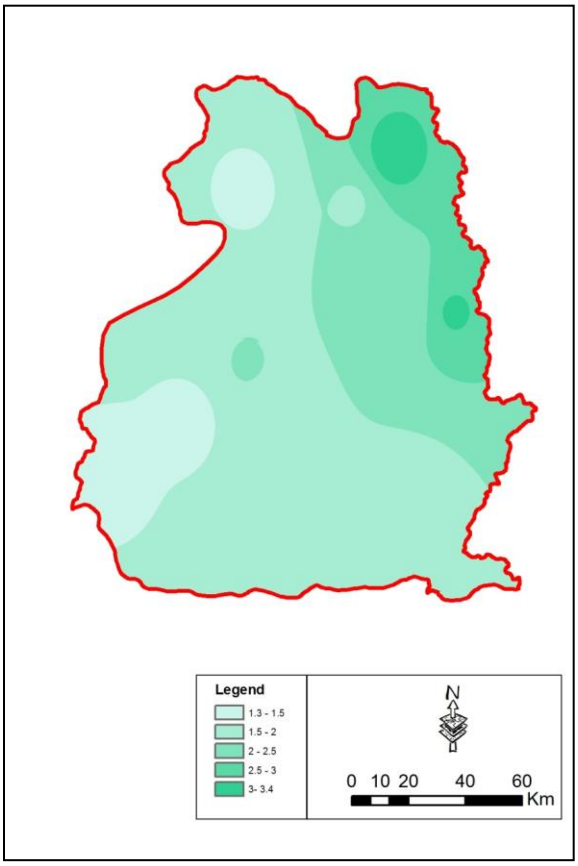


Figure 3. Annual Wind Map

When examining the annual average wind condition of Van province, it was calculated that the average wind speed was below 1.5 m/s in 11.22% of the province, 1.5-2 m/s in 57.47%, 2-2.5 m/s in 19.59%, 2.5-3 m/s in 9.4%, and faster than 3.0 m/s in 2.32%. Based on these results, it can be stated that in most parts of the province (68.69%), the wind speed is slower than 2 m/s. The annual average precipitation map of Van province is presented in Figure 4.

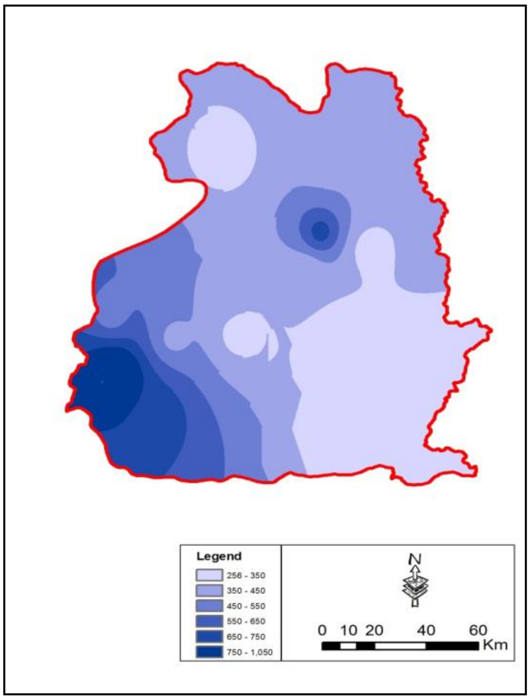


Figure 4. Annual Precipitation Map

When examining the annual average precipitation condition in Van province, it was calculated that approximately 29.68% of the province receives less than 350 mm of rainfall, 42.3% receives 350-450 mm, 13.13% receives 450-550 mm, 5.73% receives 550-650 mm, 5.52% receives 650-750 mm, and 3.64% receives more than 750 mm. In general, it can be said that precipitation decreases from west to east. The annual average temperature map of Van province is presented in Figure 5.

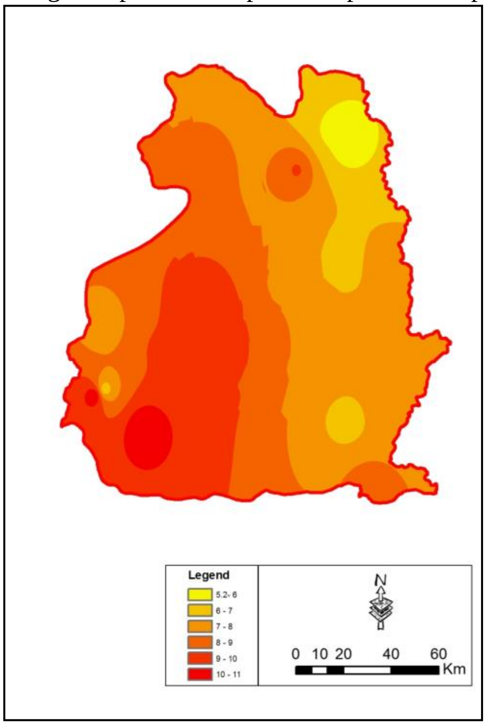
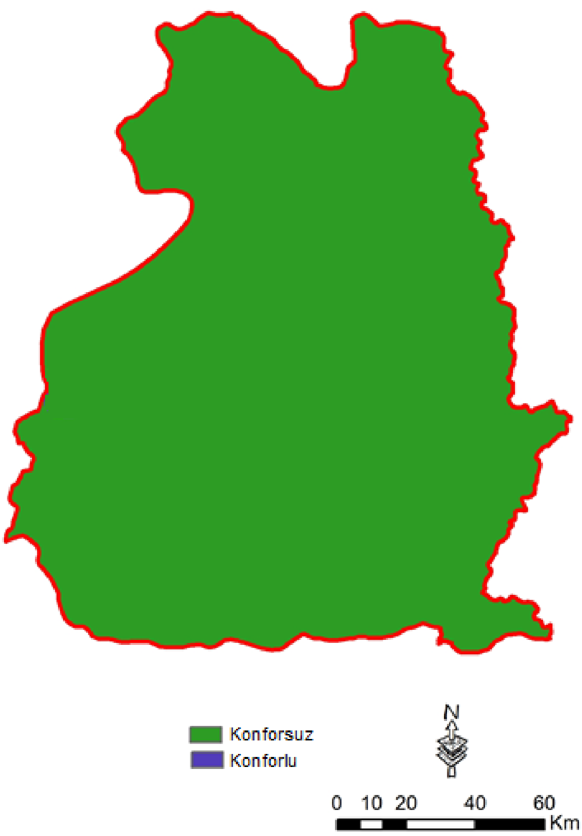


Figure 5. Annual Temperature Map

When examining the annual average temperature change in Van province, it was observed that the average temperature was below 6 °C in 2.47% of the province, 6-7 °C in 9.88%, 7-8 °C in 36.86%, 8-9 °C in 28.22%, 9-10 °C in 20.32%, and 10-11 °C in 2.25%. In general, it can be said that the northeastern regions of the province are the coolest areas. The biocomfort map created using the annual average meteorological data of Van province is presented in Figure 6.

Figure 6. Annual Biocomfort Map



When examining the biocomfort map created using the annual average meteorological data of Van province, it is observed that the entire province is unsuitable in terms of biocomfort. This is also observed in the seasonal biocomfort maps. According to the calculations, the entire province remains in uncomfortable areas for three of the four seasons.

DISCUSSION

As a result of the study, the biocomfort of Van province was evaluated, and it was determined that the entire province is unsuitable in terms of biocomfort, according to the biocomfort map created using annual average meteorological data. According to the seasonal evaluations, the entire province is uncomfortable during the spring, autumn, and winter months, while 99.18% of the province is suitable in terms of biocomfort during the summer, and 0.82% is unsuitable.

This situation is related to climate data and is largely influenced by temperature. When examining the meteorological data of Van province, it is observed that the average temperatures remain below 10 °C from November to April, are 13.1 °C in May, and 11.3 °C in October. Therefore, outside of June, July, August, and September, average temperatures are quite low for the other eight months. According to the summer index values for Van province, the entire province remains largely in the 1st zone, even during the warmest months of June, July, and August, and it is noted that although most people feel comfortable in this zone, some people feel cool (Güçlü, 2010). This is an indication that Van province falls within a relatively cool climate zone.

Biocomfort is a condition related to climate data, and due to our country's location in different climate zones, very different results can be obtained in biocomfort studies conducted in various provinces. Elhadar (2020) used the same method employed in this study to evaluate the biocomfort of Gaziantep province and calculated that approximately 88.83% of the province is suitable in terms of biocomfort, while 11.17% is unsuitable, based on annual average data.

However, in the same study, when evaluated seasonally, it was calculated that the entire province is unsuitable in terms of biocomfort during the winter season, whereas approximately 98.11% of the province is suitable and 1.89% is unsuitable in autumn, 23.02% is suitable and 76.98% is unsuitable in summer, and 75.76% is suitable and 24.24% is unsuitable in spring (Elhadar, 2020).

When examining the meteorological data of Gaziantep evaluated by Elhadar (2020), it is noted that the average temperature never falls below zero in any month, while the average temperature exceeds 27 °C in July and August. In this study, it was observed that summer temperatures in Van province range between 17-22.2 °C, while in Gaziantep, summer temperatures range between 26.6-30.7 °C. In Gaziantep, areas unsuitable for biocomfort during the summer are largely due to high summer temperatures (Elhadar, 2020).

Biocomfort is related to climate data, and climate data, especially temperature values, change with altitude. Therefore, in many studies on biocomfort, a significant relationship between altitude and biocomfort has been found. Daneshvar et al., (2013) evaluated bioclimatic comfort conditions in Iran using the PET method and noted that areas with an altitude of 1,000-2,000 meters had better comfort conditions, with more suitable areas for comfort found in the spring season, while the southern coastal regions near the Gulf of Oman and the Persian Gulf were more suitable for comfort in the winter.

Çalı (2018) in a study conducted in Manisa, indicated that the bioclimatic comfort period in Manisa was at its highest level in summer, especially in areas with lower altitudes and at elevations above 300-500 meters. Zeren Çetin (2019) stated that in Trabzon, the comfortable areas were at sea level, and comfort conditions decreased as altitude increased (Zeren Çetin, 2019).

Biocomfort is a condition related to climate, and today climatology plays an important role in environmental planning by examining the effects of climate structures. It is also of great importance in tourism planning because tourists always seek suitable climates or climate comfort. Therefore, the mapping of bioclimatic comfort can be highly useful for city managers and planners (Çetin, 2015).

One of the applications of climatology in environmental planning is the examination and regionalization of thermal climate conditions based on statistical climate indices. Today, bioclimatic studies, particularly in urban and settlement matters, architecture, and tourism services, form the basis of many regional development plans. Given the fact that climate conditions significantly influence tourists' satisfaction, mapping bioclimatic comfort on a regional basis can also be highly useful for tourism planning.

CONCLUSION

Climate directly affects almost the entire ecosystem and, consequently, many aspects of human life, especially human health and comfort. Therefore, it is crucial to identify regions where comfort conditions are within suitable ranges for people, and many studies have been conducted on this subject in recent years.

In most of the studies conducted so far, annual average climate data has been evaluated. However, comfort conditions vary depending on the climate, and as a result, annual average data can be misleading. For example, in a region where winter temperatures are -20°C and summer temperatures are 45°C, the average temperature may be calculated as 25°C, leading to a false conclusion of comfort. However, the temperature values in this region are outside the comfort range in both winter and summer seasons. Therefore, it would be beneficial to evaluate seasonal data in studies on this topic.

In urban planning, the selection of areas where new settlements will be established is of great importance. Considering biocomfort conditions in the identification of these areas can be effective in creating energy-efficient and comfortable cities. Hence, it is recommended that biocomfort studies be integrated into urban planning efforts. Identifying areas suitable in terms of biocomfort for the establishment of new settlements can significantly reduce heating and cooling costs, thereby contributing to energy savings and the establishment of comfortable living spaces. For this reason, it is suggested that similar studies be conducted in all regions. Additionally, it may be beneficial to gather meteorological data through mobile weather stations and evaluate these along with long-term meteorological data.

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COMPLIANCE WITH ETHICAL STANDARDS

a) Authors' contributions

Original idea: MMMB, HMSA, AHME and MC. Experiment design: MMMB, HMSA, AHME and MC. Measurement: MMMB, HMSA, AHME and MC. Data analysis: MMMB, HMSA, AHME and MC. Manuscript preparation and revisions: MMMB, HMSA, AHME and MC.

b) Conflict of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

c) Code availability

Not applicable.

d) Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

e) Consent for publication

Not applicable

f) Ethics approval and consent to participate

Not applicable

g) Funding

Not applicable

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