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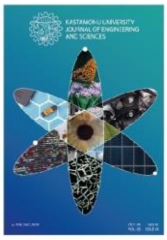

Determining the biocomfort zones in near future under global climate change scenarios in Antalya

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Abstract: Climate is a factor that affects the entire life of humans such as physiological development and characteristics, housing and house structures, food and cloth selections, and distribution on land. It is projected that global climate change would cause important changes in climate parameters in near future and affect the lives of all organisms on the earth directly or indirectly. It is estimated that these changes would cause significant changes in biocomfort zones. Thus, it is important to determine the biocomfort zones depending on the climate change scenarios and to use them in urban planning studies. In this study, it was aimed to determine the change in bioclimatic comfort zones in Antalya depending on the projected climate change scenarios. Within the scope of this study, considering the SSPs 245 and SSPs 585 scenarios of Coupled Model Intercomparison Project Phase 6, that is the 6th assessment report of IPCC, it was aimed to determine the current status and possible changes in biocomfort zones in Antalya in years 2040, 2060, 2080, and 2100. The results showed that the comfort zones in Antalya will generally shift from cold to hot towards the year 2100, that this shift will be at important level, and that the highest level of increase will be seen in southern regions with high population density and intense touristic activities.

Keywords: ETv, Radiation intensity, SSPs 245, SSPs 585, Temperature-humidity index.

Öz: İklim, fizyolojik gelişim ve özellikleri, barınma ve ev yapıları, yiyecek ve giysi seçimleri, karadaki dağılımı gibi insanın tüm yaşamını etkileyen bir faktördür. Küresel iklim değişikliğinin yakın gelecekte iklim parametrelerinde önemli değişikliklere neden olacağı ve yeryüzündeki tüm organizmaların yaşamını doğrudan veya dolaylı olarak etkileyeceği öngörülmektedir. Bu değişikliklerin biyokonfor bölgelerinde önemli değişikliklere neden olacağı tahmin edilmektedir. Bu nedenle iklim değişikliği senaryolarına bağlı olarak biyokonfor bölgelerinin belirlenmesi ve kentsel planlama çalışmalarında kullanılması önemlidir. Bu çalışmada, öngörülen iklim değişikliği senaryolarına bağlı olarak Antalya ilinde biyoklimatik konfor bölgelerindeki değişimin belirlenmesi amaçlanmıştır. Bu çalışma kapsamında, IPCC'nin 6. değerlendirme raporu olan Eşleştirilmiş Model Karşılaştırma Projesi Faz 6'nın SSPs 245 ve SSPs 585 senaryoları dikkate alınarak, Antalya'daki biyokonfor bölgelerindeki mevcut durum ve 2040, 2060, 2080 ve 2100 yıllarında olası değişimlerin belirlenmesi amaçlanmıştır. Sonuç olarak, Antalya'da konfor bölgelerinin 2100 yılına doğru genel olarak soğuktan sıcağa kayacağını, bu kaymanın önemli düzeyde olacağını ve en yüksek artışın nüfus yoğunluğunun yüksek ve turistik faaliyetlerin yoğun olduğu Antalya'nın güney bölgelerinde görüleceğini tespit edildi.

Anahtar Kelimeler: ETv, Radyasyon yoğunluğu, SSPs 245, SSPs 585, Sıcaklık-nem indeksi.

1. Introduction

In the rapid economic growth in the last 30-to-40 years in the world and the urbanization and industrialization process increased the need for energy and raw material and the activities performed for their production resulted in extraction of underground mineral resources and their use in industry as raw material [1-3]. As a result, the structure and composition of atmosphere have changed, and the CO_2 concentration has significantly increased in the atmosphere [4, 5]. This process caused global climate change through direct and indirect effects. Nowadays, the effects of global climate change can be seen everywhere, and it is estimated that the climatic anomalies would further increase [6-9]. As a result of climate change, the air temperature has been raised by almost 1 ºC in the 20th century and keeps increasing in this century [10], and environmental stresses and drought events have become more frequent and severe in natural habitat [11-15] arid and semi-arid regions, and marginal lands worldwide [16]. Urban areas are about 10 ºC warmer than adjacent rural surroundings because of heat islands [17].

Climate is a factor shaping the physiological development and characteristics, housing and house structures, food and cloth selections, and distribution of humans on the earth [18-20]. Since humans are warm-blooded organisms, they are significantly affected by external environmental conditions; the lives of humans depend on a specific range of climatic parameters [21, 22]. Humans feel comfortable at specific levels of climatic parameters such as temperature, humidity, and wind. The conditions meeting these criteria are named "bioclimatic comfort" or, in shortly, "biocomfort". Climatic parameters exceeding beyond these values considered comfortable may cause various problems such as anger, weariness, respiratory and circulatory problems, burning eyes, and dry throat [23, 24].

Hence, it is recommended for humans to live in places, which are suitable in terms of biocomfort, for health, performance, comfort, and peace. The peoples living in places, which are not suitable in terms of biocomfort, utilize various heating and cooling systems in order to adjust the microclimate conditions to the ranges that are suitable for humans. However, these systems cause important environmental damages and high levels of energy consumption. Thus, for the health, comfort, and happiness of humans and for energy efficiency, it is very important to determine the biocomfort zones and to plan the residential areas in this parallel [25-27].

Biocomfort conditions are shaped the climate parameters and the climate changes also alter the biocomfort zones. It can be stated that the global climate change might cause significant changes in biocomfort zones. Turkey, one of the countries to be affected by this change at most, is very sensitive to climate change and is one of the “countries under risk”; it is estimated that the annual temperatures will increase countrywide until year 2100 and the temperature increases might reach 6 ºC in several regions [9, 28, 29]. Hence, effort is made to calculate possible effects on the fields such as forestry, agriculture, and tourism and to develop strategies against future changes [30].

It is clear that climate change will cause important changes in climate parameters in near future and these changes will bring significant changes in biocomfort zones. However, no study examining how the biocomfort zones, which have an important role in urban planning studies, might change depending on the global climate change in the future. Thus, using the projected climate change scenarios, the present study aims to determine the changes in biocomfort zones in Antalya province, which is of significant important from both residential and touristic aspects.

2. Material and Method

Study Area

This study was carried out in Antalya, which is the fifth-largest city of Turkey. Antalya is a province that is widely preferred as a residential area for its geographical location and climatic and edaphic conditions. Besides that, since it is one of the most important hotspots for the tourists, it is considered as the capital city of tourism. For these reasons, population gradually increases, and it becomes a necessity to open new residential areas [31]. The geographical location of study area is illustrated in Figure 1.

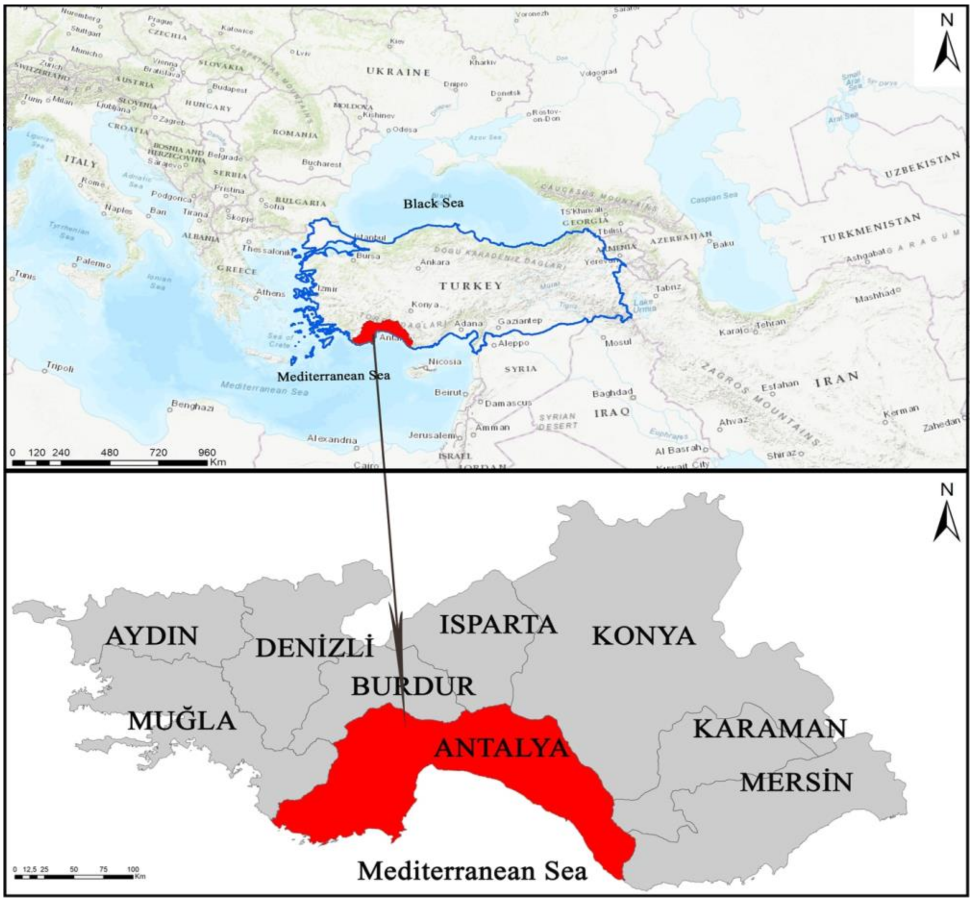

Figure 1. Geographic location of Antalya

Method

The global models among Coupled Model Intercomparison Project (Phase 6, CMIP6) that are prepared by the World Climate Research Programme (WCRP) are modified by IPCC in parallel with the recent events and used together with climate scenarios of IPCC [32]. CMIP6 in the 6th assessment report of IPCC (Intergovernmental Panel on Climate Change) was utilized in determining the scenarios used in this study.

The climate data obtained from the measurements made by 24 meteorology stations of the General Directorate of Meteorology between 2000 and 2020 were utilized in preparing the climate maps by using "Inverse Distance Weighted (IDW)" method. The future biocomfort maps were obtained by implementing the biocomfort indices formulas to the maps prepared using this method.

The base data to be used in such local or regional climate change and effect assessment studies were obtained from the data system of Department of Energy of Lawrence Livermore National Laboratory. These data allow the preparation of high-resolution (50 km resolution) climate projections. The climate data of CNRM-CM6-1 climate change model's SSPs 245 (an intermediate – radiative force is 4.5 W/m2) and SSPs 585 (the most extreme - radiative force is 8.5 W/m2) scenarios were downloaded in Netcdf file format. Then, these data were entered Arcmap 10.8 program and conversion procedures were performed. The mapping of data obtained was performed using the "Inverse Distance Weighted (IDW)" method which the simple equation of IDW is as follows:

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

X0 location, where the estimations are made, is the function of n, which is the adjacent measurements, [z(X0i) and i=1,2,…,n]; r is the exponent that identifies the assigned range of every observation, whereas d indicates to the distance among observation location Xi and estimation location X0. The assigned weight of observations distant from the estimation location declines with the increase in exponent. The increasing exponent means that estimations are very similar to the nearest observations. The mathematical formulas are as explained above. The climate maps were prepared with calculations made using ArcGIS software [33, 34]. Then, by implementing two different biocomfort formulas to the climate maps of each scenario, the biocomfort maps were obtained. These maps were created throughout the projection period, from today and 20-year intervals (2020, 2040, 2060, 2080, and 2100) until 2100.

First of these indices was DI (Temperature-humidity index (discomfort indices)) and applied as reported by Cetin et al. (2019) [35].

$$DI = T-(0.55-0.0055 \times RH) \times (T-14.5) \quad (2)$$

Where;

DI: Temperature-humidity indices (discomfort index);

T: Monthly mean temperature (°C);

RH: Relative humidity (%).

This study was carried out in Antalya, which is the fifth-largest city of Turkey. Antalya is a province that is widely preferred as a residential area for its geographical location and climatic and edaphic conditions. Besides that, since it is one of the most important hotspots for the tourists, it is considered as the capital city of tourism. For these reasons, population gradually increases, and it becomes a necessity to open new residential areas [31]. The geographical location of study area is illustrated in Figure 1.

Table 1. Classification of indices and thermal comfort for people [35].

Thermal comfort category for people	Index values (DI)
Extremely ice	< − 40.0
Freezing cold	− 39.9 to − 20
Extremely cold	− 19.9 to − 10
Very cold	− 9.9 to − 1.8
Cold	− 1.7 to + 12.9
Cool	13.0 to + 14.9
Comfortable	15.0 to + 19.9
Hot	20.0 to + 26.4
Very hot	26.5 to + 29.9
Extremely hot	> + 30.0

The second index used in this study is Effective Temperature taking wind velocity (ETv) and its implementation was explained as follows [36]:

$$ETv = 37–(37-T)/[0.68–0.0014RH+1/(1.76+1.4v0.75)]-0.29T(1-RH/100) \quad (3)$$

Where; T is dry bulb temperature (°C); RH is relative humidity (%); and v is wind speed (m/s).

Table 2. Categories of ETv values [36].

ET (°C)	Degree of Physiological Stress	Thermal Sensation
ET < 5	Extreme cold stress	Very cold
5 ≤ ET < 10	Extreme cold stress	Cold
10 ≤ ET < 13	Shivering	Moderately cold
13 ≤ ET < 16	Cooling of the body	Quite cool
16 ≤ ET < 19	Slight cooling of the body	Slightly cool
19 ≤ ET < 22	Contraction of blood vessels	Mild
22 ≤ ET < 25	Thermal neutrality	Comfortable
25 ≤ ET < 28	Slight sweating, Dilation of blood vessels	Warm
28 ≤ ET < 31	Sweating	Quite hot
31 ≤ ET < 34	Profuse sweating	Hot
ET > 34	Thermoregulatory failure	Very hot

Within the scope of the present study, the biocomfort maps of Antalya province were prepared using the data of existing meteorology stations first. Then, the climate parameter changes projected according to SSPs 245 and SSPs 585 scenarios of CNRM-CM6-1 model were added to current data and how the biocomfort zones in Antalya province will be shaped if these scenarios take place was identified by making use of ID and ETv indices.

3. Results

Models Developed Using DI Method

The map illustrating the future situation of biocomfort zones of Antalya province in years 2020, 2040, 2060, 2080, and 2100 by using DI method according to SSPs 245 and SSPs 585 scenarios is presented in Figure 2. The numeric values of regions mapped in Figure 2 are presented in Table 3.

As a result of the calculations made using DI method, it was determined that the comfort zones will increase in the province in general according to both of SSPs 245 and SSPs 585 scenarios. Today, the province consists of 40.78% cold, 29.74% cool, and 29.39% comfortable zones but not hot zone. As a result of the calculations made using SSPs 245 scenario, the province in 2040 will consist of 27.92% cold, 35.36% cool, and 36.72% comfortable zones. In year 2060, the province will consist of 5.30% cold, 34.91% cool, 59.58% comfortable, and 0.21% hot zones. In year 2080, the province will consist of 16.80% cold, 36.65% cool, and 46.55% comfortable zones, whereas the projections made for the year 2100 indicate that the composition of province will be 6.28% cold, 36.27% cool, 57.29% comfortable, and 0.26% hot zones. Given the calculations made according to SSPs 245 scenario, it was determined that comfortable zones will constitute approx. 60% of the province.

Considering the SSPs 585 scenario, the calculations showed that the province in year 2040 will consist of 28.81% cold, 33.20% cool, and 37.99% comfortable zones, whereas the composition in year 2060 will be 6.90% cold, 35.62% cool, 57.13% comfortable, and 0.34% hot zones. In year 2080, the province is projected to consist of 1.14% cold, 13.95% cool, 81.27% comfortable, and 3.64% hot zones. For the year 2100, the province will consist of 1.53% cold, 76.61% cool, and 21.86% comfortable zones. As a result of the calculations performed, it is projected that there will be no cold zone in year 2100 in the province according to SSPs 585 scenario and comfortable zones will constitute approx. three-fourths of province and hot zones are projected to constitute one-fifth of province.

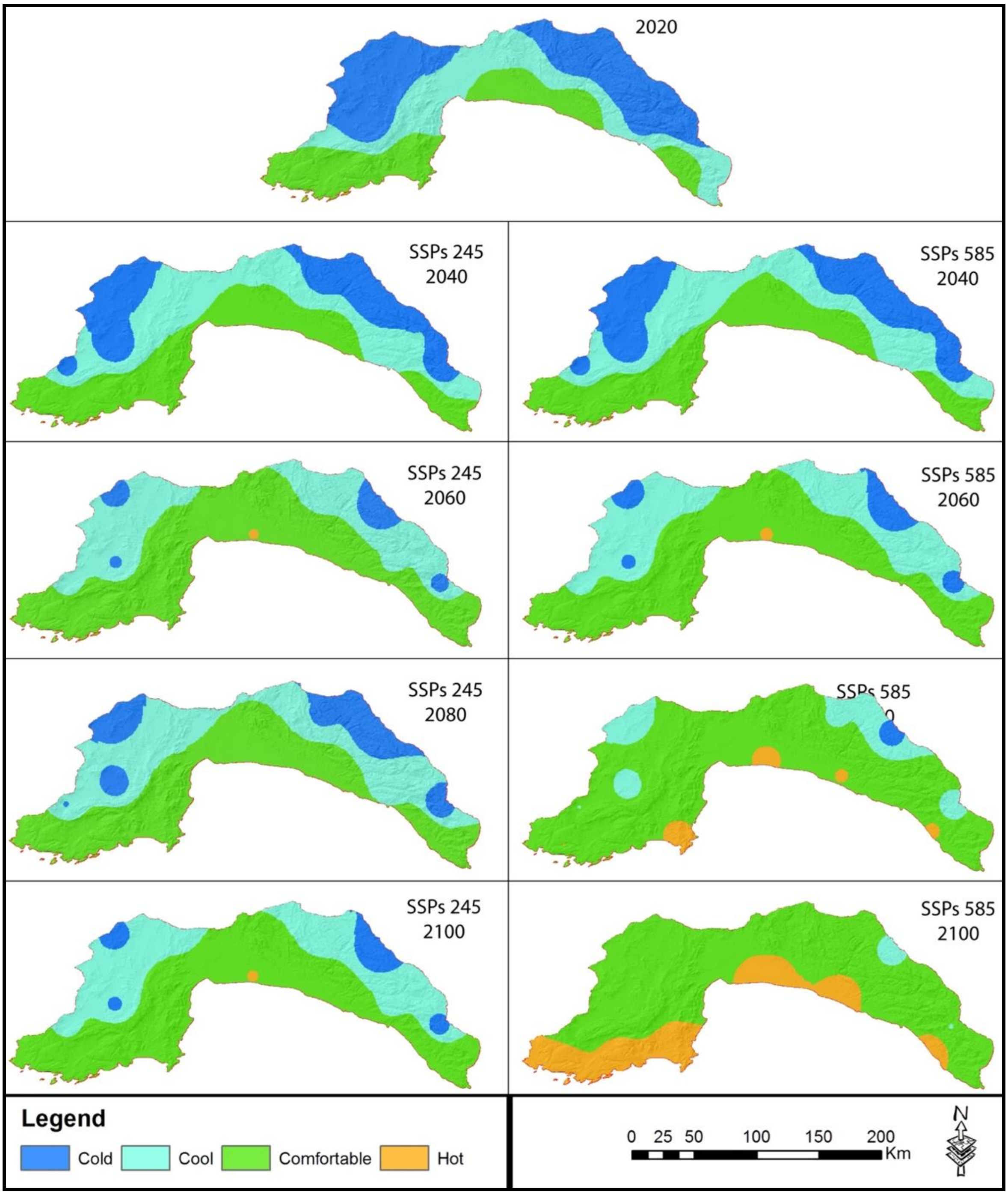

Figure 2. Models created using DI method

Table 3. The numeric values of current and future status of suitable areas mapped given in Figure 2 under the SSPs 245 and SSPs 585 scenarios.

Scenario	Spatial Distribution	Relevance	Years				
			Today	2040	2060	2080	2100
SSPs 245	Hectare (Ha)	Cold	28597.0	19539.0	3710.0	11753.0	4392.0
		Cool	20814.0	24743.0	24427.2	25648.0	25314.0
		Comfortable	20568.0	25697.0	41693.0	32578.0	40094.0
		Hot	-	-	149.0	-	179.0
	Percentage (%)	Not suitable	40.87	27.92	5.30	16.80	6.28
		Suitable	29.74	35.36	34.91	36.65	36.17
		Very Suitable	29.39	36.72	59.58	46.55	57.29
		Hot	-	-	0.21	-	0.26
SSPs 585	Hectare (Ha)	Cold	28597.0	20159.0	4830.0	801.0	-
		Cool	20814.0	23233.0	24930.0	9760.0	1071.0
		Comfortable	20568.0	26587.0	39979.0	56873.0	53610.0
		Hot	-	-	240.0	2545.0	15298.0
	Percentage (%)	Not suitable	40.87	28.81	6.90	1.14	-
		Suitable	29.74	33.20	35.62	13.95	1.53
		Very Suitable	29.39	37.99	57.13	81.27	76.61
		Hot	-	-	0.34	3.64	21.86

Models Created Using ET*v* Method

The map illustrating the future situation of biocomfort zones of Antalya province in years 2020, 2040, 2060, 2080, and 2100 by using ETv method according to SSPs 245 and SSPs 585 scenarios is presented in Figure 3. The numeric values of regions mapped in Figure 3 are presented in Table 4.

As with the DI method, the calculations made using the ETv method showed that, according to SSPs 245 scenario, the comfortable zones will increase until the year 2060 and, after a decrease in 2080, they will further increase in 2100. According to SSPs 585 scenario, it was determined that the comfortable zones will increase until 2060 but then decrease. The province currently consists of 0.19% moderate cold, 12.19% quite cold, 32.94% slightly cool, 43.06% mild, and 11.13% comfortable zones. Based on the calculations made according to SSPs 245 scenario, it is projected that the province in year 2040 will consist of 1.82% quite cool, 38.99% slightly cool, 44.52% mild, and 14.67% comfortable zones. In year 2060, the province is estimated to consist of 0.91% quite cool, 15.60% slightly cool, 45.40% mild, and 33.20% comfortable zones, whereas warm zones are projected to cover 4.89% of province. For the year 2080, the projected composition is 0.74% quite cool, 31.14% slightly cool, 44.84% mild, 23.07% comfortable, and 0.21% warm zones. In the year 2100, the province will have 19.13% slightly cool, 46.46% mild, 31.70% comfortable, and 2.71% warm zones.

Given the calculations made using SSPs 585 scenario, the province is projected to consist of 16.73% slightly cool, 44.55% mild, 37.59% comfortable, and 1.13% warm zones in 2040 and 9.36% slightly cool, 49.33% mild, 39.50% comfortable, and 1.80% warm zones in 2060. Moreover, the projections showed that the province will consist of 9.62% slightly cool, 46.75% mild, 37.54% comfortable, and 6.09% warm zones in 2080 and 28.91% comfortable, and 53.62% warm zones and 17.46% hot zones, which have not existed before, in year 2100. According to SSPs 585 scenario, there will be no moderate cool and quite cool zones until 2080 and the slightly cool and mild zones will disappear in until 2100.

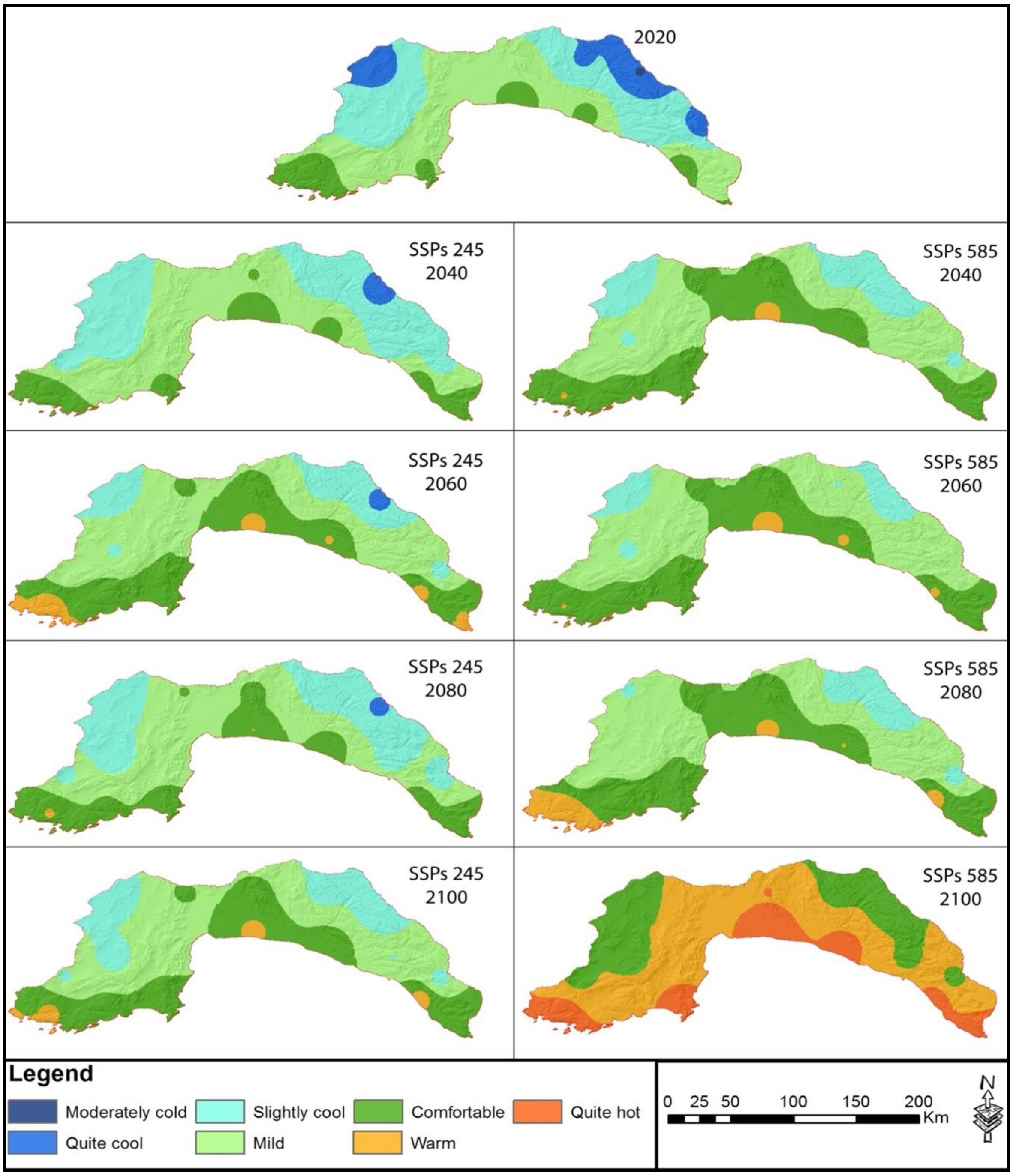

Figure 3. Models created using ET*v* method

Table 4. The numeric values of the current and future status of suitable areas mapped given in Figure 3 under the SSPs 245 and SSPs 585 scenarios

Scenario	Spatial Distribution	Relevance	Years				
			Today	2040	2060	2080	2100
SSPs 245	Hectare (Ha)	Moderate Cold	130.0	-	-	-	-
		Quite Cool	8602.0	1272.0	637.0	521.0	-
		Slightly Cool	23050.0	27282.0	10917.0	21790.0	13388.0
		Mild	30131.0	31157.0	31770.0	31376.0	32512.0
		Comfortable	8066.0	10286.0	23230.0	16142.0	22180.0
		Warm	-	-	3425.0	150.0	1899.0
	Percentage (%)	Moderate Cold	0.19	-	-	-	-
		Quite Cool	12.19	1.82	0.91	0.74	-
		Slightly Cool	32.94	38.99	15.60	31.14	19.13
		Mild	43.06	44.52	45.40	44.84	46.46
		Comfortable	11.53	14.67	33.20	23.07	31.70
		Warm	-	-	4.89	0.21	2.71
SSPs 585	Hectare (Ha)	Moderate Cold	130.0	-	-	-	-
		Quite Cool	8602.0	-	-	-	-
		Slightly Cool	23050.0	11708.0	6552.0	6731.0	-
		Mild	30131.0	31176.0	34520.0	32717.0	-
		Comfortable	8066.0	26306.0	27645.0	26269.0	20234.0
		Warm	-	789.0	1262.0	4262.0	37524.0
		Hot	-	-	-	-	12221.0
	Percentage (%)	Moderate Cold	0.19	-	-	-	-
		Quite Cool	12.19	-	-	-	-
		Slightly Cool	32.94	16.73	9.36	9.62	-
		Mild	43.06	44.55	49.33	46.75	-
		Comfortable	11.53	37.59	39.50	37.54	28.91
		Warm	-	1.13	1.80	6.09	53.62
		Hot	-	-	-	-	17.46

4. Discussion and Conclusion

Study results showed that, according to both methods and scenarios, significant changes would occur in the biocomfort zones of Antalya province due to global climate change. The temperature increase will cause a shift from cold to hot, and the hot zones will significantly increase in 2100. The temperature increase will be felt from north to south and reach a remarkable level on the southern side of province.

This study suggests that global climate change will significantly affect biocomfort. These findings show that a significant risk is coming. Given the maps created within the scope of this study, it can be stated that significant temperature increases will occur in Antalya, especially in the southern region, until the year 2100, and warm and hot zones will form in these regions. The first point drawing attention here is that the regions with a high level of temperature increase are those with high population density and are important, especially for summer tourism. Temperatures further increase in the city centers due to the buildings, hard surfaces, cooling systems, vehicles, and human activities, and the mean temperatures in heat islands show up to reach much higher levels [27, 37]. Hence, it can be stated that the mean temperatures will reach much higher levels in regions having the highest population density.

Another point to consider is that the values obtained here were calculated using the annual mean meteorological data. According to the mean values of the whole Antalya province for the period 1930-2020, the annual mean temperature was 18.8 °C, whereas the mean temperatures were 25.3 °C in June, 28.5 °C in July, and 28.4 °C in August [38]. Thus, the temperature increase will reach significant levels in the summer months, which are important for tourism, and it will negatively affect touristic activities.

The results obtained showed that the comfort zones will shift from cold to hot until the year 2100, that the change will be at a remarkable level, and that the highest level of changes will be observed in regions with both high population density and touristic activities. Considering that the temperatures are already very high in the summer, and people need air-conditioning systems in the summer season, it is projected that this need and use of air-conditioning systems will increase much more in the future. This will result in a high level of energy consumption. It is estimated that worldwide energy consumption will increase by 60% in 2030, and it will double in our country. Given the fact that the population will increase only by 1% in this period, it can be understood how high the increase in energy consumption will be [39-41]. The air-conditioning systems needed to adjust the microclimate conditions to levels suitable for humans are very important for energy consumption and costs. Moreover, the production to be made to meet the energy need may cause an increase in carbon release, and it may accelerate global climate change [25].

The temperature increase will cause changes affecting all the organisms, besides the changes in biocomfort zones for humans. Climate is one of the most important factors affecting the living conditions of organisms, and all the phenotypic characteristics of organisms are shaped by the mutual interaction between genetic structures [42, 43] and environmental variables [39, 44, 45]. The climatic factors are the most important factors influencing plant development and their distribution on the earth [43, 46, 47], and climate changes, directly and indirectly, affects all organisms. Hence, it is projected that the global climate change might have destructive and irreversible effects on the organisms and ecosystems, cause climate-dependent natural events such as forest fires, drought, floods, desertification, and erosion, and increase the ecological degradation rates and the most important effects will be the temperature increase and the decrease in water resources [18, 48-50]. Climate change is an effective result in the ecosystem's distribution and function and will shape the ecosystem's reactions to habitat changes [9, 51, 52]. The change in temperature and precipitation regime will increase the frequency of biotic damages such as insects and fungus and abiotic damages such as forest fires and floods [47, 53, 54].

It was reported that the most destructive effect of global climate change would be on the plants, which have no effective migration mechanism. Climate changes endangering the ecosystem continuity cause reactions among trees such as adaptation to climate, local adaptation, migration, and loss of life [55, 56]. Furthermore, besides the adverse effects such as invasion by foreign species, it was also reported that climate change would slow down the growth of several species, and it might have significant effects on the carbon balance of tropical forests [57]. It was stated that the projected increase in heavy rainfalls would bring uncertainties in food cycles, soil fertility, and food flows in the medium- and long-run [58]. Hence, it is emphasized that many plant species will not be able to adapt to the effects that occur depending on the climate change, and it might cause many problems such as the extinction of several species (especially the rare and endemic ones), ecosystem losses, and loss of biodiversity [9].

The negative effects of climate change on the ecosystem will also negatively affect the lives of humans, a part of the ecosystem, and the destructive effects of climate change on food and water resources, which are very important for the human life, will cause difficulties in access to those resources and it will significantly and irreversibly affect the lives of humans [8]. For this reason, considering the result of the present study from various perspectives, it can be stated that the results obtained for Antalya province will be observed in similar ways throughout the world, and the changes that will significantly affect the lives of all organisms in the world may occur in a short period.

5. Suggestions

The results of present study suggest that significant changes will occur in the biocomfort zones in Antalya province in near future, that this change will be in form of general warming, that the comfort zones will shift from cold to hot towards 2100, and that the highest level of temperature increase will occur in the regions with the highest population density and intense touristic activities. This finding can be interpreted in the way that the use and cost of cooling systems in order to ensure the suitable comfort conditions will increase. Cooling systems are systems that contribute to the increase in global climate change due to their energy consumption and use of gases and the increase in temperature will cause these systems to be used more and the higher level of use of these systems will cause a higher level of temperature increase.

Many studies reported that the global climate change will have direct or indirect effect on the entire world. Of course, the most effective method for avoiding these effects is to slow down the climate change first and then to stop it. However, it seems not possible. In this case, the most effective defense mechanism against the global climate change is to predetermine the possible changes and to take the required measures. Local and regional measures play an important role in the conflict with negative effects of global climate change. In this study, it is projected that, throughout the province of Antalya, the comfort zones will shift from south to north. Hence, the northern settlement areas should be planned for the new settlement plans in this province.

The results obtained in this study suggest that the uncomfortable zones will increase in the areas with high population density. Considering that the buildings, impermeable surfaces, vehicles, and human activities and, consequently, the mean temperature will be at a higher level in these regions, the regulations should be immediately made in accordance with these factors. It might be recommended to increase the green areas within the city, replace the hard grounds reflecting the light with grass or any more suitable hard grounds, establish rooftop gardens, sheath the outer surfaces of buildings with suitable materials, and prioritize the green-building problem. In order to minimize the effects of global climate change in medium- and long-run, it can be recommended to minimize the fossil fuel consumption, take measures decreasing the use of vehicles (developing public transportation systems, planning cycle roads, and increasing electric vehicles, etc.), and increase the use of renewable energy resources. Furthermore, it is known that the most significant effects of this process will be on the water, which is an essential source for life. Hence, it is necessary to save water, decrease the factors polluting the waters, and use wastewaters for agricultural purposes by recycling them.

Competing Interest / Conflict of Interest

The authors declare that they have no competing interests.

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