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Sustainability of beach tourism in Türkiye in the era of climate change

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Beach Tourism,
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ABSTRACT

Tourism is vulnerable to climate change. Türkiye is one of the leading tourism destinations. Beach tourism, based on the trio of sea, sun, and sand, is the main type of tourism in Türkiye. Climatic comfort in a destination is important for tourism attractiveness. Knowing how climate change will affect tourism is very important for the sustainability of the tourism sector. Therefore, applying climate indices to beach tourism in order to accurately evaluate climate conditions today and in the future is very important for the sustainability of tourism. In this study, to determine the impact of climate change on beach tourism the Climate Index for Tourism (CIT) is applied. CIT is specifically designed for beach tourism. Data is gathered from the Copernicus Climate Change Service (C3S). Both historical observations and future climate projections are used. Considering the net zero targets of greenhouse gas emitter countries, only Representative Concentration Pathways (RCP) 4.5 scenario is implemented. Panoply software is used to visualize CIT maps. The future of beach tourism in Türkiye is evaluated for near (2021-2040), mid (2041-2060) and late-century (2081-2100). As a result, it has been shown that the Mediterranean and Aegean coasts will continue to be suitable for beach tourism in the summer. In the late century, due to warming temperatures, ideal conditions may shift to acceptable on the Mediterranean coasts. On the other hand, the CIT scores of the Black Sea shores will be lower and only part of this region will have acceptable climatic conditions under the RCP 4.5 scenario. The coastlines around the Marmara Region will represent a transition between the Aegean and Black Sea coasts.

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1. Introduction

Tourism causes climate change by employing greenhouse gas emissions and suffers from climate change due to weather changes, water scarcity, travel pattern changes, etc. (Leal Filho *et al.*, 2023). Moreover, tourism is a major contributor to national economies especially among the Mediterranean countries like Türkiye. Therefore, the impacts of climate change will negatively affect the national economies (Leal Filho *et al.*, 2023; Mejjad *et al.*, 2022). The Turkish tourism sector has faced many unexpected situations in the last few years. Many tourists have had to change their destinations due to the Türkiye-Russia aircraft crisis, the problems that started with the pandemic, the war between Russia and Ukraine, economic uncertainties, natural disasters, and climate change. For example, the economic embargo after the aircraft crisis caused a decrease in tourist arrivals from Russia to Türkiye (Aydınbaş & Tabak, 2020). The Covid-19 pandemic resulted in up to 99% reduction in foreign tourist arrivals to Türkiye in April-May of 2020 in Türkiye (Zeydan & Gürbüz, 2020). Forest fires in Marmaris (Muğla, Türkiye) in 2021 brought about 70% economic loss to tourism businesses (Coşandal & Partigöç, 2022). On the other hand, the detrimental impact of climate change on tourism is long-lasting. The effects of climate change have raised concerns about the sustainability of tourism. For this reason, the relationship between tourism and climate change is among the most important issues in the World and Türkiye (Demiroglu *et al.*, 2020). Climate is the long-term expected weather conditions at a given location (Moghari, 2012). Nowadays, our climate is changing due to anthropogenic effects. Burning fossil fuels (coal, oil, and natural gas) caused increasing greenhouse gas (GHG) concentrations in the atmosphere (Wang *et al.*, 2023). This phenomenon enhanced the greenhouse effect and caused the warming of the entire planet (Moghari, 2012). Warming resulted in changes in climatic factors (temperature and precipitation patterns etc.). The adverse impacts of climate change are increased temperatures, extreme weather events, floods, drought, desertification, forest fires, sea level rise, decreased agricultural productivity, decreased freshwater resources, and melting of glaciers (Wang *et al.*, 2023). Due to these climatic

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disasters, socioeconomic systems, human security, health, and well-being will be ultimately affected (Yokohata *et al.*, 2019). For example, difficulties in accessing food, extreme weather events, and forest fires will negatively impact tourism activities (Aygün Oğur, 2022). Tourism is climate climate-dependent sector and will be a significant victim of climate change (Pang *et al.*, 2013). Tourism makes a significant socioeconomic contribution to established and developing destinations in the Mediterranean basin (Kaya & Güngör, 2022; Mejjad *et al.*, 2022). The International Panel on Climate Change (IPCC) has classified the Mediterranean Region as highly vulnerable to climate change (Bafaluy *et al.*, 2014).

Türkiye is one of the leading tourism destinations (Cinar *et al.*, 2023). In 2023, Türkiye ranked fourth in the world (UNWTO, 2024) with foreign 56,693,837 tourist arrivals. For the same year, Türkiye's tourism revenue increased by 16.9% compared to 2022, reaching 54.3 billion dollars. This contributed to 5.1% of gross domestic product (TÜROFED, 2024). Türkiye has a wide range of tourism types including beach tourism, winter tourism, health and thermal tourism, congress tourism, golf tourism, yachting, air sports, rafting, underwater diving, mountaineering, hunting, and faith tours (KTB, 2024). Among them, beach tourism is a dominant type in Türkiye (Aygün Oğur, 2022). The majority of accommodation facilities are built on the Aegean and the Mediterranean shorelines and tourism infrastructure is well-developed in these regions which are closely related to beach tourism (Aygün Oğur, 2022; Ceylan & Yakut, 2021). Türkiye ranked third in the world according to the 2024 Blue Flag statistics. Türkiye has 566 blue flag beaches (one beach is excluded near Van Lake) around the four surrounding seas (TÜRÇEV, 2024). As seen from given statistics, beach tourism is vital for Türkiye. The sustainability of tourism against the adverse impacts of climate change must be ensured. The sustainability of tourism is linked to the length of the tourism season. This period is determined by the climatic conditions prevailing in a destination. Climatic comfort refers to conditions in which a person feels healthy and dynamic, and can adapt to the environment by spending the minimum amount of energy. Climatic comfort is important in terms of social life, health, tourism, and economic activities (Bağcı & Kılıç, 2023). In order to benefit from tourism activities comfortably, the climatic conditions of that region must be between the determined threshold values (Güçlü, 2010). Climatic conditions affect the decision-making process of tourists before and during the visit to the destination (Arabadzhyan *et al.*, 2021). It is known that beach tourism, in particular, is extremely sensitive to weather conditions (Morgan *et al.*, 2000). By the application of climatic indices, it can be determined whether a destination has convenient climatic conditions for a certain type of tourism activity or not.

The application of climatic comfort indexes for coastal tourism in Türkiye under climate change scenarios is quite limited in the literature. For example, Guclu (2011) studied the sea tourism season with respect to climatic conditions in the Black Sea Region. Deniz (2011) calculated the Tourism Climate Index scores of Turkish coasts. Sancar and Güngör (2020) determined bioclimatic comfort areas in Antalya. Mansuroğlu *et al.* (2021) evaluated the bioclimatic comfort levels in Antalya. Koç (2022) determined the bioclimatic comfort zones under climate change scenarios in Antalya using the Temperature Humidity Index. Cinar *et al.* (2023) analyzed the summer thermal comfort conditions in Muğla Province. Bilgin *et al.* (2023) examined the effects of climate change on coastal tourism over the southwestern provinces of Türkiye including İzmir, Aydın, Muğla, and Antalya. Aygün Oğur & Baycan (2023) evaluated the climate change impacts on tourism demand in 30 destinations in Türkiye. As seen in the cited literature, the majority of studies did not cover the entire coastal zones of Türkiye or lack climate change scenarios. To fill this literature gap, this study aims to investigate the convenience of climatic conditions for beach tourism on Turkish coasts in the era of climate change. The results of this study will contribute to the development of sustainable beach tourism. The Ministry of Culture and Tourism, local authorities in coastal cities, accommodation facilities in coastal regions, travel agencies, and other tourism businesses may benefit from the results of this paper. The rest of the paper is structured as follows. The literature section covers the studies about climatic comfort indices and their applications in tourism. The materials and method section provides information about climate change scenarios, the details of the Climate Index for Tourism (CIT), and data acquisition. Results are given in the next sections and findings are discussed with similar studies. The paper finishes with a conclusion, implications, limitations, and future study suggestions.

2. Literature

Adapting climate indices to tourism is a complex and difficult issue. Following the unprecedented growth of international tourism, tourism climate indices have become more important. In the 1970s, journal articles showing the relationship between tourism and recreation climatology were published for the first time. One may refer to Rutty *et al.* (2021) for the history of previous studies. In the following years, Mieczkowski (1985) identified the need for an index that evaluated the climatic conditions of destinations for tourists. Especially during their visit, tourists are greatly interested in the climatic conditions. Therefore, Mieczkowski developed the Tourism Climate Index (TCI), the first index for the relationship between tourism and climate, to evaluate positive and negative climatic conditions according to the needs of visitors (Deniz, 2011). Morgan *et al.* (2000) developed the Beach Climate Index (BCI), a slightly modified version of the TCI, to evaluate 3S tourism (sun, sea, and sand) on beaches. BCI is designed to allow for thermal sensations, making improvements to TCI's daytime comfort index ratings. Another index for beach tourism, the Climate Index for Tourism (CIT), was designed in 2008. De Freitas

et al. (2008) mentioned that for a climate index to be comprehensive and universal, it must be theoretically sound, simple to calculate, easy to use, and understandable by users in the tourism sector and integrate the effects of all aspects of climate. G. Yu *et al.* (2009) improved the CIT slightly and designed the Modified Climate Index for Tourism (MCIT). Instead of using daily average or daily maximum data, MCIT uses hourly data to achieve high temporal resolution (G. Yu *et al.*, 2009). The Holiday Climate Index (HCI) was developed in 2016 to try to address various shortcomings of climate indices for tourism. The key difference of the HCI, relative to the TCI and other indices, is that it draws on existing literature on tourist climate preferences from a series of surveys compiled in the previous decade to determine the rating scales and weights of sub-items in a way that does not rely on subjective opinions (Demiroglu *et al.*, 2020). In addition to these indexes, the Summer Simmer Index (SSI), the Temperature Humidity Index (THI), Humidex, Discomfort Index (DI), Relative Climate Index (RCI), and the Coastal Tourism Climate Index (CTCI) are widely used climatic indexes for coastal tourism in literature (Bilgin *et al.*, 2023; Demiroglu *et al.*, 2020; Zeydan & Zeydan, 2023). Table 1 depicts some examples of these studies.

As seen in Table 1, the majority of studies in Türkiye were limited to certain cities and not focused on the coastal regions. Only the work of Zeydan and Zeydan (2023) evaluated the Black Sea coast using observational data. The study of Efe *et al.* (2022) covered the entire Türkiye again using historical data. None of these studies except the works of Bilgin *et al.* (2023) and Demiroglu *et al.* (2020) used climate change scenarios. Different from the cited literature, our study uses both observational data and climate change scenarios and focuses on the entire shoreline of Türkiye in terms of beach tourism.

Table 1. Summary of Studies Covering Climate Indexes and Their Applications in Tourism

Study area	Indexes used	Main results	Reference
Cide-Kastamonu (Türkiye)	THI, SSI, TCI	It was determined that Cide has a hot class THI between 1 July - 30 August. 2nd zone SSI was found between 23 June and 24 July and 17–30 August. TCI was under the "good" category from May to September.	(Ibret *et al.*, 2013)
The European and Mediterranean coastlines	CIT	The optimal climatic conditions may shift from the summer to shoulder seasons in the Mediterranean in the late century (2075-2094).	(Amengual *et al.*, 2014)
Bay of Palma (Spain)	CIT	CIT is applied to determine the present and future climatic conditions for several tourism activities (cycling, cultural tourism, football, golf, motor boating, sailing, and hiking).	(Bafaluy *et al.*, 2014)
France and the Mediterranean Basin	TCI	The sources of uncertainties in TCI are investigated. It is suggested that tourism comfort indices should be used more carefully, paying more attention to the robustness of the data (validation, elimination of bias, uncertainty assessment, etc.)	(Dubois *et al.*, 2016)
Lakes Region (Türkiye)	THI, SSI	Thermal comfort conditions were not suitable on a monthly average in the October-May period. When THI and SSI index values are assessed together, the most suitable periods for outdoor tourism and recreation activities are 5 - 25 June and 29 August - 16 September.	(Guclu, 2016)
Europe	HCI, TCI	HCI and TCI are compared across HCI: urban rates the climate of many cities higher than TCI, especially in shoulder seasons and winter. The study mentioned that TCI use should be discontinued.	(Scott *et al.*, 2016)
Thrace Region (Türkiye)	THI	In terms of climatic comfort, THI values show that May, June, September, and October are suitable months for coastal tourism, while temperatures are very high in July and August.	(Erginal, 2017)
The Caribbean	HCI, TCI	HCI: Beach has a stronger relationship between index scores and tourist arrivals compared to that of TCI.	(Rutty *et al.*, 2020)
Antalya (Türkiye)	HCI, Humidex	In the 2070-2099 under the RCP8.5 scenario, Antalya loses its ideal conditions, especially in July–August but keeps Very Good to Excellent conditions from April to October.	(Demiroglu *et al.*, 2020)
Antalya (Türkiye)	SSI	Along the Antalya coastline, the 3rd, 4th, and 5th zones of SSI classes were determined in June, July, and August months.	(Sancar & Güngör, 2020)
Antalya (Türkiye)	SSI	The bioclimatic comfort levels of individuals were examined with SSI. It has been revealed that people living in central regions of Antalya are negatively affected by climate change.	(Mansuroğlu *et al.*, 2021)
Iran	SSI	An upward trend was observed which indicates increasing temperatures in Iran. It is mentioned that the SSI is easier to calculate and interpret. It is recommended to use SSI as a thermal stress screening index to adopt preventive policies in outdoor environments in the Iranian climate.	(Asghari *et al.*, 2021)
China	HCI, CTCI	The Coastal Tourism Climate Index (CTCI) was applied to nine coastal tourism cities in China, compared with the Resort Climate Index (HCI: Beach). According to the results, CTCI is more suitable for evaluating the coastal tourism climate in China.	(Gao *et al.*, 2022)
Türkiye	TCI	TCI values were evaluated for 98 stations in Türkiye for 1981-2020. TCI values in spring and autumn fall into the "Acceptable" category. Winter is the season with the smallest TCI values. In summer, a decreasing trend at different significance levels is observed in 54 of 98 stations, and an increasing trend is observed in four of them.	(Efe *et al.*, 2022)
Malaysia	TCI, HCI	Climatic conditions potentially affect tourism demand in Malaysia. Therefore, both TCI and HCI provide valuable information to the Malaysian government and tourism industry managers in designing tourism policies and products.	(Jong *et al.*, 2023)
Spain	CIT	CIT is implemented to assess the present and future climatic potentials of cultural, golf, sailing, hiking, cycling, and football activities.	(Cardell *et al.*, 2023)
The Black Sea coast, Türkiye	THI	Four different THI comfort classes were found on the Black Sea coastline as cold, cool, comfortable, and warm. It was found that the Western Black Sea is more suitable for sea tourism and the Eastern Black Sea Region is more suitable for nature and highland tourism.	(Zeydan & Zeydan, 2023)
İzmir, Aydın, Muğla, and Antalya (Türkiye)	DI	The threshold of discomfort may be exceeded in the near future (2026–2050) and mid-future (2051–2075) periods in July and August months.	(Bilgin *et al.*, 2023)

Source: Authors' own eaboration

Table 2: Calculation of CIT Ratings

ASHRAE scale TSN [T]	Cloud (<45%) [A]	Cloud (≥45%) [A]	Rain (>3mm) [P]	Wind (≥6m/s) [P]
Very hot (+4)	4	3	2	3
Hot (+3)	6	5	2	4
Warm (+2)	7	5	2	4
Slightly warm (+1)	6	4	1	4
Indifferent (0)	5	3	1	2
Slightly cool (-1)	4	3	1	2
Cool (-2)	3	2	1	2
Cold (-3)	2	2	1	1
Very cold (-4)	1	1	1	1

Source: *(Amengual et al., 2012; De Freitas et al., 2008)*

3. Materials and Method

Climate Change Scenarios

In order to predict future climate change impacts, climate scenarios are developed. Representative Concentration Pathway (RCP) climate change scenarios are developed by the Coupled Model Intercomparison Project Phase 5 (CMIP5) and used in the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) (IPCC, 2013). RCPs indicate the radiative forcing targets till the year 2100. There are four RCP scenarios: RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5 that assume the stabilization of radiative forcing at 2.6 W/m^2, 4.5 W/m^2, 6.0 W/m^2, and 8.5 W/m^2, respectively (Andrade *et al.*, 2021; Carrillo *et al.*, 2022). RCP 2.6 is the optimistic mitigation scenario while RCP 8.5 is the pessimistic scenario with very high GHG emissions. RCP 4.5 and RCP 6.0 are two intermediate scenarios (Bienvenido-Huertas *et al.*, 2021). RCP 2.6 assumes the fulfillment of decarbonization and clearance of carbon dioxide from the atmosphere (Bienvenido-Huertas *et al.*, 2021; Doulabian *et al.*, 2021). RCP 8.5 is the most unfavorable scenario in which GHG continues to increase which will lead to about 4 °C temperature rise at the end of the century. RCP 4.5 is based on the stabilization of GHG emissions after 2040 (Doulabian *et al.*, 2021). Researchers investigating the impacts of climate change on beach tourism generally applied RCP 4.5 and RCP 8.5 scenarios (Carrillo *et al.*, 2022; de la Vara *et al.*, 2024; Spencer *et al.*, 2022; D. D. Yu *et al.*, 2022). In this present study, we applied only the RCP 4.5 scenario since 101 countries (80.7% of global GHG emissions) targeted net zero emissions by the year 2050 (ClimateWatch, 2024). Therefore, RCP 4.5 sounds more realistic future scenario compared to RCP 8.5.

Climate Index for Tourism (CIT)

De Freitas *et al.* (2008) proposed that a climate index should incorporate the findings of multi-disciplinary research from several fields including climatology, tourism, biometeorology, psychology, and geography. They also mentioned that a climate index should integrate the effects of all facets of climate. Additionally, it must be easier to calculate and understand. Therefore, De Freitas *et al.* (2008) developed the Climate Index for Tourism (CIT) to assess whether the climate conditions are suitable for sea, sand, and sun activities (beach tourism). CIT is a useful and reliable index in beach tourism. Tourists and tour operators can use CIT to choose the best time and location for travel or to plan activities appropriate to the expected climate (De Freitas *et al.*, 2008). CIT combines three facets of weather: thermal (T), aesthetic (A), and physical (P). T is the body-atmosphere energy balance including heat gains and heat losses by convection (wind), evaporation (sweating), short-wave and long-wave radiation exchanges, and metabolic heat (activity level) (Amengual *et al.*, 2014). A is the sky conditions and P is the rain or strong wind. CIT is a function of T, A, and P and reflects the satisfaction level of the climatic condition. The calculation of CIT ratings is depicted in Table 2. CIT ranges from 1 (very poor/unacceptable) to 7 (very good/ acceptable) (De Freitas *et al.*, 2008; Jong *et al.*, 2023). TSN is the thermal sensation response according to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) ranging from -4 to +4 (Cardell *et al.*, 2023). De Freitas *et al.* (2008) originally categorized the CIT classes as 1, 2, and 3 are unacceptable, 4 is marginal, and 5, 6, and 7 are acceptable. After that, Amengual *et al.* (2012) modified the rating scale to remove inconsistencies and further validated the CIT. They also used the following categorization: CIT = 1, 2, and 3: unacceptable; CIT = 4 and 5: acceptable; and CIT = 6 and 7: ideal conditions (Amengual *et al.*, 2012, 2014).

Data Acquisition and Software

Copernicus Climate Change Service (C3S) has prepared Climate Suitability for Tourism Indicators (CST) using both observations and climate projections. These indicators have two bioclimatic indices namely Holiday Climate Index (HCI) and Climate Index for Tourism (CIT). The former is associated with urban tourism while the latter focuses on beach tourism activities. The observational period covers the years between 1986 and 2005. The climate projections include RCP 2.6, RCP 4.5, and RCP 8.5 scenarios. Both historical and future projected monthly multi-model mean daily index values of CIT are acquired for analysis. The data properties used in this study are provided in Table 3. For further details of the dataset, one may refer to the webpage of the European Centre for Medium-Range Weather Forecasts (ECMWF, 2023).

Table 3: Data Properties

File format	NetCDF-4
Spatial resolution	0.11° × 0.11°
Spatial coverage	Europe (27°N - 72°N and 22°W - 45°E)
Temporal resolution	Monthly
Temporal coverage	1986-2005 (historical), 2021-2040 (short term), 2041-2060 (middle term), and 2081-2100 (long term)

Source: (Copernicus, 2024)

Climate Index for Tourism (CIT) files are stored as Network Common Data Format (NetCDF). NetCDF is a self-describing, multidimensional array file with *.nc extension. NetCDF files consist of dimensions (latitude, longitude, and time), variables (calculated CIT values in our case), and attributes (metadata that gives information about the dataset) (Uddameri, 2017). Panoply software version 5.2.5 was used to open and visualize the NetCDF files. Panoply is developed by the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies (GISS). This software is freely available and can be downloaded at NASA's website (NASA, 2024).

4. Results and Discussion

To access the climate convenience for beach tourism, a multi-model mean Climate Index for Tourism maps are generated and displayed in Figures 1, 2, and 3. Only the summer season is evaluated here. CIT values for Türkiye are depicted for June, July, and August months in Figures 1, 2, and 3, respectively. It should be noted that only shorelines are evaluated and discussed here for the climatic conditions of beach tourism. In Figure 1-a, the Mediterranean and the Aegean coasts of Türkiye displayed CIT values of 4 and 5 in June for the period of 1986-2005. CIT scores for the western and southern coasts of Türkiye were acceptable and these shorelines benefited from favorable climatic conditions. Whereas the Marmara region represented CIT values of 2 and 3, and the Black Sea coast showed CIT values of 1 and 2. These two regions were unacceptable for beach tourism due to lower temperatures and high precipitation rates (Guclu, 2011). In the near future (Figure 1-b), the Mediterranean and the Aegean shorelines will maintain acceptable conditions for beach tourism. On the other hand, the Marmara shorelines exhibited a slight increase in CIT scores shifting from 2 to 3. Similarly, CIT values of the Black Sea coasts showed a slight rise. Due to the effects of climate change, CIT scores in the Mediterranean coasts will exceed 5 in the mid-century under the RCP 4.5 scenario (Figure 1-c). The Aegean shores will have higher and acceptable CIT scores compared to the observation period. CIT values in the Black Sea shoreline will increase from 1 to 2 except the eastern side. In the late century (Figure 1-d), acceptable CIT scores will remain in the southern and the western sides of Türkiye. The western part of the Marmara region

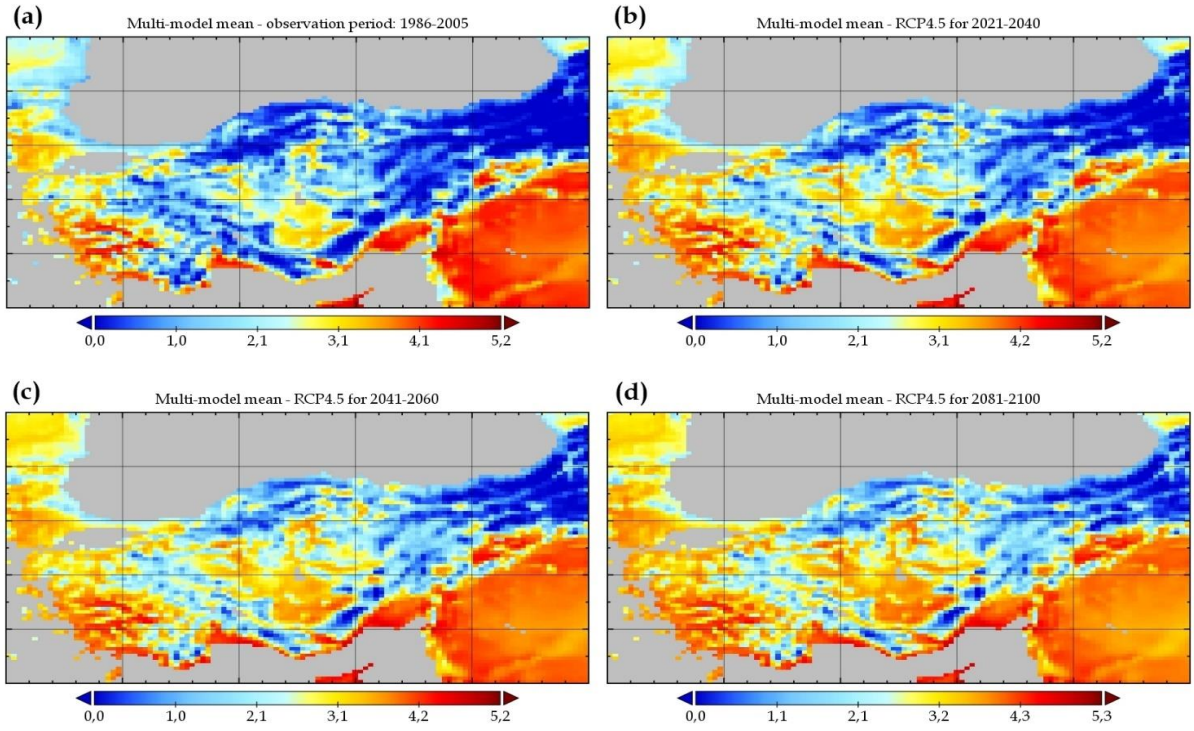

Figure 1: Climate Index for Tourism for June over Türkiye (a shows the historical observations from 1986 to 2005; b, c, and d represent the near future (2021-2040), mid-century (2041-2060), and late-century (2081-2010) projections under the RCP 4.5 scenario, respectively.)

Source: *created by using "Climate suitability indicators for tourism from 1970 to 2100 over Europe derived from climate projections" provided by Copernicus Climate Change Service*

will have CIT scores around 4, indicating these shores will favor beach tourism. The Black Sea coast will have CIT values of 2 and 3 and become unacceptable for beach tourism. Overall, for June, the Mediterranean and the Aegean coasts will be the major destinations for beach tourism and a slight benefit will be available for the Marmara Sea coasts.

Figure 2-a illustrates the historical CIT scores for July from 1986 to 2005. Near ideal conditions (CIT close to 6) were calculated for the Mediterranean coasts. The Aegean shores presented acceptable conditions for beach tourism. The CIT scores were close to 4 around the Marmara Sea. However, the lower CIT scores were calculated for the Black Sea coast, indicating unfavorable conditions for beach tourism. In the near future (Figure 2-b), there will be a notable shift in CIT score on the Black Sea shores under the RCP 4.5 scenario. CIT values will exceed 4 in the north of the Marmara Region and the middle of the Black Sea Region, especially in Samsun and Ordu shores. In the mid-century, there will be not much difference in CIT scores compared to the 2021-2040 period (Figure 2-c). On the other hand, the late-century projections indicate that the coasts of the middle and western Black Sea Region will have CIT scores higher than 4 and these shores will be acceptable for beach tourism. It should be kept in mind that CIT scores for July are higher compared to June both for observations and projections. Under the RCP 4.5 scenario, some parts of the Black Sea coasts (Samsun and Ordu) will be more attractive to tourists in July in terms of beach activities.

Historical CIT scores for August are depicted in Figure 3-a. August's CIT values displayed a quite similar pattern to that of July's except the highest value is equal to 6. The Mediterranean coasts had ideal conditions for beach tourism. The Aegean shorelines had acceptable climatic conditions. However, the Black Sea coast had lower and unacceptable CIT scores. In the near future (2021-2040), the Mediterranean and the Aegean shores maintain their CIT scores under RCP 4.5 scenario (Figure 3-b). A slight increase in CIT values in the north of the Marmara Region and the central parts of the Black Sea will be observed. In the mid-century, the central parts of the Black Sea coast and the northeast of the Marmara Region shorelines (Sakarya and Düzce coasts) will have acceptable CIT scores (Figure 3-c). These regions will be more attractive for beach tourism. In the late century, the eastern Black Sea shores and Kastamonu and Bartın coasts will have unacceptable CIT scores (Figure 3-d). The rest of the Türkiye coasts will have acceptable climatic conditions for beach tourism. However, extreme heat in the Mediterranean coasts due to climate change will lower the CIT scores below ideal (Figure 3-c and 3-d). For August, some parts of the Black Sea coasts will be acceptable for

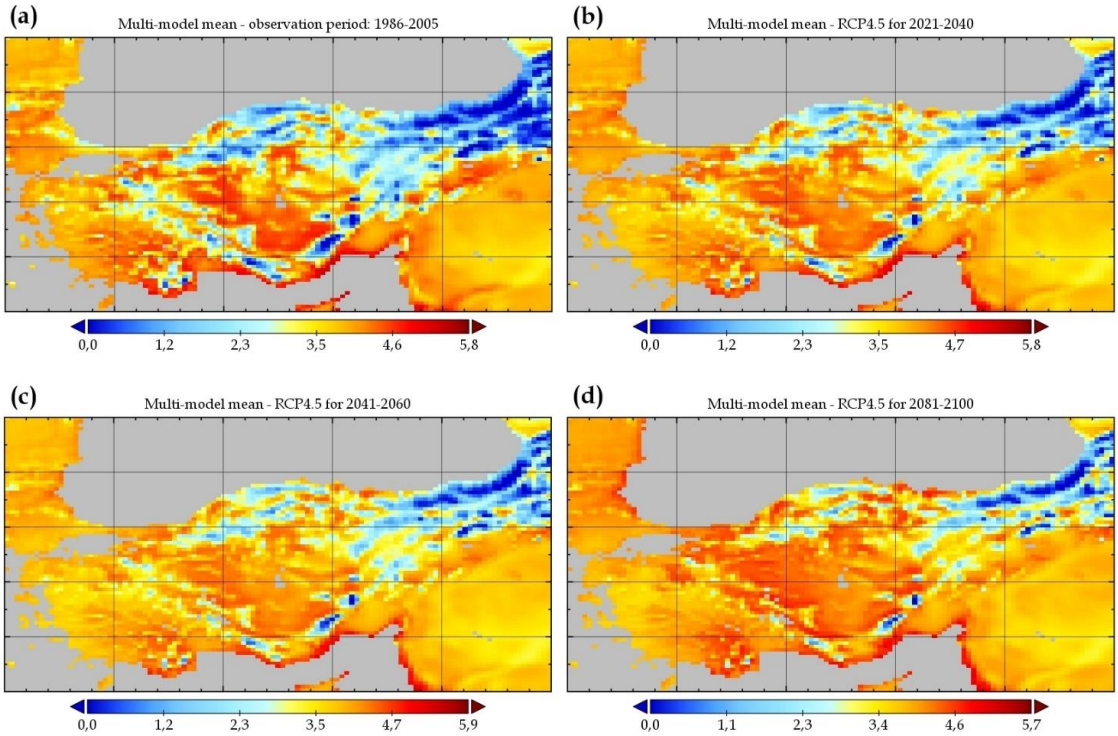

Figure 2: Climate Index for Tourism for July over Türkiye (a shows the historical observations from 1986 to 2005; b, c, and d represent the near future (2021-2040), mid-century (2041-2060), and late-century (2081-2010) projections under the RCP 4.5 scenario, respectively.)

Source: *created by using "Climate suitability indicators for tourism from 1970 to 2100 over Europe derived from climate projections" provided by Copernicus Climate Change Service*

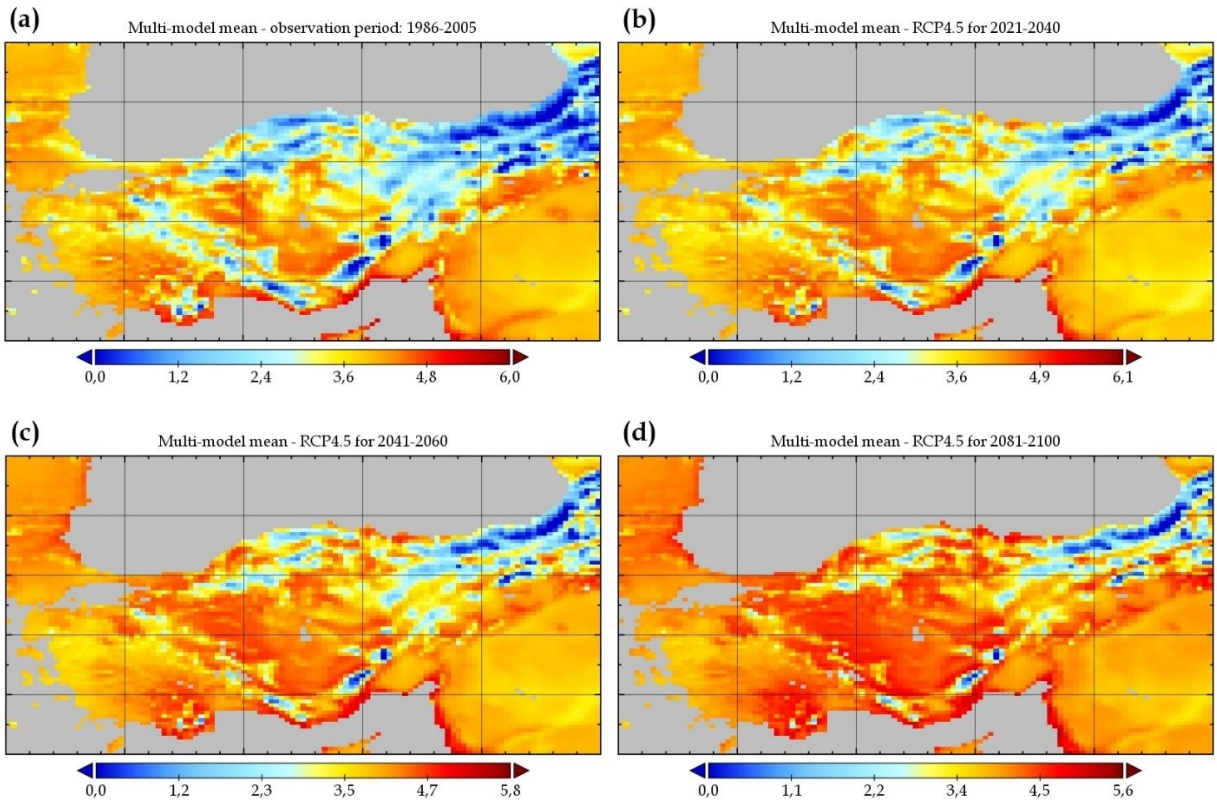

Figure 3: Climate Index for Tourism for August over Türkiye (a shows the historical observations from 1986 to 2005; b, c, and d represent the near future (2021-2040), mid-century (2041-2060), and late-century (2081-2010) projections under the RCP 4.5 scenario, respectively.)

Source: *created by using "Climate suitability indicators for tourism from 1970 to 2100 over Europe derived from climate projections" provided by Copernicus Climate Change Service*

beach tourism while the Mediterranean coasts may lose ideal conditions under the RCP 4.5 scenario.

Our findings are parallel to the literature (Amengual *et al.*, 2014; Demiroglu *et al.*, 2020). Moreno & Amelung (2009) stated that the Mediterranean basin is likely to remain an important destination for beach tourism in the summer for at least 50 years. Amengual *et al.* (2014) pointed out that in the late century (2075-2094), the number of ideal days for beach tourism (according to the CIT scale) will decrease in the Mediterranean, the Aegean, and the Marmara coasts while it will increase in the Black Sea shorelines (no data for the eastern Black Sea). On the other hand, there will be a much greater increase in the number of acceptable days in the Mediterranean, whilst less increases in the rest of the Turkish shorelines. Demiroglu *et al.* (2020) mentioned that by the 2080s for coastal tourism in the Mediterranean, it is expected that excellent conditions will occur in the spring and climatic conditions will worsen in the summer. Similarly, Carrillo *et al.* (2022) reported that the climatic conditions of the southern areas of the Canary Islands (Spain) will worsen in the summer. It can be concluded that the Mediterranean may lose its attractiveness in terms of beach tourism during the summer in the late century. On the contrary, some portions of the Black Sea coasts (Samsun and Ordu) may benefit from climate change in the same period.

5. Conclusion

This study contributed to the literature by conducting comprehensive research on analyzing the relationship between beach tourism and climate change. Also, our paper contributed to sustainable development goal number 13 - climate action. The results of this study indicated that the Mediterranean and the Aegean coasts may not be ideal but remain acceptable for beach tourism till the end of the century. On the other hand, the Black Sea coasts will have lower CIT scores, and only some parts of them become acceptable climatic conditions under the RCP 4.5 scenario. In all periods, the eastern Black Sea shores will have quite lower CIT values which means this region is not suitable for beach activities. The shorelines around Marmara Region will represent a transition between the Aegean and the Black Sea coasts.

Examining the climatic conditions in terms of climate comfort and determining the appropriate periods accordingly are important for all tourism elements such as planning, implementation, promotion, and accommodation (Güçlü, 2010). Climatic events such as sea level rise,

increasing temperatures, and extreme weather events negatively affect tourism activities. The climate change process is getting stronger day by day. Climate change has important consequences, such as changing the climatic conditions in destinations and therefore the competitive relations between destinations. Changing the tourism season due to climatic events may lead to a loss of tourism potential. Therefore, taking the necessary precautions is important for the sustainable planning of tourism. It has become necessary to develop accurate and applicable adaptation strategies against climate change.

Implications

The climatic conditions for beach tourism may shift from ideal to acceptable in August in the late century on the Mediterranean coasts. Sustainable tourism practices must be applied to mitigate the potential impacts of climate change such as water scarcity and heat waves. The tourism sector should be prepared for extreme heat events. Accommodation facilities must have health personnel. These facilities must also reduce their water usage against water scarcity. Loss of tourists may be prevented by extending the tourism season in shoulder months.

In the mid and late centuries, some parts of the Black Sea shores will have acceptable climatic conditions for beach tourism. Tourism development plans should be prepared in the light of sustainable tourism. The summer season may be short in the Black Sea Region as compared to the Mediterranean and the Aegean coasts. Therefore, tourism potential may be maximized by promoting alternative tourism opportunities such as eco-tourism, cultural tourism, or plateau tourism in this region. Also, marketing strategies for short-distance visitors can be useful for tourism development in the Black Sea Region (Moreno & Amelung, 2009).

Due to climate change, innovative and sustainable practices have gained importance in tourism. The long-term sustainability of tourism depends on protecting and improving the environment. To ensure sustainability in tourism, natural areas, and resources must first be protected. It is very important to carry out correct urban planning to improve bioclimatic comfort conditions. For this purpose, green areas should be increased. Moreover, supporting recycling, improving public transportation, and reducing all kinds of consumption (such as water and energy) are necessary to reduce carbon and water footprints. Additionally, it is necessary to ensure the participation of local people in the destination in the process of combating climate change. Tourism businesses should implement new marketing strategies and responsible tourism views not only to generate income but also against climate change. Tourism marketers should consider the climatic conditions in that region in terms of the sustainability of tourism. Public administrators can prepare climate policies that are sustainable and can be implemented in the future. Both tourist and accommodation facilities can get insurance against adverse weather conditions. Moreover, beach nourishment may be an adaptation strategy against sea level rise (Spencer *et al.*, 2022).

Limitations and future research

This study has certain limitations. The results and implications of this study are limited due to methodological limitations and choices. We used CIT scores only for the summer season. In future studies, the climatic conditions of shoulder months (such as May and September) can be investigated. Moreover, we evaluated future climatic conditions under the RCP 4.5 scenario. Although most of the GHG emitters targeted net zero emissions by the year 2050, it may not have happened. For example, a war between Russia and Ukraine resulted in a natural gas shortage in Europe, and in 2023 European countries used more coal and emitted more GHG to the atmosphere. Therefore, it would be better to evaluate climatic conditions under a pessimistic scenario (RCP 8.5) in future studies.

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INFO PAGE

Sustainability of Beach Tourism in Türkiye in the Era of Climate Change

Abstract

Tourism is vulnerable to climate change. Türkiye is one of the leading tourism destinations. Beach tourism, based on the trio of sea, sun, and sand, is the main type of tourism in Türkiye. Climatic comfort in a destination is important for tourism attractiveness. Knowing how climate change will affect tourism is very important for the sustainability of the tourism sector. Therefore, applying climate indices to beach tourism in order to accurately evaluate climate conditions today and in the future is very important for the sustainability of tourism. In this study, to determine the impact of climate change on beach tourism the Climate Index for Tourism (CIT) is applied. CIT is specifically designed for beach tourism. Data is gathered from the Copernicus Climate Change Service (C3S). Both historical observations and future climate projections are used. Considering the net zero targets of greenhouse gas emitter countries, only Representative Concentration Pathways (RCP) 4.5 scenario is implemented. Panoply software is used to visualize CIT maps. The future of beach tourism in Türkiye is evaluated for near (2021-2040), mid (2041-2060) and late-century (2081-2100). As a result, it has been shown that the Mediterranean and Aegean coasts will continue to be suitable for beach tourism in the summer. In the late century, due to warming temperatures, ideal conditions may shift to acceptable on the Mediterranean coasts. On the other hand, the CIT scores of the Black Sea shores will be lower and only part of this region will have acceptable climatic conditions under the RCP 4.5 scenario. The coastlines around the Marmara Region will represent a transition between the Aegean and Black Sea coasts.

Keywords: *beach tourism, climate change, climate index for tourism (CIT), sustainability, Türkiye.*

Authors

Full Name	Author contribution roles	Contribution rate
İlknur Zeydan:	*Conceptualism, Methodology, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization*	*50%*
Özgür Zeydan:	*Conceptualism, Methodology, Software, Writing - Original Draft, Writing - Review & Editing, Visualization*	*50%*

Author statement: *Author(s) declare(s) that All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.* ***Declaration of Conflicting Interests:*** *The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article*

This paper does not required ethics committee report

Justification: The methodology of this study does not require an ethics committee report.