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Research Article

The Effect Of Urban Areas On Human Bioclimatic Comfort Conditions; Sample Of Amasya City

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Abstract

Urban settlements, one of the most important developments in the history of humanity, expanded due to the migration movements from rural to urban areas and turned into high density built environments with high-rise buildings. This situation has caused urban areas to have different climatic conditions from the suburban and rural areas around them. Bioclimatic comfort is the state of people to feel comfortable, happy and fit in the atmospheric environment they are in. Uncomfortable conditions cause much negativity such as decrease in people's work efficiency, health conditions and increase in energy consumption. Amasya is a small Anatolian city in the Central Black Sea Region of the Black Sea Region, where industrialization has not developed. In this study, hourly data of the year 2021 of two meteorology stations, which are considered as urban and suburban, were used in order to examine the effects of urban areas on bioclimatic comfort conditions in Amasya. As a method, the PET (Physiological Equivalent Temperature) index obtained from the RayMan model, which calculates many factors together, was used. As a result of the study, suburban is 2.1 ˚C cooler than urban at the general PET average; 3.4˚C cooler at the maximum average and 2.8˚C cooler at the minimum average. The urban area is exposed to heat stress by 8.1% more throughout the year than the suburban area. In order to reduce the negative bioclimatic comfort conditions of cities and for sustainable urbanization, it is necessary to make urban design and planning that takes into account human, ecological and physical conditions.

Keywords: Amasya, Bioclimatic Comfort, Urban Climate, Urbanization, PET.

Kentsel Alanların İnsan Biyoklimatik Konfor Koşullarına Etkisi; Amasya Kenti Örneği

Öz

İnsanlık tarihinin en önemli gelişmelerinden biri olan kent yerleşmeleri, kırdan kente yaşanan göç hareketlerine bağlı olarak genişlemiş, yoğun ve yüksek yapılı yerleşmelere dönüşmüştür. Bu durum kentlerin çevrelerindeki yarı kentsel ve kırsal alanlardan farklı iklim koşullarına sahip olmalarına neden olmuştur. Biyoklimatik konfor, insanların bulundukları atmosferik ortamda kendilerini rahat, mutlu ve zinde hissetme durumudur. Konforsuz şartlar insanların iş verimlerinde azalma, sağlık koşulları ve enerji tüketiminde artış gibi birçok olumsuzluklara neden olmaktadır. Amasya, Karadeniz Bölgesi'nin Orta Karadeniz Bölümünde sanayileşmenin gelişmediği küçük bir Anadolu kentidir. Bu çalışmada Amasya'da kentsel alanların biyoklimatik konfor koşullara etkisinin incelenmesi amacıyla çalışmada kent ve yarı kent olarak kabul edilen iki meteoroloji istasyonunun 2021 yılı saatlik verileri kullanılmıştır. Yöntem olarak birçok etkeni bir arada hesaplayan RayMan modelinden elde edilen PET (Physiological Equivalent Temperature) indisinden yararlanılmıştır. Çalışma sonucunda genel PET ortalamasında yarı kent; kente göre 2,1 ˚C, maksimum ortalamasına göre 3,4˚C ve minimum ortalamada ise 2,8˚C daha serindir. Kentsel alan yarı kent alana göre tüm yıl boyunca % 8,1 daha fazla sıcak stresine maruz kalmaktadır. Kentlerin olumsuz biyoklimatik konfor koşullarını azaltmak ve sürdürülebilir kentleşme için, beşeri, ekolojik ve fiziksel koşulları dikkate alan kentsel tasarım ve planlamaların yapılması gerekmektedir.

Anahtar Kelimeler: Amasya, Biyoklimatik Konfor, Kent İklimi, Kentleşme, PET.

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1. Introduction

Cities are places where many sectors such as social, health, education, economic and trade develop and have many service branches. In this respect, cities are more attractive to people than rural areas. As a result of the increasing world population and technological developments due to the developments in medicine, the destruction of the natural environment has increased with the increase in the power of human beings to intervene in nature. Changes, especially with the industrial revolution, changes in human habits and philosophy of life, and the increase in production and consumption have increased the number and size of cities [1, 2].

Rapid migration from rural to urban areas causes an increase in housing, transportation and infrastructure services in the city. Besides increased artificial surfaces and reduced evaporation, one group of factors is anthropogenic effects including transportation, production activities, and air pollution. This situation causes the destruction of the natural environment in urban areas, the increase of impermeable surfaces such as asphalt and concrete, the increase of multi-storey structures and the dense settlements. As a result of these changes, urban areas have different climatic conditions from the rural and sub-urban areas around them. In many studies in the world and in Turkey, it has been explained that adverse climatic conditions are observed in urban areas due to the destruction of natural surfaces and the decrease in the amount of green areas [3-11].

In parallel with the population and construction density in the cities, heat islands are formed, and changes occur in the microclimatic structures of the cities. The cumulative effects of these microclimatic changes on each other can negatively affect the lives of humans and other living things on a global scale. This effect on humans can be explained by the concept of bioclimatic comfort. Bioclimatic comfort is when people feel comfortable, happy and fit in the thermal environment they are in [12, 13]. In other words, it is the state where there is no discomfort between an uncomfortable temperature and an uncomfortable cold [14]. Uncomfortable conditions can lead to physiological and psychological health conditions of people, decreased work efficiency, more energy use, heat-related symptoms and an increase in death rates [13, 15-18].

In this study, it is aimed to examine the effects of urbanization on bioclimatic comfort conditions in Amasya, a small Anatolian city where industrialization has not developed. For this purpose, hourly data of 2021, in which the city meteorology station in the city of Amasya, representing the urban area, and the meteorology stations in Amasya University, representing the sub-urban area, made simultaneous measurements, were used. Bioclimatic comfort conditions were compared according to PET (Physiological Equivalent Temperature) index by using RayMan software. Significant differences were determined between the two stations in terms of bioclimatic comfort. Amasya, according to NUTS it is located in the Samsun sub-region of the Western Black Sea Region (TR83 Level). The city center is located in the Central Black Sea Region of the Black Sea Region (between 35˚46' - 35˚51' east longitudes and 40˚40' - 40˚37' northern latitudes, in the back region of the Canik Mountains. Established along the Yeşilırmak valley, the city of Amasya developed at elevations between 390 and 500 meters. Yeşilırmak River, an important river of Turkey, passes through the city. Yeşilırmak has been decisive in the establishment and development of the city [19]. The city is surrounded by mountains from the north and south. In the city of Amasya, where industrialization has not developed, it has a dense settlement due to topographic conditions (it is located at the bottom of the valley) (Figure 1). The suburban weather station is located in a loosely structured area, while the urban weather station is located in a densely built urban area.

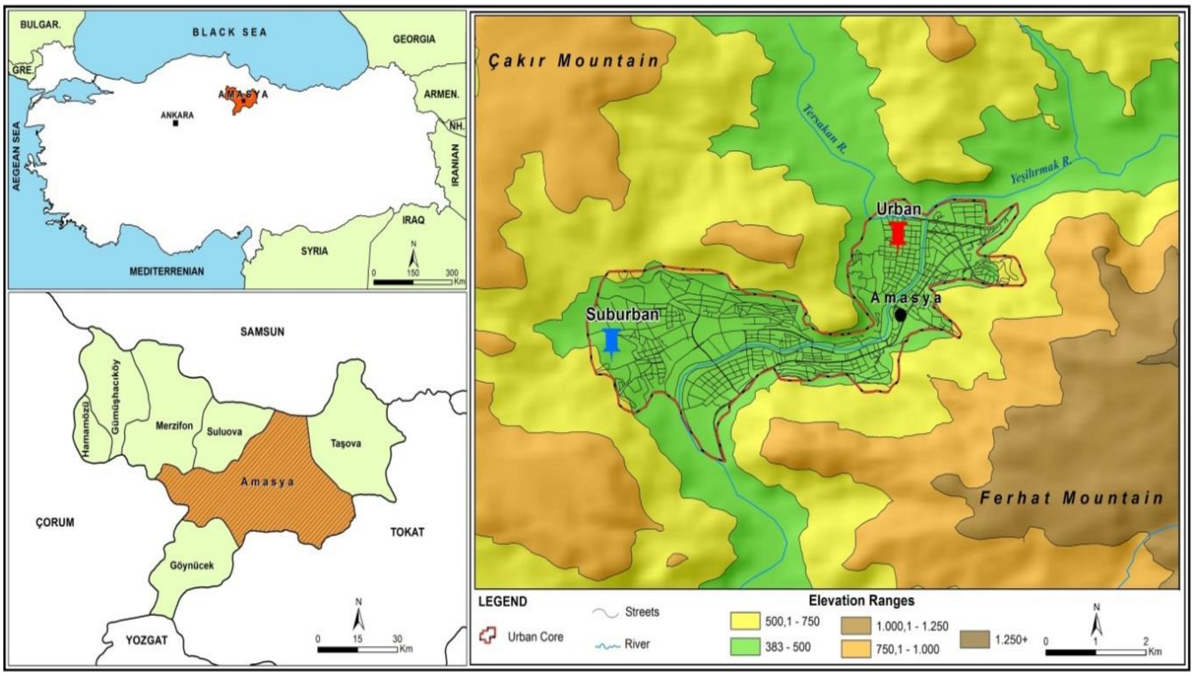

Figure 1. Location of map Amasya city

The city of Amasya has a transitional climate between the Black Sea climate and the continental climate. When evaluated according to climate classifications, in Amasya, according to Köppen-Geiger; (Csa) climate with mild winter, very hot summer and dry climate; according to Erinç; steppe-semi-arid; according to de martonne; steppe-damp, according to Thornthwaite; D,B'2,d,b'3 (D: semi-arid, B'2: mesothermal, d: little or no excess water, b'3: summer evaporation rate: 53%) [20].

2. Material and Methods

In the study, the Amasya meteorology station with the number 17085 representing the urban area and the Amasya University meteorology station with the sub-urban feature number 19911 in 2021; air temperature (ºC), relative humidity (%), wind velocity (m/s) and cloud cover (octa) hourly data were used. Table 1 represents the features of the meteorological measurement stations (Table 1, Figure 2).

Table 1. Meteorology stations used in the study

Represented Area	**Location**	**Altitude (m)**	**Surface**
Urban	40°39'59.87"N; 35°50'6.64"E	409	Dense structured
Sub-urban	40°39'0.08"N; 35°47'28.41"E	495	Loosely structured

Figure 2. Meteorology stations used in the study

PET index was used through the RayMan model, which is widely used to determine bioclimatic comfort conditions. PET (Physiological Equivalent Temperature) [21-23] index calculates human bioclimatic comfort according to body heat energy balance. The index calculates all the effects of the thermal environment on people (short and long wave solar radiation, air temperature, relative humidity and wind velocity) and the thermo-physiological conditions of the human body (clothing type and activity) [22-24]. Human temperature sensation levels and physiological stress levels on humans in each value range of the PET index; 35 years old, 175 cm height, 75 kg weight, male, 0.9 clo clothing load and 80 W workload were taken into consideration [25-27] (Table 2).

Table 2. Human thermal sensation and stress ranges for PET [22,23].

PET [°C]	Thermal sensation	Level of thermal stress	Colors
< 4°C	very cold	extreme cold stress	
4.1 - 8°C	cold	strong cold stress	
8.1 - 13°C	cool	moderate cold stress	
13.1 - 18°C	slightly cool	slight cold stress	
18.1 - 23°C	**neutral (comfortable)**	**no thermal stress**	
23.1 - 29°C	slightly warm	slight heat stress	
29.1 - 35°C	warm	moderate heat stress	
35.1 - 41°C	hot	strong heat stress	
41°C >	very hot	extreme heat stress	

The values obtained by using the hourly data of 2021, which meteorology stations made joint measurements, were calculated as daily averages and hourly numbers. In total, 8760 hours (365 x 24) of data were calculated for each station.

3. Results and Disscussion

Among the environmental factors that cause global warming or climate change, the most important factor is urbanization. With the industrial revolution, many families who were unemployed in the countryside had to migrate to the city. Especially in urban areas, the increasing need for labor and the development of the city's service functions such as education and health have made migration from rural to urban attractive. Population growth in cities with migrations has created a need for more housing. Both the increase in the number of residences and the development of infrastructure and transportation services have caused the expansion and concentration of urban areas. This situation has led to the destruction of natural areas in urban areas, the destruction of green areas, the increase in air pollution with the increase in the use of motor vehicles, and the increase in asphalt and concrete surfaces. Due to such anthropogenic factors, cities have different climatic conditions from the suburban or rural areas around them. This situation caused the bioclimatic comfort conditions of the cities to be negatively affected. Many studies in the world and in Turkey reveal that urban areas cause climate change.

In the study, it was seen that the suburban area had more positive results than the urban area. On the general PET average, suburban is 2.1˚C cooler, with a maximum average of 3.4˚C and a minimum average of 2.8˚C cooler than a city (Figure 3). Although urban land use differences are effective in the emergence of such a difference, the altitude difference (86 meters) between the two stations is also effective.

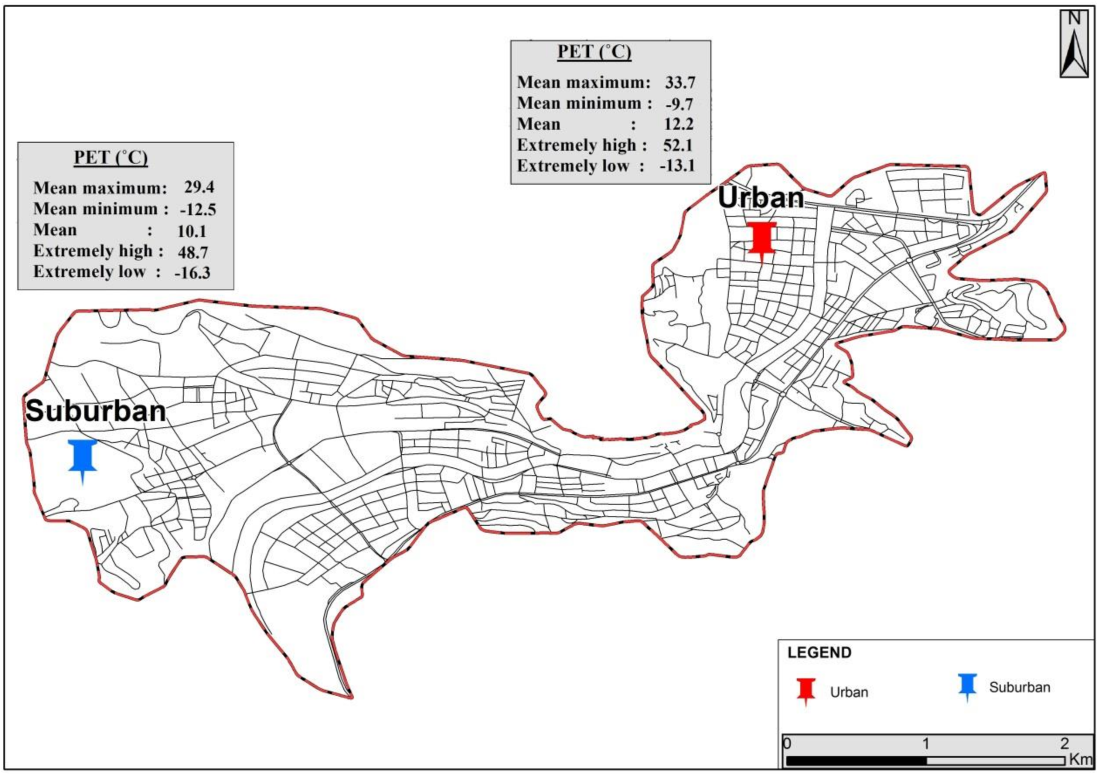

Figure 3. Urban and suburban meteorological stations

According to these findings, it is expected that those living in suburban areas will feel more comfortable than those living in urban areas. In heat stresses, it is possible for those living in urban areas to be exposed to higher thermal stresses.

Hourly suburban and urban comparisons of the whole working period and the hot months (June, July, August and September) were made. According to hourly comparisons; suburban has higher “comfortable” conditions (general; 7.9% and summer 13.1%) than urban, both in summer and all year round. Cold stresses (< 18.1 ˚C) are perceived as 72.1% in suburban and 64.8% in urban areas. Suburban is 7.2% colder than the city. In heat stresses; “slightly warm” stress is in suburban in the whole period, at a rate of 0.9% compared to the city (7.3% and 6.4%, respectively) and 1.7% in the summer period (7.3% and 6.4%, respectively) (respectively 13.1% and 11.4%) are more common. In the "warm", "hot" and "very hot" stresses, the city is exposed to 0.5%, 4.1% and 5.4% more exposure than the suburban, respectively. On the other hand, in the summer period, the city has more stressful conditions in the "hot", "very hot" and "extremely hot" stresses, respectively, by 1.1%, 8.7% and 13.6% compared to the suburban (Table 3).

Table 3. Hourly suburban and urban comparison

Annual Values						
PET (°C)	Thermal sensation	Level of thermal stress	Suburban (hour)	Suburban (%)	Urban (hour)	Urban (%)
<4	Very cold	Extreme cold stress	2689	30,7	2541	29,0
4,1–8,0	Cold	Strong cold stress	984	11,2	995	11,4
8,1–13,0	Cool	Moderate cold stress	1308	14,9	1122	12,8
13,1–18,0	Slightly cool	Slightly cold stress	1341	15,3	1014	11,6
18,1–23,0	Comfortable	No thermal stress	695	7,9	631	7,2
23,1–29,0	Slightly warm	Slightly heat stress	640	7,3	564	6,4
29,1–35,0	Warm	Moderate heat stress	612	7,0	657	7,5
35,1–41,0	Hot	Strong heat stress	411	4,7	683	7,8
>41,0	Very Hot	Extreme heat stress	80	0,9	553	6,3
		Total	**8760**	**100**	**8760**	**100**
Summer Months						
PET (°C)	Thermal sensation	Level of thermal stress	Suburban (hour)	Suburban (%)	Urban (hour)	Urban (%)
<4	Very cold	Extreme cold stress	20	0,7	8	0,3
4,1–8,0	Cold	Strong cold stress	28	1,0	24	0,8
8,1–13,0	Cool	Moderate cold stress	436	15,7	219	7,6
13,1–18,0	Slightly cool	Slightly cold stress	776	26,9	439	15,2
18,1–23,0	Comfortable	No thermal stress	376	13,1	327	11,4
23,1–29,0	Slightly warm	Slightly heat stress	403	14,0	348	12,1
29,1–35,0	Warm	Moderate heat stress	440	15,3	473	16,4
35,1–41,0	Hot	Strong heat stress	321	11,1	571	19,8
>41,0	Very Hot	Extreme heat stress	80	2,8	471	16,4

It has been determined that comfortable conditions are less experienced in the city station during the whole time period and in the summer period than in the sub-urban, and cold thermal conditions are experienced more frequently in the suburban. In heat stresses, it has been observed that the city is exposed to more heat stresses than the suburban in the whole time period and especially in the summer period. It has been determined that suburban areas are more advantageous than urban areas according to thermal conditions. According to the daily percentage distribution of bioclimatic comfort conditions in the study; in the winter season it is seen that colder conditions are experienced in the suburban. In the summer season, especially in July and August, "very hot" and "hot" stresses are effective in the city, while "warm" and "slightly warm" stresses are effective in the suburban. “Comfortable” conditions are perceived more in sub-urban than urban (Figure 4, Figure 5).

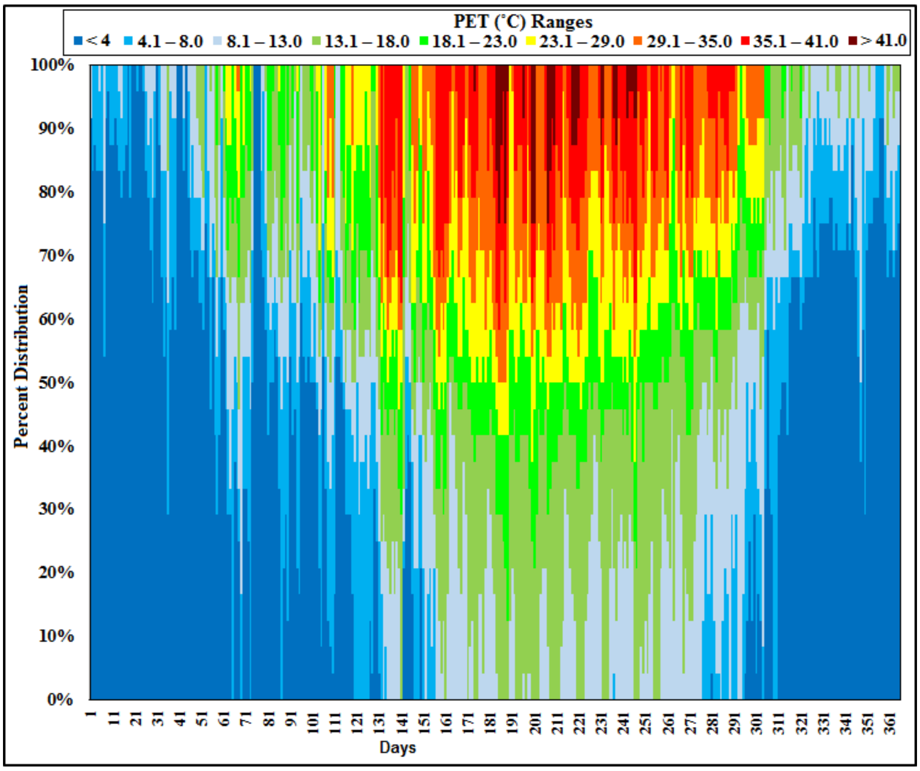

Figure 4. Temporal distribution of bioclimatic comfort conditions in sub-urban area

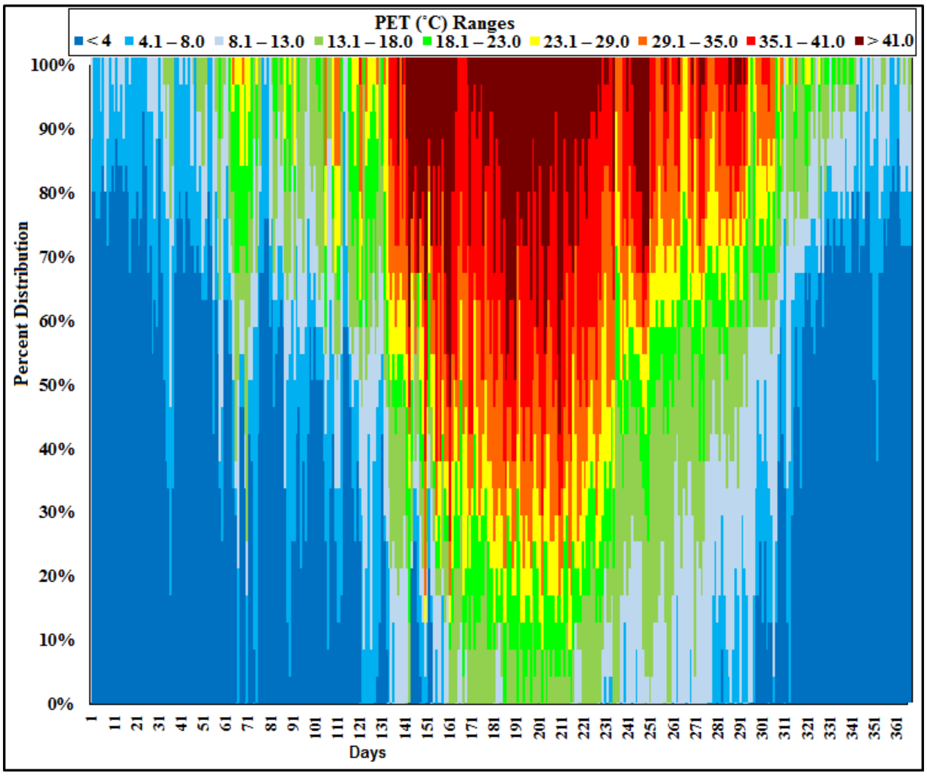

Figure 5. Temporal distribution of bioclimatic comfort conditions in the urban area

In this study, the effects of urbanization movements in the world and in Turkey on bioclimatic comfort conditions were examined in Amasya, a small city where industrialization was not developed. As a result of the study, it was seen that the suburban area had more positive results than the urban area. Suburban is 2.1 ˚C cooler than urban at the general PET average; 3.4˚C cooler at the maximum average and 2.8˚C cooler at the minimum average. In addition, suburban area has higher “comfortable” conditions (7.9%) all year round than the city. It has been observed that the urban area is exposed to heat stresses 8.1% more throughout the year and 21.5% more in summer than the suburban area. Although urban land use differences are effective in the emergence of such a difference, the altitude difference (86 meters) between the two stations is also effective. When the results obtained are compared with other studies, the difference between the city and the suburban was found as; 1,4 – 2,2 °C in Ankara, the capital of Turkey [28], 8,7 °C in Atina [7], 1,5 °C in Belgrade [29], 1,4 °C in Eskişehir [10] and 2,5-5,5 °C in Kolkata , India [11]. The results of the study are similar to the results of the studies in the literature.

4. Conclusion

Even in Amasya, a small Anatolian city where industrialization has not developed, it has been revealed that urban areas have more negative comfort conditions than the suburban areas around them. It has also been explained in many studies that bioclimatic comfort conditions have negative effects in urban centers where more than half of the world's population and more than 90% of Turkey's population live. The fact that the city of Amasya was established on the valley floor and accordingly the limited expansion area caused the settlements to become dense. This situation caused a decrease in wind speed in the city, excessive concreting and asphalting.

Depending on climate change, it is possible to experience more adverse bioclimatic comfort conditions in the city in the future. Therefore, the climate and bioclimatic comfort conditions of the city should be considered in the planning and designs to be made in urban areas. The amount of green areas in cities should be increased and these green areas should be distributed in a balanced way. In addition, afforestation to be made by choosing suitable species on streets will improve bioclimatic comfort conditions. Green buildings should be preferred in building designs. It is recommended to make urban design and planning from a geographical perxpective to reduce the negative effects of bioclimatic comfort conditions and for sustainable cities.

Ethics in Publishing

There are no ethical issues regarding the publication of this study.

Author Contributions

The collection and calculation of the data and the writing of the article were made by Savaş ÇAĞLAK. The evaluation and general design of the results of the study was made by Süleyman TOY.

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