Tourism Climate Index under Climate Change Scenarios: Aegean and Mediterranean Regions

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Abstract: All technological developments aim to provide individuals with a more comfortable life. Thermal comfort, consisting of climatic conditions in which heat exchange between the human body and the environment is balanced, gains importance in planning studies. In this study, the most suitable time for sea tourism in the Mediterranean and Aegean regions and how the most suitable tourism areas will change with climate change are modelled using the Tourism Climate Index (TCI). The model uses the mean temperature, relative humidity, total precipitation, and wind data produced for the present and future. The results show that in the present situation, tourism climate is comfortable for the whole region between April and November; however, in the future scenario, according to Shared Socioeconomic Pathway SSP5-8.5, 70% of the area will be uncomfortable for tourism activities from June to August. These results will significantly contribute to creating a climate-based tourism strategy for Turkey.

Keywords: Thermal comfort, climate change, tourism climate, tourism planning, Mediterranean Turkey

1 Introduction

Evaluation of thermal comfort in tourism planning can provide information for tourists and tourism operators choosing destinations. Understanding how climatic conditions develop for tourism is becoming increasingly important for strategic planning in a changing climate, especially in rapidly developing tourism destinations such as the Mediterranean and Aegean regions in Turkey. Adverse environmental conditions caused by global climate change are factors that will affect the thermal comfort situation.

Since the 1950s, tourism has experienced rapid growth, driven by socioeconomic changes such as increased leisure time and wealth and factors such as accessible means of transport. Tourism is currently one of the largest economic sectors worldwide, and international tourism flows are unevenly distributed among different regions in the world. Europe is currently the world's leading destination with a 53% market share. The popularity of the Mediterranean is a dominant factor in Europe's leading position. The Mediterranean has become an important regional destination, leaving all other world regions such as the Americas behind. Most international arrivals to the Mediterranean come from Europe itself, particularly Northern Europe. Including the historical attractions and cultural riches in the southern countries ensures the flow of tourists from the north to the south. However, the number one factor is the search for warm air and sunshine by the sea, which makes the beach one of the main attractions of the Mediterranean. Thus, climatic conditions, hotter summers and winters, and extreme weather events (such as floods, floods, tornadoes) will affect tourism. Service quality, demand patterns and costs will change.

For tourism, climate as a resource is multifaceted and includes the complexity of weather variables (FREITAS et al. 2008), so choosing an appropriate index to assess climate is crucial. In addition, specific outdoor tourism themes, especially ski tourism or beach tourism with

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their unique climatic requirements, are highly sensitive to weather conditions (DUBOIS et al. 2016). These requirements require climate assessment indices for tourism. In the last 30 years, many tourism climate indices have been proposed and developed. MIECZKOWSKI (1985) was the first to devise a Tourism Climate Index (TCI) on composite tourist activity. It is mainly due to integrating climate aspects (thermal and physical) and widespread availability and applicability to evaluate a destination's current conditions and potential (HUANG et al. 2019) and assess future climate conditions (SCOTT & MCBOYLE 2001).

Tourism is not a sector that takes part in international commitments to combating climate change. However, climate determines many factors such as biodiversity, coastal areas, natural life, food and water quantity and quality, forest areas, snowfalls that provide input to tourism (UNWTO et al. 2007). Therefore, climate change will affect the spatial distribution of tourism, the timing of travels and the duration of stay with the pressure it will create on the ecosystem. Sectors and destinations may also be sensitive to climate change; the type, duration, service quality and even the expenditures of the tourist and the cost of the service may be affected. The economic and social returns of the sector may decrease as unexpected extreme weather events will cause uncertainty for tourists and service providers. The destructions that climate change will cause in water, biological diversity, historic and natural environment and health will change the attraction centres. Expectations may not be met, especially in branches related to natural conditions, such as sea and ski tourism. This strong connection mentioned above requires establishing adaptation policies to prevent the sector from adversely affecting climate change. The Joint Research Center of the European Union (PESATA) 's report stating the possible effects of climate change on the economic sectors in Europe emphasizes that the TCI evaluation is made according to the potential temperature increase scenarios in Europe, North Africa and most of Turkey in 2020 and 2080. The vulnerabilities of these areas in terms of the tourism sector should be assessed. It is generally advocated to use various global circulation model scenario combinations to express uncertainty in future forecasts (UNWTO et al. 2007). To be assessed the impact of climate change on tourism climate and thermal comfort, SSP5-8.5 (Fossil-fueled Development – Taking the Highway (High challenges to mitigation, low challenges to adaptation)) scenario according to the 6th Assessment Report (AR6) of the Intergovernmental Panel on Climate Change for 2061-2080 years has been selected. In this study, long-term present data (1991-2010) interpolated from 110 climate stations and the data of SSP5-8.5 (downscaling from HadGEM3-GC31 to RegCM4) determined in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) covering the period 2061-2080 were used in the calculation of TCI.

2 Materials and Methods

2.1 Study Area

The study area is in the south and southwest of Turkey, and it is important for tourism activities around the year (Fig.1). Its uniquely beautiful scenery, starting from the west of Turkey and extending to the Syrian border, includes mountains, canyons, coasts, coves and beaches. The more famous the region is for its sun, sea-track and entertainment, the richer it is in culture and faith tourism. The presence of many ancient city ruins in the Aegean and Mediterranean regions provides opportunities for all kinds of tourism activities. The terrain is quite

mountainous and rugged. The mountains are perpendicular to the sea in the Aegean region, allowing the mild climate to penetrate the interior. The Taurus Mountains determine the landforms parallel to the coast in the Mediterranean region and cause the hot weather between the mountains and the sea. Summers in this climate are hot and dry. Winters are warm and rainy. However, continental climate can be seen towards the inner parts of the area. On the slopes of the mountains facing the sea, there is a climate type covered with maquis and high forests in places, and the pits behind them, where terrestrial effects increase. The average of the hottest month is 27-28 °C on the coast and 23-25 °C in the interior; while the average of the coldest month is around 10 °C on the coast, it drops to 1.5-2 °C in the interior. The comfortable climatic conditions, natural beauties and historical riches in the coastal part of the region have contributed to tourism development.

Fig. 1: Study area

The calculation of the TCI index is based on climate data. This study obtained historical and future climate data from the Copernicus Climate Change Service. Future climate data is based on the framework of the sixth phase of the Coupled Model Intercomparison Project (CMIP6). CMIP6 data underpins the Intergovernmental Panel on Climate Change 6th Assessment Report. Climate projection experiments combine the Shared Socioeconomic Pathway (SSP) and the Representative Concentration Pathway (RCP) under CMIP6. The Hadley Global Environment Model (HadGEM3-GC31), model data developed by the Hadley Center, a research institution affiliated with the British Meteorological Service (Met Office), was used in this study.

2.2 Methods

The most important factor in coastal and sea tourism is the climate-destinations where climate comfort conditions are suitable to become important attraction centres with these advantages. In this study, the effects on tourism under climate change scenarios (SSP5-8.5) will be examined in terms of climate comfort in the 2061-2080 periods. These changes in climate comfort will be modelled with the TCI. TCI summarises the ratings of five human comfort indexes related to leisure tourism. TCI has proposed an index that relates general findings of

human comfort to specific activities related to recreation and tourism (AMELUNG & MORENO 2009). This index summarizes and aggregates seven climate variables that affect climate suitability for outdoor tourism.

This study examined 1991-2010 and 2061-2080 (SSP5-8.5) on tourism climate comfort. These changes in climate comfort are modelled with the TCI. TCI is created by calculating five human comfort indexes related to sightseeing tourism according to equality. The values used here are standardized to the scale by MIECZKOWSKI (1985) (Table 1).

$$TCI = 8 * CID + 2 * CIA + 4 * R + 4 * S + 2 * W$$

In this equation, CID (Daytime comfort index); a calculation of the ratios of maximum temperature and minimum relative humidity, CIA (Daily comfort index); a calculation of the ratios of average temperature and average humidity, P (Precipitation); a calculation of total precipitation, S (Sunshine); represents a calculation consisting of the ratio of total sunshine durations, and W (Wind) represents a calculation consisting of the ratio of average wind speeds. Each parameter is scaled between -3 and 5 (Table 1).

Table 1: TCI rating system (modified from MIECZKOWSKI 1985, MCBOYLE & SCOTT 2007)

Rates	Effective temperature (°C)	Mean Monthly Precipitation (mm)	Insolation variable (hour)	Wind speed (m/s)		
				Normal system (15 – 24 °C)	Trade system (24 – 33 °C)	Hot climate system (>33 °C)
5.0	20 – 27	0.0 – 14.9	9 – 9.59	<0.79	3.40 – 5.49	
4.5	19 – 20 27 – 28	15.0 – 29.9	8 – 8.59	0.80 – 1.59		
4.0	18 – 19 28 – 29	30.0 – 44.9	7 – 7.59	1.60 – 2.50	2.51 – 3.39 5.50 – 6.74	
3.5	17 – 18	45.0 – 59.9	6 – 6.59	2.51 – 3.39		
3.0	15 – 17	60.0 – 74.9	5 – 5.59	3.40 – 5.49	1.60 – 2.50 6.75 – 7.99	
2.5	10 – 15	75.0 – 89.9	4 – 4.59	5.50 – 6.74	0.80 – 1.59	
2.0	5 – 10	90.0 – 104.9	3 – 3.59	6.75 – 7.99	<0.79 8.00 – 10.70	<0.79
1.5	0 – 5	105.0 – 119.9	2 – 2.59			0.80 – 1.59
1.0	-5 – 0	120.0 – 134.9	1 – 1.59	8.00 – 10.70		1.60 – 2.50
0.5		135.0 – 149.9	<1			2.51 – 3.39
0.0	-10 – -5	>150.0		>10.71		>3.40
-1	-15 – -10					
-2	-20 – -15					
-3	<-20					

The numerical values obtained from TCI are categorized in determining the effects of climate on tourism activities. In the classification, values below 50 are not suitable for tourism, while values between 50-59 are acceptable for tourism comfort and values between 90-100 are considered ideal.

3 Results and Discussion

Tourism-based climatic comfort conditions for the Mediterranean and Aegean regions were estimated according to TCI. The calculations produced monthly TCI data for the current (1991-2010) and future (2061-2080, SSP5-8.5) periods using the temperature, relative humidity, precipitation, sunshine duration, and wind speed parameters. By evaluating all the variables, tourism climate comfort classes were categorized as "unsuitable (below 50)", "acceptable (50-59)", "good (60-69)", "very good (70-79)", "excellent (80-89)" and "ideal (90-100)". Their spatial distribution was determined according to current and future TCI values (Fig. 2).

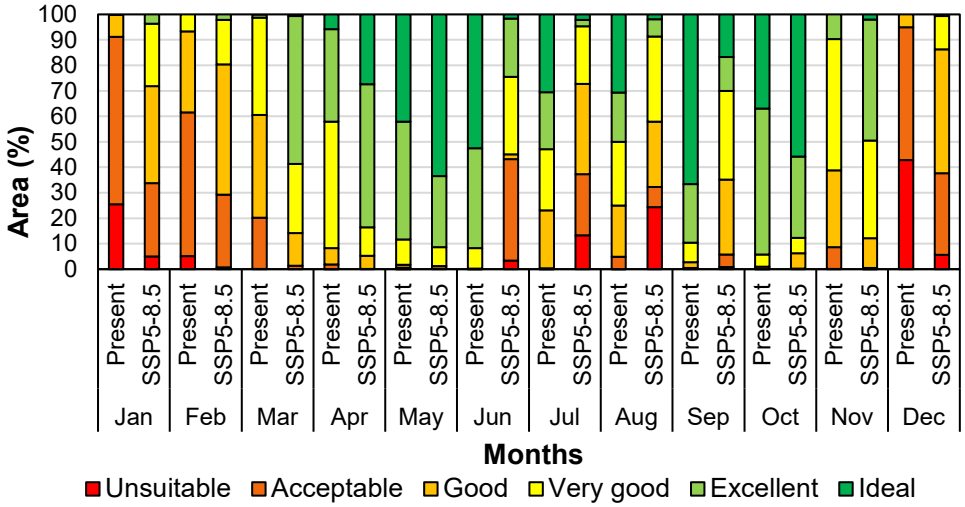

Fig 2: Spatial distribution of present (1991-2010) and future (SSP5-8.5 Scenarios 2061-2080) TCI categories on a monthly basis

When the results are evaluated according to TCI categories, while 26% of the area is unsuitable, 5% will be unsuitable in the SSP5-8.5 scenario in January because the air temperature increases in the future during cold periods. The TCI in the SSP5-8.5 scenario will be higher than in the present situation from January to May. However, between June and September, this situation will be vice-versa. Between June and September, the ideal comfortable area will decrease from 45% to 6%. Results show that climate change would negatively affect tourism thermal comfort during the summer months. Moreover, TCI will also increase the future climate change scenario from October to December. There is no ideal TCI area for the study area between November and March.

In the monthly evaluations of the current situation, the tourism comfort is comfortable for the whole region in April-November. However, in the SSP5-8.5 scenario, 70% of the area will be uncomfortable for tourism activities in June-August. The diversity of tourism activities in these months has also increased the importance of this period. In addition, the comfort level is “good” and “very good” increases the region's tourism potential, where tourism activities can be carried out for long periods in the summer period. For this purpose, activities carried out in areas with “good” comfort levels during the summer should be supported and diversified for this purpose. Therefore, making the climatic comfort conditions based on tourism in all provinces will contribute significantly to Turkey's tourism strategy.

The present situation shows that coastal areas and low-altitude areas have high tourism comfort. However, according to the SSP5-8.5 scenario, it is seen that the comfort situation will decrease especially in Antalya and Adana provinces for the years between 2061 and 2080 and the comfort will increase in the high-altitude areas. On the contrary, the future TCI will increase in the northern Aegean coastal areas (Fig 3).

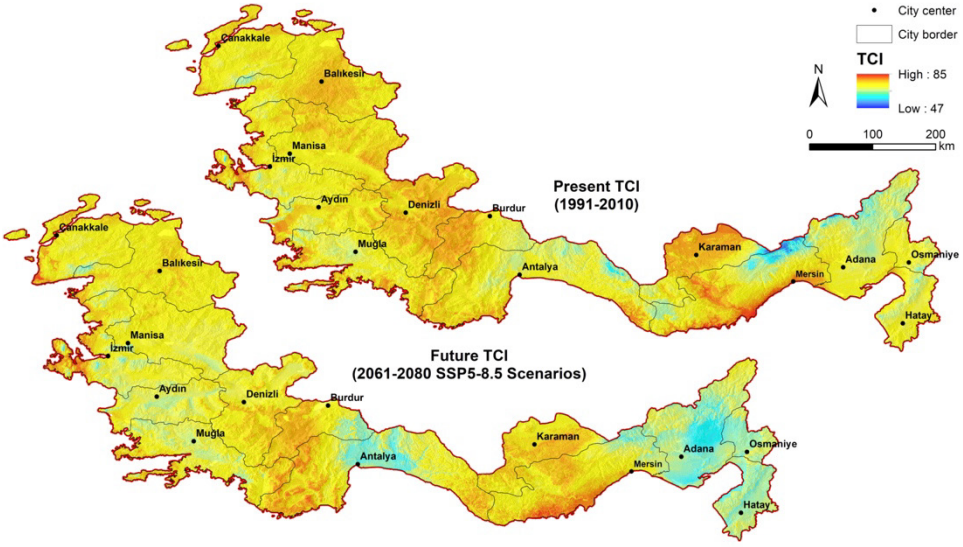

Fig 3: Spatial distribution of present (1991-2010) and Future (SSP5-8.5 Scenarios 2061-2080) TCI categories on a monthly basis

TCI difference map between future and present indicates that tourism comfort will increase up to one category class in green areas while decreasing it to one category class in red areas (Fig 4). Adana, Mersin, Hatay (Eastern Mediterranean), Antalya (Central Mediterranean), Muğla and Aydın (Southwest Aegean parts) are the provinces with the highest TCI decrease. However, green areas are high altitude areas and they will become more comfortable for tourism due to the increase of future temperature. As a result, when the impact of climate change is evaluated on a yearly basis, it is seen that the most negative effect will be on the low-altitude southern coasts.

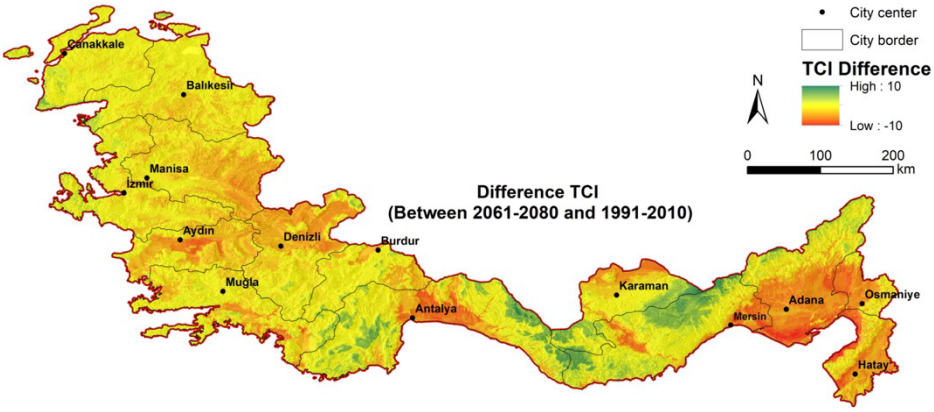

Fig 4: TCI Difference Map based on Present (1991-2010) and Future scenarios (SSP5-8.5 Scenarios 2061-2080)

It has been used in many studies to measure the effect of climate on the preferability of tourism destinations and to determine ideal climate coefficients. Previous studies on beach activities stated that temperature and sunlight are the most important climate components, after not rainy and windy days. This situation validates the order of different climate variables used in TCI. TCI is not specialized for a particular type of activity, making it suitable for macro-level analysis of potential climatic availability changes due to climatic conditions (AMELUNG et al. 2007). ROSSELLÓ-NADAL (2014) states that TCI is a good predictor for tourist numbers, as it correlates strongly with current popular destinations. Other studies have focused on determining TCI according to certain types of activities. MORGAN et al. (2000) attempted a calibration procedure using field surveys in beach environments in Wales, Malta, and Turkey to modify the TCI index to identify better sun-sand-sea (3S) tourism specifically.

4 Conclusion and Outlook

Mediterranean and Aegean Regions are well-known and developed tourism regions in Turkey. According to the Turkey Climate Change Action Plan, this study aimed to determine how the tourism comfort changes in future thermal conditions and evaluate these data in spatial planning. It is expected that climate change and adaptation processes will create significant vulnerabilities that will create different dimensions and types of results on cities and tourism sectors. In particular, the Aegean and Mediterranean regions will be greatly affected by climate change. The increase in intense domestic and foreign tourist movements in these regions will make the impact of climate changes more exposed in the tourism sector in the future. Accordingly, there is a need for climate change adaptation approaches regarding the tourism sector and spatial planning in the plans, policies, and reports on climate change. In this context, the importance of climate change for the tourism sector and the usability of spatial planning as a tool have been revealed and will guide local stakeholders.

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