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CASE STUDY

Assessing climate change impacts on tourism demand in Turkey

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Abstract
This study focuses on quantifying the impacts of climate change on international tourism in Turkey through the estimation of the future number of international tourists for different tourism destinations. For this purpose, 30 tourism destinations were selected from different regions in Turkey offering different kinds of tourism attributes and climatic conditions. Future tourism demand was estimated based on comfort level change, a major determinant of tourist preference, and evaluated through the Tourism Climate Index. Changes in climate comfort levels between a base period (1963–2017), a projected medium term period representing the 2050s (2040–2069), and a projected long term period representing the 2080s (2070–2099) were correlated with the number of international tourists using a regression model developed by Hein et al. (Current Opinion in Environmental Sustainability,1:170–178, 2009). The results of this study project extreme drops in demand, seasonal shifts, and the emergence of new alternative destinations. The study is significant as the first quantitative evaluation of climate change impacts on tourism demand in Turkey through a comparison of the spatial exposures of destinations. The results will help lead the way to a national tourism development roadmap in Turkey through the revelation of regional risks and opportunities and will serve as a benchmarking study for tourism destinations that have similar climate conditions and tourism patterns.

Keywords Climate change · Tourism demand · Regression analysis · Turkey · Climate change impact assessment

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1 Introduction

The tourism and travel industry is one of the most important global economic sectors, accounting for 10.4% of GDP and 10% of employment worldwide (WTTC, 2019). According to the UNWTO, international tourist flow has reached 1.1 billion, generating US$ 1.25 trillion in market value in 2015, which rose to 1.32 billion and US$ 1.33 trillion, respectively, in 2017, lending needed support to the economic development of many nations and creating millions of employment opportunities (Michailidou et al., 2016).

Tourism remains a promising sector for those economies already particularly dependent on it (Doğru and Bulut, 2018); however, climate change threatens the natural resources that comprise destinations' most important attributes (Doğru et al., 2019). The impacts of climate change on the tourism sector pose a threat to not only this specific industry but also the global economy (Burke et al., 2018). The economies most vulnerable to climate change are those projected through current trends to become the fastest growing tourism destinations, in particular Asia, Africa, and Small Island Developing States (SIDS). Given that a high dependency on tourism renders economies more vulnerable to climate change impacts (Berrittella et al., 2006; Deutsche Bank, 2008; Scott, Hall and Gössling, 2019), it is crucial to understand the dynamics between tourism demand and climate change in tourism-dependent destinations (Mushawemhuka et al., 2018).

Annual global international tourist arrivals are projected to increase as a result of rising global income and more accessible travel options. Climate change is not expected to halt this rise (Deutsche Bank, 2008); instead, it will influence the decisions of tourists concerning where and when to travel, or the geography and timetable of tourism expenditures (Scott et al., 2016). Climate is a crucial factor in determining both the seasonality and the geography of global tourism spending (IPCC, 2018).

Turkey is one of the ten most popular destinations in the world, offering different tourism activities all over the country. In 2019 it hosted over 48 million tourists, mostly from OECD countries, because of its natural heritage, historical background, cultural diversity, and pleasant climate. The most popular tourism season is summer, during which diverse activities are available within the nature, beach, city, culture and alternative tourism types. Tourism is one of Turkey's most important economic sectors, accounting for 3.1% of the national GDP (Turkish Republic Ministry of Culture and Tourism, 2019). Since the 1980s, the tourism sector has received an enormous amount of public and private investment. However, projections of climate change indicate critical risks for the tourism industry in the Mediterranean Basin, where Turkey is located (Ciscar et al., 2014; Grillakis et al., 2016; Scott et al., 2016). Despite these risks, awareness of the climate crisis is not yet widespread in Turkey, with climate change impacts on the tourism sector neglected in tourism planning and investment management programs (Aygün and Baycan, 2020). And while there are academic studies that focus on the impact of climate change on the tourism sector for specific destinations in Turkey, there is no comprehensive quantitative research that might be able to direct future tourism development plans and investment strategies.

In such a vulnerable region, this is a critical gap that puts the future viability of an important sector at risk. This study therefore aims to evaluate the quantitative impacts of climate change on international tourism demand in Turkey, focusing on open-air tourism activities, which are in the highest demand. In order to compare the climate change impacts on different regions and create an alternative adaptation pathway for the industry, 30 different tourism destinations from varying geographic locations and which offer diverse tourism activities, climates, and features were selected as case studies. The impacts have been

assessed through shifts in the number of tourists as a result of changes in destinations' comfort levels. These comfort levels were evaluated in accordance with the *"Tourism Climate Index" (TCI)* (Mieczkowski, 1985), with a base period of 1963–2017 and reference periods comprising 2040–2069, representing the 2050s, for the medium term and 2070–2099, representing the 2080s, for the long term, and compared in terms of their climate comfort levels. The rating results of the TCI evaluations were utilized as independent variables for the regression model, with the number of tourists as the dependent variables, indicating the change in the number of tourist overnights for each destination on a monthly basis in the 2050 and 2080s. The results of this study fill a gap in the knowledge of the quantitative impacts of climate change on tourism in Turkey through a comparison of destinations in terms of risks and potentials and generate an outlook for the future of the tourism industry under climate change risks. These results are crucial for informing future investment and strategic development plans in Turkey and adapting to and mitigating the risks of climate change. This study also contains benchmarking results for other countries, specifically for those located in the Mediterranean basin that are expected to experience similar impacts and require climate change management plans for tourism.

The first part of this study presents a literature review of the potential impacts of climate change on the tourism industry, relevant research, and findings. The second part outlines the methodologies used in assessing climate change impacts on tourism, along with their contribution to the field. The third part presents the case study of climate change impacts on tourism demand in Turkey, explaining case study region, methodology, and data, and relays the findings of the empirical study. The final part contains a discussion of the study's results and highlights the contribution of this paper to climate change and tourism literature.

2 Potential impacts of climate change on tourism

Climate conditions are considered a motivator for travel, an image and asset of a destination, and a determinant of tourism activities (Day et al., 2013) in tourism discourse. In other words, climate is part of the attraction of a destination and has a significant impact on a destination's image and tourist satisfaction (Smith, 1993; Giles and Perry, 1998; Harrison et al., 1999; Rossello-Nadal, 2014). The literature is accordingly clear that climate change will inevitably affect tourism demand trends, the pattern of tourism flow, destination choice, travel period, length of visitation, and activities undertaken and indirectly influence the socio-economic structure of destinations as well as investments in and the costs of the tourism industry (Scott, 2003; Hamilton and Lau, 2005; Hamilton and Tol, 2007; Scott & Lemieux, 2010; Michailidou et al., 2016; Scott and Gössling, 2018; Tervo-Kankare et al., 2018).

An IPCC report (2018) confirms that tourism has already been affected by global warming and projects more intense impacts should temperatures increase by 1.5°C. Moreover, the report indicates higher risks with "very high confidence" in tropical and subtropical regions, as well as for seasonal tourism staples such as summer coastal activities and snow tourism due to natural degradation and temperature increases.

The direct impacts of climate change on tourism are expected to take the form of warmer summers and winters, precipitation change, and increased extreme weather events, all of which spell reduced climate suitability for tourism activities. Climate change's indirect impacts, on the other hand, might include environmental changes such as rising sea levels,

decreasing snowfall, natural degradation, biodiversity loss, and diseases (UNWTO and UNEP, 2008; Rossello-Nadal, 2014). There is also a direct relationship between rising temperatures and the magnitude of their possible impacts (IPCC, 2018). A study by Dube and Nhamo (2019) confirmed a temperature increase and rainfall decrease on the Zimbabwean side of the Victoria Falls, as well as the negative impacts of these trends on tourism revenue and tourist experiences.

Considering their permanent populations, coastal destinations are threatened not only physically but also socio-economically by sea level rise and extreme weather events (Jarratt and Davies, 2020). Negative impacts such as coral reef bleaching, coastal erosion, decreasing snow levels, wild fires, hurricanes, and heat waves are expected to occur more intensely and frequently (IPCC, 2018). Natural features, including glaciers, beaches, and biodiversity, are also important tourism assets and an essential part of destination image. According to the study by Marzeion and Levermann (2014), under a 1 °C warming scenario, 47 of 720 UNESCO World Heritage sites would be at risk from sea level rise, with the number increasing to 110 under 2 °C and 136 under 3 °C of warming.

Setting aside both the direct and indirect impacts of climate change, Gössling et al. (2012) discussed the consequences of mitigation policies and climate-induced social changes for tourism demand, stressing that mitigation policies have no significant impact on international demand, which continues to increase. However, they argue, any GDP reduction due to climate change would result in reduced tourism demand. The reaction of tourists to climate change impacts correlates significantly with how they perceive climate-related changes in destination attributes.

The impacts of climate change on tourism destinations are expected to vary according to geographic location, exposure, the state of the natural environment, resources, adaptive capacity, perceptions of personal security, and proposed activities (UNWTO and UNEP, 2008; Gössling et al., 2006; Scott et al., 2012; Kajan et al., 2015). Moreover, each destination has, in terms of local stakeholders, vulnerabilities that vary in both scope and scale over time (Student et al., 2020). Impacts might thus include shifting seasonality and changes in available activities and tourists' satisfaction (Dillimono and Dickinson, 2015). Unsatisfied tourists may result in destinations losing their current popularity, or vice versa (Rossello and Wagas, 2015). Under such conditions, certain destinations might be affected negatively, while others benefit, creating both winners and losers (Pang et al., 2013; Mushawemhuka et al., 2018).

Global projections indicate that the potential losers in tourism due to climate change are those destinations located in tropical regions, South Asia, the Mediterranean Basin, the Middle East, and the SIDS (Small Island Developing States) (UNWTO and UNEP, 2008; Scott, Hall and Gössling, 2019). On the other hand, more temperate destinations such as New Zealand, Canada and the US would likely benefit from climate change (Deutsche Bank, 2008). According to Hewer and Gough (2018), increasing temperatures will have positive impacts on tourism in Canada by helping to sustain a more suitable climate for park or zoo visits, golf, and general tourism activities. On the other hand, winter tourism activities dependent on snow accumulation and the presence of ice will be threatened by warming. Increasing rainfall has negative impact on national park visitation, while rising temperatures have inconsistent impacts on tourism demand (Liu, 2016).

Scott, Hall, and Gössling (2019) have developed a Climate Change Vulnerability Index for Tourism (CVIT) based on 27 variables and applied to 181 countries in order to provide a systematic vulnerability assessment tool that enables the comparison of different nations' vulnerabilities, filling a gap in regional vulnerability knowledge. This study reveals the spatial pattern of vulnerabilities, defines global "hotspots" for "tourism assets, tourism

operating costs, tourism demand, host country deterrents, sectoral adaptive capacity, country's adaptive capacity" and analyzes the economic importance of the tourism sector as a part of countries' national economies. According to their results, the most vulnerable countries are those in South Asia, the Middle East, Africa, and SIDS, while the least vulnerable are those at northern latitudes: northern and western Europe, Canada, and central Asia. A study by Seetanah and Fauzel (2019) on the impacts of climate change on tourism demand in SIDS also confirms their vulnerability, exposing the negative impacts of changing climate variables (precipitation and temperature) in both the long and short term.

There are important assessments that focus on risks for European and especially Mediterranean tourism. The tourism sector of the Mediterranean region is vulnerable to climate change because (i) tourism is an important economic sector for most of the countries therein, (ii) increasing temperatures may create excessively hot, unfavorable climate conditions, and (iii) tourist origin countries may have more favorable climate conditions than they do at present (Berrittellaa et al., 2006). Moreover, mass tourism mobility in Mediterranean coastal cities may work to contribute to congestion and GHG emissions and intensify local impacts unless practices are put in place to reduce emissions based on the characteristics of the cities (Cavallaro et al., 2017).

The 5th assessment of the IPCC (2014) states that tourism is one of the most affected sectors in Europe, with tourism activities in Southern Europe projected to decline with "low confidence," while tourism in Continental and Northern Europe is projected to increase with "medium confidence." The Mediterranean region is expected to be affected by a shift in the spatial and temporal preferences of tourists and subsequent revenues (Scott et al., 2016). Ciscar et al. (2014) conducted an econometric model to project tourism demand under hotter climate change conditions, predicting an overall 5% decline in tourism demand for Europe, with an 11% decrease for the Mediterranean region and a slight rise for destinations in Northern Europe.

Tourist comfort is a further concern; a rise in average temperatures of 1.5 °C is expected to make western, central, and northern Europe more preferable tourist destinations while demand (overnight stays) decreases in the Mediterranean, especially in summer. A 2 °C warming scenario would portend a serious decline in the number of winter tourist overnights in Europe (Jacob et al., 2018), with a commensurate transition of risk from the medium of 1.5°C warming to high, especially for climate-sensitive tourism types such as snow and coastal tourism (IPCC, 2018). The IPCC's position is in accord with the results of a study by Grillakis et al. (2016) which projected comfort level changes in Europe in case of 2°C warming, revealing that in July and August such levels (based on the Tourism Climate Index – TCI) are expected to decrease in Spain, Portugal, Turkey, Albania, Cyprus, and Greece (the Mediterranean Basin) and increase in April, May, and October. On the other hand, the tourist comfort levels of Luxemburg, Belgium, Denmark, Montenegro, Liechtenstein, Switzerland, and Andorra (Continental and Northern Europe) are expected to improve with increased TCI scores. Grillakis et al. claim that these shifts will lead to a jump in the competitiveness of northern destinations in the tourism sector.

These studies also support Deutsche Bank's (2008) climate change impact assessment based on direct and indirect climate effects, regulatory burdens, and adaptability, which projects a high risk for tourism in the Mediterranean region (the eastern Mediterranean in particular) in Europe due to rises in temperature and commensurate water shortages, while predicting gains in tourism demand in central and northern Europe. International tourists originating from northern regions are likely to prefer domestic tourism to fulfill their need for relaxation and vacation in the event of a warmer climate in the north, and these regions may become new popular tourist destinations (Hamilton et al., 2005a).

For similar reasons, according to a tourism demand assessment study conducted in Spain by Bujosa, Riera, and Torres (2015), the northern cost of Spain will have an advantage over southern coastal destinations under climate change conditions, regardless of their severity. Such an advantage would mean the reallocation of tourism demand within Spain, especially during the summer period. This result is consistent with global projections and makes clear the advantages of northern destinations over southern ones.

3 Methodologies used to assess the impacts of climate change on tourism

The interaction between climate change and tourism has gained prominence in tourism discourse (Scott et al., 2012; Weir, 2017; Fang et al., 2018), with increased awareness of the potential impacts of climate change on the tourism sector (Gössling and Scott, 2018). Recently, climate change impacts have become the focus of tourism studies on tourist behavior and the attractiveness and vulnerabilities of a destination (Berrittella et al., 2006) on global, national, and regional (islands, coastal areas, parks, ski areas) scales (Hamilton et al., 2005a; Hamilton & Tol, 2007; Moreno and Amelung, 2009; Scott et al., 2016; Mushawemhuka et al., 2018; Scott, Hall, and Gössling, 2019). Varying methodological approaches have been attempted to assess the impacts of climate change on the tourism industry and tourism demand. These methodologies can be grouped into five categories: qualitative approaches, evaluation of physical changes, statistical models, econometric models, and tourism demand models.

The qualitative approaches used in assessing climate change impacts on tourism are based on surveys, constructed scenarios, and discussions within tourist and tourism industry groups (Hamilton and Tol, 2007; Mushawemhuka et al., 2018). These approaches highlight the importance of climate and the perceived influence of climate change on travel destination choice from the perspective of tourists.

Evaluations of physical changes focus on the physical attributes of the supply side of the tourism industry. Activities requiring certain specific climate conditions such as winter sports, trekking, hiking, and even beach or city tourism are the subjects of these assessments (Rossello-Nadal, 2014). Research utilizing these methods center around the availability of a destination's optimal physical condition under climate change impacts and its effect on destination attractiveness. Studies on snow reliability (Dawson and Scott, 2007; Steiger et al., 2019; Scott et al., 2020) or climatic comfort appropriateness for outdoor tourist activities (Mieczkowski, 1985; Scott and McBoyle, 2001; Scott et al., 2016, 2019) can be listed in this category. The Tourism Climate Index (TCI) developed by Mieczkowski (1985) is the most widely used methodology for assessing climate suitability for tourism activities.

Statistical models seek to establish a statistical relationship between demand and climate variables (Hamilton and Tol, 2007). These models use regression techniques based on the correlations between variables to estimate future demand under changing climatic conditions (Hein et al., 2009; Day et al., 2013; Köberl et al., 2016).

Several econometric models have been adopted by climate change and tourism studies, such as the Time Series Analysis or Computable General Equilibrium (CGE) models. Time series analysis, applied from a perspective of tourism and climate change, aims to uncover any relationship between tourism demand patterns and weather events (Rossello-Nadal, 2014). This approach is based on the assessment of past trends and predictions for

the future. Econometric models focus on the direct costs and benefits of climate change. Computable General Equilibrium (CGE) models have been applied by climate change and tourism studies to analyze economic impacts, including climate change as a shock to the economy (ex: Barrittella et al., 2006; Hamilton and Tol, 2007; Priego et al., 2015).

Tourism demand models provide a simulation of future tourism demand based on socio-economic and climatic projections. The most popular tourism demand model is the "Hamburg Tourism Model" (HTM) developed by Hamilton et al. (2005a, b) to simulate future global tourism flow under climate change conditions. Bujosa et al. (2015) utilized a destination choice model for Spain they had developed based on domestic travel surveys to predict future tourism demand shifts under different climate change scenarios. Another significant study by Seetanah and Fauzel (2019) expanded the classical international tourism demand model by including climate variables (precipitation and temperature) and investigated the impact of climate change on SIDS.

Most climate change and tourism impact assessments are global and based on comparison of different nations, with limited country-specific research. However, different states have destinations with different natural, climatic, and tourism attributes within their borders. In recent years, alternative and experience-seeking tourism demand has risen, with a focus on unique local attributes. In this environment, local and sub-regional assessments would be of greater help in defining region-specific risk and opportunities and managing incentives and encouragements wisely. The destination-comparison approach may thus play a guiding role in national tourism strategies, which would be beneficial in managing the impacts of climate change in particularly tourism-dependent countries.

4 Climate change impact assessment on tourism demand in Turkey

Turkey is located in the Mediterranean climate zone, one of the regions highly exposed to climate change risks (UNWTO and UNEP, 2008; IPCC, 2018). The country's rising tourism sector will thus come under threat from climate change, and while the impacts of global warming on the tourism sector may not be negative in the short term, in the long term its adverse effects are expected to be more destructive. Climate projections made using the IPCC scenario estimate a dramatic increase in temperatures, which inevitably will result in decreasing comfort levels and extremely hot summer periods (TDGM, 2015). Viner and Agnew (1999) state that the number of extreme heat days above 40°C along the Mediterranean coasts of Turkey will increase by 2100. This change is likely to cause coastal regions to lose their climatic attractiveness. Summer tourism may consequently lose its popularity, with tourism demand potentially shifting to alternative regions and tourism types and the peak tourism period to spring and autumn. Changing meteorological conditions, extreme weather events, and disasters may result in the loss of the unique natural habitats and environments that comprise the most important component of the tourism sector. The increasing risk of forest fires may cause loss of ecosystems, putting eco-tourism under risk (Gülbahar, 2008; Sevim & Ünlüönen, 2010; Aydemir & Şenerol, 2014).

The coastal regions of Turkey are also vulnerable to sea level rise resulting from climate change. Although the nation doesn't have as high a risk as SIDS or tropical regions, a 1-m rise would lead to salination, erosion, storm damage, and coastal flooding (Karaca and Nicholls, 2008). Such a rise in sea level would threaten the coastline's natural heritage, beaches, businesses, investments, and infrastructure (Somuncu, 2018).

A PESETA research project study on climate change impacts on European tourism, including that of Turkey, based on TCI changes over years indicated that climate comfort levels will increase in Northern and Western Europe, while summer climate conditions worsen in Southern Europe, including along the Aegean and Mediterranean coasts of Turkey, and that the negative impacts would be more significant toward the end of 21st century. (Ciscar et al., 2009). As Russia, Germany, and the UK are the top three northern countries that favor Turkey for tourism activities due to its warm climate, historical background, and pleasant beaches and environment (Turkish Ministry of Culture and Tourism, 2019), these projected changes in tourist preferences are likely to cause a decline in the number of international tourists in Turkey and put stress on tourism-dependent markets.

Although there has been research on the potential impacts of climate change on Turkey's tourism sector, quantitative studies on this topic are limited. This study aims to assess the quantitative impacts of changing climatic conditions on international tourism demand, looking in particular at regional comfort levels. For this purpose, the study compares different tourism destinations that offer different tourism types in order to determine those most negatively affected. This comprehensive study is significant as the first quantitative tourism demand assessment model that includes a multi-regional comparison for Turkey. It will help guide future investments and development strategies in national and regional tourism plans. The achievement of tourism development is only possible when climate change impact assessments direct strategies to eliminate risks and exploit potential.

4.1 Case study area

Tourism activities vary in Turkey, ranging from sea-sand-sun summer tourism that take advantage of its picturesque beaches and pleasant climate, nature tourism resulting from its unique natural heritage, culture and belief tourism due to its multicultural and historical background, and skiing, trekking, and mountain tourism because of its geographical advantages. We have chosen the case study regions in accordance with three major criteria. First, we focused on open-air tourism activities dependent on and greatly affected by outdoor climate conditions and comfort levels. We therefore eliminated health, congress, and expo tourism. Winter (ski) tourism has not been included because the fundamental condition for winter tourism is snow accumulation rather than climate comfort, which is an issue in the domain of completely different research. Secondly, we examined the "Tourism Strategic Plan for 2023 and Action Plan for 2007–2013 for Turkey" prepared by the Turkish Ministry of Culture and Tourism, which addresses the thematic development of tourism centers in Turkey and highlights major tourism destinations and the strategic development of tourism. Thirdly, taking into consideration the domestic and international tourist numbers over the 10 year period between 2008 and 2017, we evaluated the ratio of international tourists to the whole and selected the cities that hosted the majority of these visitors. Table 1 presents the list of the case study cities and their featured tourism types, while Fig. 1 displays the locations of the provinces in which these cities are located. As seen in the figure, the case study cities are samples of different geographical regions with different climatic and tourism-related attributes.

4.2 Methodology and data

In order to assess the impact of climate change on Turkey's tourism sector, the study was designed with two stages. In the first stage, climatic conditions related to tourism were

Fig. 1 Locations of the case study cities in Turkey

Table 1 The selected cities and their tourism themes

Selected city	Theme
ADANA	Culture & belief
ADIYAMAN	Culture & thermal, culture & belief
AMASYA	Culture & belief
ANKARA	City tourism
ANTALYA	Present tourism center, city tourism, cruise
AYDIN	Present tourism center, cruise, culture & thermal
BALIKESİR	Culture & thermal
BOLU	Eco-tourism
BURSA	Culture & thermal, culture & belief
ÇANAKKALE	Culture & thermal
DENİZLİ	Culture & thermal
EDİRNE	Culture & belief
ESKİŞEHİR	Culture & thermal
GAZİANTEP	Culture & thermal, culture & belief
HATAY	Culture & belief
İSTANBUL	City tourism, cruise
İZMİR	Present tourism center, city tourism, cruise, culture & belief
KARS	Culture & belief
KONYA	Eco-tourism, culture & belief
KÜTAHYA	Culture & belief
MANİSA	Culture & belief
MARDİN	Culture & thermal, culture & belief
MERSİN	Cruise, eco-tourism, culture & belief
MUĞLA	Present tourism center
NEVŞEHİR	Culture & thermal

Table 1 (continued)

Selected city	Theme
SAMSUN	Cruise
ŞANLIURFA	Culture & thermal, culture & belief
SİVAS	Culture & belief
TRABZON	Cruise, upland tourism
VAN	Culture & thermal

assessed for each case study city. Mieczkowski's Tourism Climate Index (TCI) (1985) was used to evaluate the suitability of the cities' current climate conditions for general tourism activities and simulate their future suitability in a climate change scenario. The second stage involved linking climate conditions and tourist flow to provide an analysis of the impacts of changing climate conditions on tourism demand. The model developed by Hein et al. (2009) was used to forecast the future number of tourists and the percentage change in tourism demand for each case study city.

TCI is used to assess climate suitability for general outdoor tourism based on 7 climate variables. It is one of the most commonly used methods for quantifying climate change impacts because of its comprehensive approach, with variables including thermal comfort, the aesthetic sense of sunlight, and the physical aspects of wind, rain and humidity. Because different tourism activities require different climatic conditions, a single tourism demand index is not capable of assessing climate change impacts on these tourism activities together. However, the focus of TCI is on general outdoor tourism activities. Despite some shortcomings, the index is one of the most appropriate methodologies for the creation of a macro-scale assessment not specialized for any specific activity. Using accessible data from current meteorological statistics and climate change models (Grillakis et al., 2016), TCI has a holistic aspect that can be utilized to compare destinations objectively (Scott et al., 2016). Furthermore, the seasonality and TCI results for popular tourism destinations are compatible, which makes TCI the preferred method for predicting tourist demand (Rossello-Nadal, 2014). As this study involves a macro-scale comparative perspective which doesn't focus on a single tourism type but a diversity of outdoor tourism alternatives, TCI is the most appropriate methodology.

Table 2 Tourism Climate Index (TCI) scores (Mieczkowski, 1985)

Numeric Value of Index (Score)	Description of Comfort Level	Categories
90-100	Ideal	EXCELLENT
80-89	Excellent	
70-79	Very good	VERY GOOD
60-69	Good	GOOD
50-59	Acceptable	ACCEPTABLE
40-49	Marginal	
30-39	Unfavorable	UNFAVORABLE
20-29	Very unfavorable	
10-19	Extremely unfavorable	
9-(-30)	Impossible	IMPOSSIBLE

Table 3 The variables of the model

	Parameters	Data	Source
V	Number of international tourist overnights	Average monthly number of foreign tourist overnights for 2007-2017	Turkish Ministry of Culture and Tourism Statistics
A	Attractiveness factor	Relative factor when the climate is similar in all regions	Calculated by authors for this study
C	Monthly climate	Monthly TCI results	Author's study submitted to Climatic Change
r	Region	30 case study cities	–
m	Month	12 months of a year	–
λ	Scaling parameter	Calibration for the reference year variables	–
α	coefficient	Calibration for the reference year variables	–
β	coefficient	Calibration for the reference year variables	–
u	Disturbance (error) term	All other non-climatic factors	–
e	Natural logarithm	All other non-climatic factors	–

TCI assessments give ratings between -30 and 100 indicating the suitability of climate conditions to tourism activities (Table 2). Using monthly meteorological variables, TCI ratings were compiled for each month and each case study city for the reference period (1963-2017) and for the projected periods 2040–2069, representing the 2050s, and 2070–2099, representing the 2080s. For the purpose of projection, two different time periods were selected to represent both medium-term and long-term impacts and determine breaking points. The projections cover a period of 30 years, which is a significant period for a climate change study in accordance with both the literature and global climate change projections (Scott et al., 2004; Amelung and Viner, 2006; Moreno and Amelung, 2009; Hein et al., 2009).

The TCI scores of each month and each city were adopted as independent variables for a regression model to estimate change in tourism demand. The regression model has three main variables; *tourism demand*, data on the number of overnight visitors, *the intrinsic attractiveness of the destination*, a comparative parameter created only for specific regions, and *the climate factor*, comprising the TCI scores. The data set fit perfectly with the panel data analysis. After trial and error, the *one-way random effect model* was selected for the evaluation. Hein et al. (2009) used the log-log regressing model for the same evaluation; however, the data were more suited to panel data analysis. The model was correlated using base period TCI results, and future demand was predicted through projected TCI results. This model is useful for integrating the index results for tourism demand with the quantified results. It stabilizes the non-climate factors, considering climate as the only variable, and is the most commonly used method in climate change tourism literature. Since this study primarily compares the impact of climate change in different regions, this model was the most appropriate for achieving relative results among the case study cities

In this model, tourism flow is assumed to be dependent on two main factors: (i) the destination's intrinsic attractiveness and (ii) its climate conditions. The non-climatic factors are assumed to be constant. High tourist demand for a destination with somewhat suitable climate conditions can be explained by attractiveness. Tourism destination choice is assumed to be based on joint consideration of these two factors. The variables used in this model are explained in Table 3. The equation is as follows:

$$V_{r,m} = \lambda \bullet A_r^{\alpha} \bullet C_{r,m}^{\beta} \bullet e^{u_{r,m}}$$

where V represents the number of international tourist overnights in a specific region *(r)* and in a specific month *(m)*. For each case study city, the average of monthly foreign tourist overnights for 2008-2017 were used as reference points in order to eliminate exogenous factors affecting the number of tourists.

A is the intrinsic attractiveness parameter of a destination, representing all attributes of a region unrelated to its climate. This parameter is used to isolate the climate factor from all others such as landscape, nature, culture, facilities, services, accessibility, etc. A is calculated for current tourist flow and assumed to be constant over time. For this reason, any investment over time meant to increase the attractiveness of a destination and any change in tourist preferences for tourism activities are underrepresented.

C is the climate factor of a specific region for a specific month. A region's TCI results were used as an indicator of climate factors for both current and future models.

α, β and λ are calculated through model calibration for the current monthly tourist demand for the case study cities and are considered constant factors over time. e^u represents all other non-climatic factors expressed as a disturbance (error) term.

For each case study city, the meteorological data were gathered from the Turkish General Directorate of Meteorology through an official document supplied by the institution to the authors for the period between 1963 and 2017, the largest available data range for each variable. This period served as reference (base) year conditions. Climate change projection data were subsequently obtained from the Turkish General Directorate of Meteorology (TGDM, 2015). These data were prepared based on the HadGEM2-ES Model, RCP4.5 scenario with a 20km resolution, and the downscaled regional climate model RegCM4.3.4. The RCP4.5 scenario represents a rise in temperature of 1.1–2.6 °C in the period between 2081 and 2100 in comparison with 1986–2005. It projects that the global average temperature will exceed values prior to the Industrial Revolution by more than 1.5 °C (high confidence) but less than 4 °C (medium confidence). Meteorological data concerning forecasted seasonal anomalies between 2040 and 2099 were also obtained for each city and each month. Two periods within these data were scrutinized: 2040–2069, representing the 2050s (medium term) and 2070–2099, representing the 2080s (long term)

Tourism statistics on the number of international tourists and overnights per month between 2008 and 2017 were obtained from the Turkish Ministry of Culture and Tourism (Table 4). The averages of the monthly tourist overnights for each city were used to estimate future tourism demand. Using the average of these numbers over ten years instead of only one allowed for the elimination of non-climatic external factors that can cause critical fluctuations in the number of visitors in different years and gave more reliable results on seasonality and the general characteristics of Turkey's attractiveness. From a tourism perspective, an average over ten years is valid for statistical studies, as it has already used in the studies of Hewer, Scott, and Fenech (2016) and Hewer and Gough (2016).

4.3 Empirical findings

The TCI assessment projected dramatic changes in Turkey, as shown in Fig. 2 (reference) and Fig. 3a (2050s) and b (2080s). In the reference period, the TCI ratings were lowest in winter, highest in spring and autumn, and acceptable in summer along the coastline and good or very good inland. However, the TCI ratings for the projected periods dropped sharply in all seasons except winter, which saw an increase. Due to overheating, comfort levels will decline by 2099, especially in the most popular tourism seasons. The coastline had lower ratings than inland. The 2050 and 2080s had similar results, with winter climate suitability higher and autumn lower in the far future. The TCI model results provide insights into the physical climate change impacts on tourism destinations through a consideration of outdoor comfort levels and their possible impacts on tourism demand. The TCI scores were used to assess the changes in tourism demand resulting from changes in TCI ratings.

A comparison of the proportion of monthly visitors to each city under a constant TCI variable helped to evaluate the relative attractiveness of the destinations independent of climate. However, it was not possible to find the same TCI score within the same month for all the cities, as these scores vary for each city and each month. Therefore, we evaluated the standard deviations of each month's reference TCI scores to find the specific month that offered the smallest difference in proximate TCI levels for each city. Table 5 shows the standard deviations for each month.

April was found to contain the smallest deviation; its attractiveness was thus assumed to be more independent of climate and the only determinant of tourist visits. An A value

Table 4 The average of international tourist overnights between 2008 and 2017

CITIES	Jan.	Feb.	Marc.	April	May	June	July	Aug.	Sept.	0ct.	Nov.	Dec.
ADANA	7854	7501	9716	10,259	10,628	10,067	9549	10,186	10,778	11,270	8895	7563
ADIYAMAN	181	136	249	998	1386	1143	874	1067	1503	1204	472	297
AMASYA	532	425	909	1007	1297	1112	1733	2867	1266	854	766	569
ANKARA	56,563	58,234	69,628	69,221	80,593	72,245	73,937	70,283	79,153	73,213	67,396	61,607
ANTALYA	1,483,160	1,659,150	2,222,014	3,338,215	6,458,388	7,565,533	8,151,777	8,134,524	7,879,579	6,334,378	2,338,754	1,608,717
AYDIN	60,500	69,280	108,880	168,909	383,138	488,424	516,566	514,179	541,992	284,592	105,006	101,617
BALIKESİR	14,861	17,668	24,701	29,713	35,697	31,530	32,717	32,185	39,608	28,112	22,388	18,318
BOLU	3122	2929	2904	3715	3809	5676	11,399	11,568	6037	3762	2714	3484
BURSA	38,989	24,919	30,491	33,723	35,295	40,920	62,247	73,991	47,618	40,503	35,274	35,530
ÇANAKKALE	9831	10,374	14,965	26,367	32,969	32,175	32,453	36,400	33,054	29,137	17,965	15,118
DENİZLİ	39,418	50,210	70,088	79,091	74,025	69,032	63,203	68,568	71,772	82,973	65,458	50,282
EDİRNE	1716	1712	2725	3044	3626	3984	5235	6025	4331	3863	2927	2523
ESKİŞEHİR	2363	2584	3115	2735	2986	2889	3528	3373	3307	3060	2930	2033
GAZİANTEP	10,738	11,185	12,547	12,254	14,139	12,675	13,546	13,354	13,705	14,317	11,808	12,609
HATAY	10,329	9228	10,427	11,001	12,047	11,614	13,047	14,891	14,470	13,080	11,252	11,380
İSTANBUL	806,302	862,348	1,126,167	1,197,509	1,272,488	1,089,990	1,222,439	1,430,878	1,361,225	1,264,237	1,063,575	950,583
İZMİR	65,030	72,894	99,102	168,635	244,980	272,848	301,049	354,903	321,636	263,282	107,024	86,520
KARS	1358	1621	1190	801	1620	1743	1724	1944	2928	1340	946	843
KONYA	8879	9682	14,402	17,357	18,674	18,689	13,023	14,504	18,266	18,637	12,404	15,337
KÜTAHYA	842	759	850	1371	974	1435	1495	1456	1343	1753	997	962
MANİSA	3126	2493	3873	3465	4101	3723	3234	4029	3673	3090	2645	2671
MARDİN	1123	1115	1913	1901	2496	1949	2049	2463	2524	2168	1703	1474
MERSİN	11,189	10,596	12,785	12,625	21,559	28,159	37,149	38,127	35,390	19,912	13,203	14,022
MUĞLA	69,408	54,185	114,063	548,559	1,786,826	2,163,270	2,287,256	2,360,881	2,218,951	1,413,860	107,841	103,304
NEVŞEHİR	44,429	62,744	108,354	151,895	154,378	109,170	98,286	114,119	144,753	132,895	99,815	64,206
SAMSUN	1689	1949	2710	2210	2198	2405	4819	3964	2355	2646	2454	1707
SİVAS	495	467	1172	778	1143	936	1237	1591	973	786	680	434

Table 4 (continued)

CITIES	Jan.	Feb.	Marc.	April	May	June	July	Aug.	Sept.	0ct.	Nov.	Dec.
ŞANLIURFA	2183	2186	2804	3187	4222	3101	3132	3331	4536	3814	2309	2563
TRABZON	11,495	10,966	19,838	16,362	20,054	23,850	40,753	45,746	31,156	18,450	12,617	10,865
VAN	2649	4609	10,304	5072	6049	9471	9252	11,868	13,487	8179	5327	4401
TOTAL	7854	7501	9716	10,259	10,628	10,067	9549	10,186	10,778	11,270	8895	7563

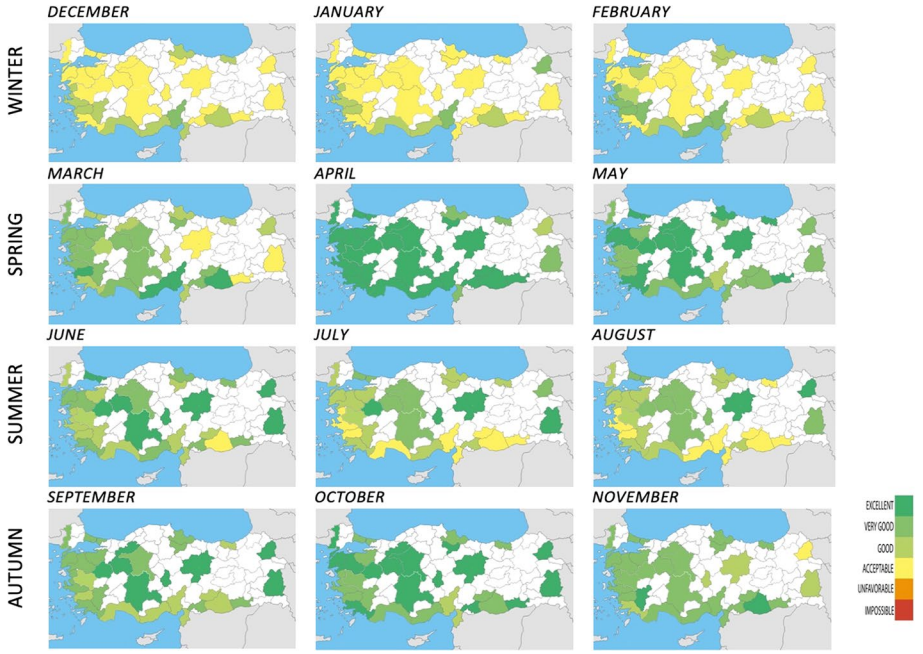

Fig. 2 The reference period's TCI results

was generated for each case study city by comparing the international tourist overnights in April (Table 6).

The minimum TCI was 68 in Kars, and the maximum 88 in Mersin. The disparity between these values was significant, with those of Kars significantly lower than most of the cities, resulting in an underestimation of its attractiveness. However, this difference can be ignored for April, as the deviations are smallest then. The results revealed a wide range in values for the cities, with Antalya having the highest attractiveness multiplier, followed by İstanbul and Muğla (shown in bold in Table 6), with Adıyaman possessing the lowest.

After the establishment of the A values, the model was calibrated using the TCI scores of the reference period and the average number of international overnights from 2008 to 2017 through a "one-way random effect model." The scaling parameter λ and coefficients α and β were subsequently estimated to be 11,64, 0,99, and 0,92, respectively, where the model is significant with $n = 360$; $R^2 = 0{,}89$; and $p < 0{,}001$, as seen in Table 7 [1].

Using the model formula and the projected TCI scores for each month and city, international tourist flows were projected for the periods 2040–2069 and 2070–2099, forecasting the average change within them. The output of the model indicates a decrease in total overnights in Turkey, as shown in Table 8. While winter overnights increase in parallel with the increase in TCI values for that season, summer overnights clearly decline. In the coming decades, the pattern and amount of tourist flow into Turkey will clearly undergo major changes due to the impacts of climate change

[1] The structure of the panel data regression was determined to be a "unit effective one-way random effect model" through the Hausman Test. The panel data consists of a 12-month period, 30 regions, and 1360 observations. The coefficient estimations were obtained via the STATA and EViews software

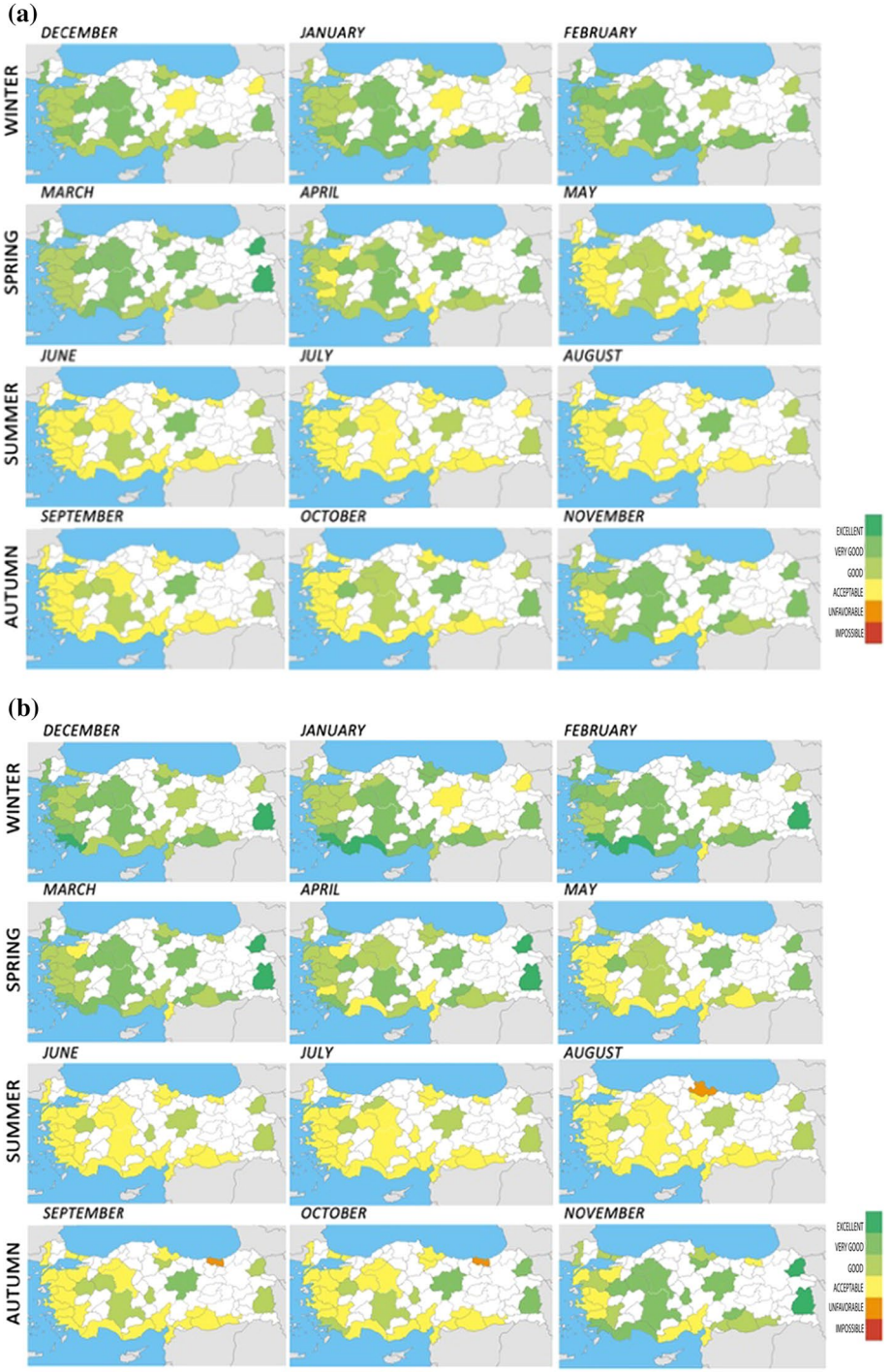

Fig. 3 TCI results for the a) 2050s (2040-2069) and b) 2080s (2070-2099)

Table 5 Standard deviation of TCI scores of case study cities by month

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
6,36	6,83	7,00	3,89	6,13	8,09	8,98	8,72	8,63	6,27	5,2	6,97

Table 6 Relative attractiveness factor (A) for each city

CITY	# OF OVERNIGHTS	TCI (BASE YEAR)	A FACTOR (10^{-3})
ADANA	10,259	83	1.73
ADIYAMAN	998	84	0.16
AMASYA	1007	82	0.17
ANKARA	69,221	83	11.70
ANTALYA	**3,338,215**	**85**	**564.67**
AYDIN	168,909	83	28.57
BALIKESİR	29,713	84	5.02
BOLU	3715	80	0.62
BURSA	33,723	80	5.70
ÇANAKKALE	26,367	84	4.46
DENİZLİ	79,091	85	13.37
EDİRNE	3044	84	0.51
ESKİŞEHİR	2735	83	0.46
GAZİANTEP	12,254	86	2.07
HATAY	11,001	75	1.86
İSTANBUL	**1,197,509**	**83**	**202.56**
İZMİR	168,635	85	28.52
KARS	801	68	0.13
KONYA	17,357	86	2.93
KÜTAHYA	1371	81	0.23
MANİSA	3465	84	0.58
MARDİN	1901	81	0.32
MERSİN	12,625	88	2.13
MUĞLA	**548,559**	**84**	**92.79**
NEVŞEHİR	151,895	80	25.69
SAMSUN	2210	78	0.37
SİVAS	778	80	0.13
ŞANLIURFA	3187	86	0.53
TRABZON	16,362	79	2.76
VAN	5072	78	0.85

Table 7 Summary Output of Panel Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN-A	0.987197	0.018451	53.50483	0.0000
LN-C	0.917438	0.155561	5.897629	0.0000
LN-λ	11.64088	0.670810	17.35347	0.0000

Table 8 Projected percentage of change in tourist overnights during the 2050 and 2080s

CITIES		JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
Adana	2050s	48	46	−2	−11	−22	−22	−18	−21	−28	−33	−4	28	−6
	2080s	38	46	1	−11	−22	−22	−18	−21	−26	−40	−26	30	−9
Adıyaman	2050s	392	670	355	11	−26	−17	0	−18	−41	−21	134	218	**24**
	2080s	384	681	355	11	−26	−23	−2	−23	−41	−26	137	218	**22**
Amasya	2050s	107	175	24	8	−25	−14	−47	−67	−29	14	55	93	−7
	2080s	112	175	27	8	−25	−19	−50	−70	−25	10	56	93	−8
Ankara	2050s	27	27	1	2	−23	−22	−22	−17	−28	−13	12	17	−5
	2080s	27	27	1	−1	−23	−20	−22	−23	−25	−23	8	17	−7
Antalya	2050s	133	82	52	−8	−57	−68	−72	−70	−69	−69	38	77	−42
	2080s	152	111	52	−21	−60	−67	−72	−72	−69	−71	36	67	−42
Aydın	2050s	186	128	35	−16	−67	−74	−75	−76	−76	−55	23	68	−50
	2080s	186	131	35	−18	−67	−74	−76	−76	−76	−58	23	64	−50
Balıkesir	2050s	99	71	16	−11	−28	−27	−29	−28	−40	−18	30	55	−4
	2080s	93	78	15	−3	−28	−27	−31	−29	−42	−24	25	61	−4
Bolu	2050s	26	17	38	1	−9	−48	−71	−72	−44	−5	49	13	−30
	2080s	23	45	38	1	−6	−46	−69	−72	−44	−16	45	15	−28
Bursa	2050s	−17	34	1	−17	−28	−39	−59	−65	−46	−40	−15	−10	−32
	2080s	−17	36	−4	−17	−21	−39	−59	−65	−48	−46	−18	−10	−33
Çanakkale	2050s	153	163	73	−6	−33	−34	−41	−45	−37	−29	36	74	−5
	2080s	160	163	73	−3	−31	−34	−39	−42	−41	−29	26	78	−4
Denizli	2050s	103	62	5	−12	−10	−16	−5	−10	−7	−23	16	61	**7**
	2080s	108	64	5	−12	−13	−13	−5	−12	−10	−23	10	63	**7**
Edirne	2050s	82	100	19	−2	−27	−44	−55	−60	−37	−36	2	29	−19
	2080s	87	100	19	−2	−27	−44	−56	−60	−42	−36	7	29	−19
Eskişehir	2050s	29	21	−5	−3	−12	−16	−29	−26	−21	−12	1	46	−5
	2080s	29	23	−5	6	−12	−13	−30	−27	−23	−19	4	46	−5

Table 8 (continued)

CITIES		JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
Gaziantep	2050s	17	23	1	1	−24	−15	−25	-27	−23	−26	8	0	−9
	2080s	18	23	3	4	−22	−21	−31	−29	−28	−29	4	2	−10
Hatay	2050s	−1	8	−21	−30	−33	−29	−37	−45	−47	−43	−28	−9	−28
	2080s	−1	6	−28	−25	−30	−29	−38	−45	−48	−47	−28	−9	−29
İstanbul	2050s	33	32	3	−5	−18	−15	−23	−38	−35	−32	2	7	−11
	2080s	30	33	2	−3	−18	−16	−28	−37	−38	−27	5	15	−10
İzmir	2050s	135	107	48	−13	−47	−56	−59	−66	−57	−54	20	84	−31
	2080s	145	116	48	−13	−42	−54	−60	−66	−60	−52	25	94	−29
Kars	2050s	−47	−52	−16	17	−49	−54	−56	−60	−71	−36	1	−11	−45
	2080s	−46	−50	−14	28	−42	−52	−52	−58	−72	−33	6	−5	−42
Konya	2050s	117	106	31	6	−14	−14	16	4	−10	−9	55	23	**17**
	2080s	117	106	27	6	−9	−19	14	2	−11	−10	55	26	**16**
Kütahya	2050s	65	109	86	10	47	−7	−7	−7	2	−15	57	55	**23**
	2080s	74	109	86	15	55	−2	−8	−9	2	−17	61	57	**25**
Manisa	2050s	7	36	−15	−13	−30	−26	−14	−30	−15	−15	12	29	−9
	2080s	10	33	−17	−7	−28	−23	−14	−33	−23	−7	19	33	−8
Mardin	2050s	70	88	7	−2	−27	−14	−22	−39	−34	−20	19	33	−4
	2080s	75	88	7	4	−27	−14	−26	−40	−34	−19	19	28	−4
Mersin	2050s	26	24	−6	−10	−53	−66	−75	−76	−73	−52	−18	−18	−49
	2080s	17	27	−3	−10	−53	-66	−75	−76	−73	−51	−18	−16	−49
Muğla	2050s	561	759	308	−13	−75	−82	−82	−83	−80	−71	325	351	−60
	2080s	759	1037	411	−1	−74	−81	−82	−83	−81	−66	415	483	−54
Nevşehir	2050s	251	158	44	−3	−10	27	33	14	2	10	60	143	**38**
	2080s	259	158	44	0	−8	25	31	12	−5	1	52	143	**36**

Table 8 (continued)

CITIES		JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
Samsun	2050s	37	25	−24	−1	−10	−19	−67	−60	−29	−34	−13	32	−23
	2080s	40	23	−24	−1	−8	−26	−66	−73	−31	−41	−16	30	−26
Sivas	2050s	32	68	−22	21	−22	−5	−36	−46	−9	16	35	58	−5
	2080s	41	71	−22	21	−22	−10	−36	−49	−9	9	34	74	−6
Şanlıurfa	2050s	64	74	18	−5	−35	−18	−22	−26	−44	−30	34	39	−4
	2080s	64	74	18	−2	−35	−18	−22	−25	−45	−31	34	45	−4
Trabzon	2050s	45	60	−15	−14	−31	−50	−74	−78	−66	−45	6	45	−38
	2080s	45	60	−20	−12	−28	−46	−74	−77	−69	−48	2	45	−39
Van	2050s	110	24	−40	17	−9	−44	−47	−59	−61	−34	11	33	−27
	2080s	121	37	−37	27	−5	−44	−48	−60	−62	−33	14	41	−24
TR	2050s	**110**	**80**	**41**	**−8**	**−54**	**−63**	**−67**	**−67**	**−65**	**−61**	**34**	**62**	**−37**
	2080s	**125**	**102**	**44**	**−14**	**−55**	**−63**	**−67**	**−69**	**−66**	**−61**	**36**	**64**	**−37**

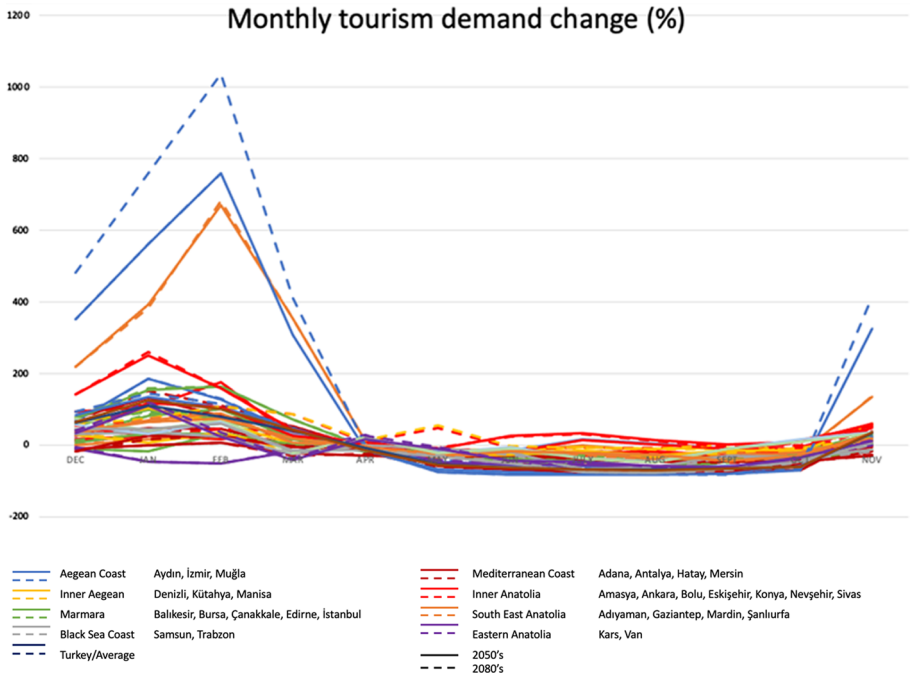

Fig. 4 Monthly tourism demand change (%).

As shown in Table 8; Figs. 3 and 4, there is no significant difference between the projections for the 2050 and 2080s; however, the drop in overall tourism demand is significant. While the acceleration of this decline from the reference period to the 2050s is very striking, it falls to a very insignificant level between the 2050 and 2080s. These results indicate that Turkey will in all likelihood experience its highest exposure to potential climate change impacts on tourism in the mid-term and that the country may not have until the long-term projection period to respond to these shifts; in other words, intense negative impacts may be observed in the mid-term. Moreover, the projection reveals that, because of increased temperatures, the increase in tourism demand may be slightly higher in winter in the 2080s than in the 2050s. Although the rate of increase in winter tourism between the 2050 and 2080s is small, it highlights a gradually increasing seasonality change. Accordingly, urgent adaptation to seasonal shifts in tourism and coordination in the winter season may be of the utmost importance (Fig. 5).

The shift in seasonal patterns is similar in every region, with the increased demand in winter for the Aegean coast (Aydın, İzmir, and Muğla), South East Anatolia (Adıyaman, Gaziantep, Mardin, and Şanlıurfa), and Inner Anatolia – Cappadocia (Amasya, Ankara, Bolu, Eskişehir, Konya, Nevşehir, and Sivas) standing out. In the summer period, Inner Anatolia – Cappadocia (Amasya, Ankara, Bolu, Eskişehir, Konya, Nevşehir, and Sivas), the Inner Aegean (Denizli, Kütahya, and Manisa), and South East Anatolia (Adıyaman, Gaziantep, Mardin, and Şanlıurfa) are slightly on positive side of the graph. According to the total change results, Inner Anatolia – Cappadocia (Amasya, Ankara, Bolu, Eskişehir, Konya, Nevşehir, and Sivas), the Inner Aegean (Denizli, Kütahya, and Manisa), and South East Anatolia (Adıyaman, Gaziantep, Mardin, and Şanlıurfa) fare well, with increasing or static demand ratios. The highest decline was observed in the Aegean (Aydın, İzmir,

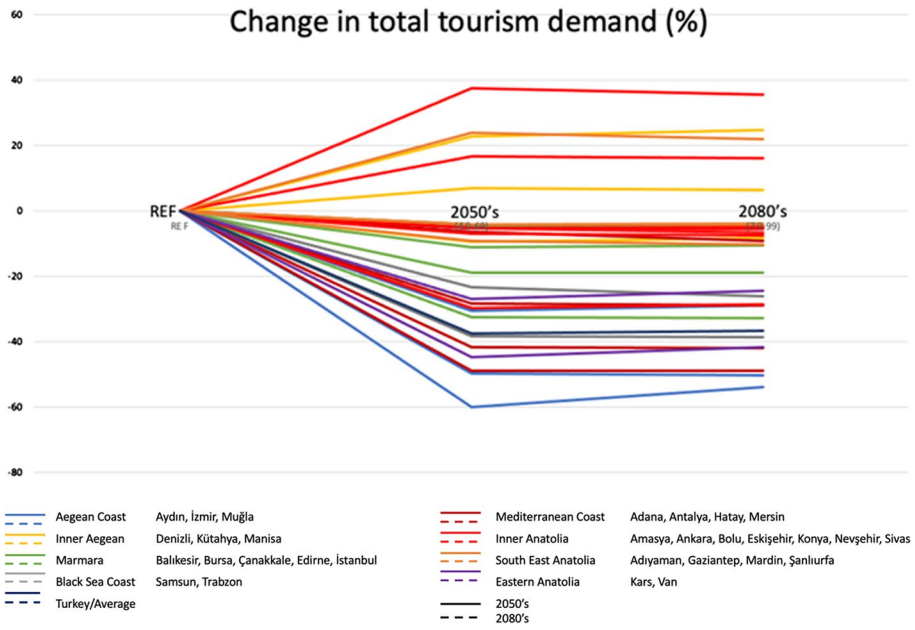

Fig. 5 Total tourism demand change (%).

and Muğla) and Mediterranean (Adana, Antalya, Hatay, and Mersin) coasts, the Black Sea coast (Samsun and Trabzon), and Eastern Anatolia (Kars and Van).

As displayed in Table 8; Figs. 3 and 4, the rate of change in winter tourism demand is significantly higher than that of summer tourism demand. Specifically, in Muğla (a popular destination on the Aegean coast), despite a clear increase in the rate of in winter demand and a relatively low drop in the rate of summer demand, the total tourism demand decreases sharply. Underlying this result are the low tourism demand in winter and high tourism demand in summer in the reference period, along with the high A factor multiplier of specific destinations. This result implies a higher potential in winter period for highly attractive tourism destinations.

Figure 6, which portrays these shifts in detail, indicates that in winter, the number of overnight tourists will probably increase on the coastline, Inner Anatolia, and almost all over Turkey except in Bursa, Mersin, Hatay, Gaziantep, and Kars in December; Bursa, Hatay, and Kars in January; and Kars in February in projections for both the 2050 and 2080s. The negative impacts intensify toward the end of spring season, especially on the Mediterranean and Aegean coasts in Aydın, Muğla, Antalya, and Mersin, where the most popular summer tourism destinations are located. Kütahya is the only city that maintains its positive tendency during spring. Summer has the most striking yearly outcomes, with a potential drop in the number of tourists in every city except Nevşehir, Konya (in July and August), and Adıyaman (in July). The decline in overnights totals more than 50% along the western and southern coastlines in all summer months, as well as on the Black Sea coast in July and August. Based on these estimations, the most significant decrease may take place in September and October on the Mediterranean and Aegean coasts. However, toward November, the number of tourists' overnights increases gradually. These results

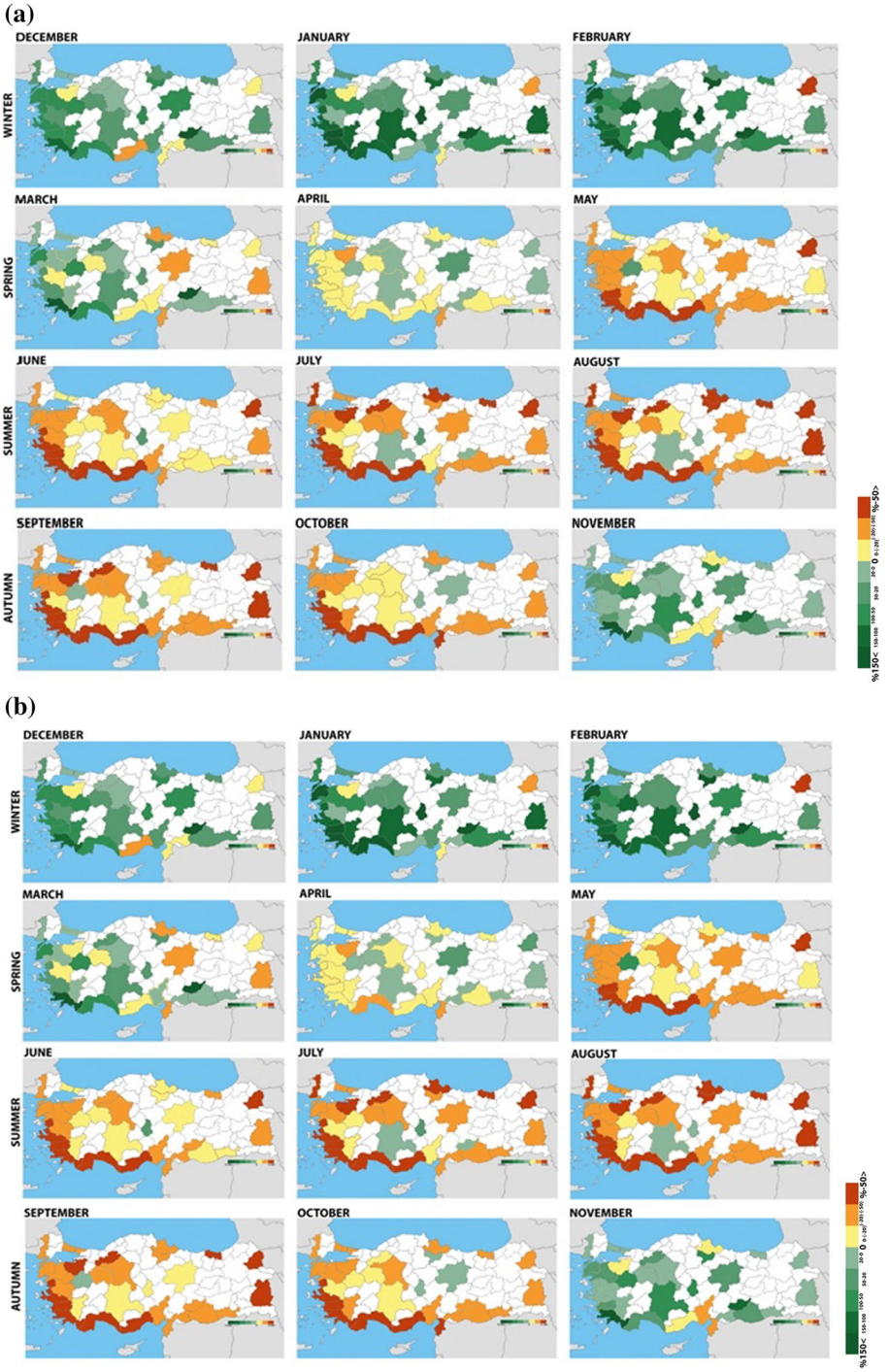

Fig. 6 Percentage change in the number of overnights each month for **a** the 2050s **b** the 2080s.

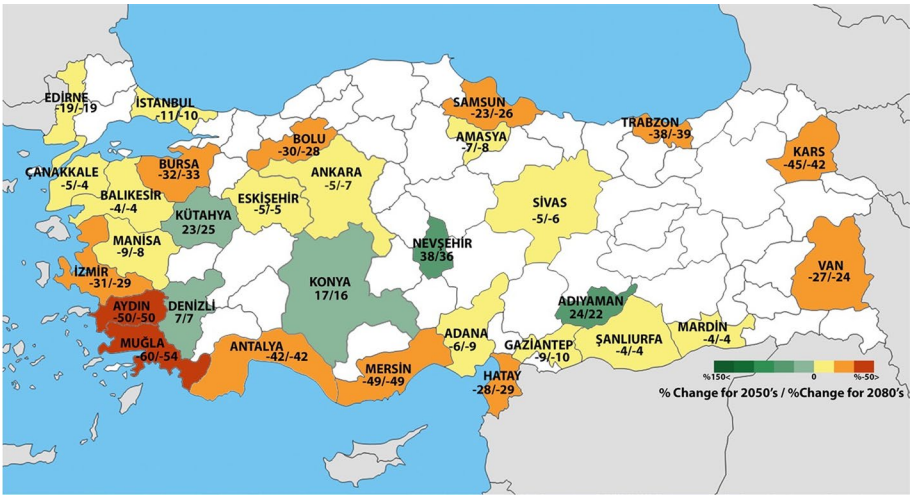

Fig. 7 Percentage change in the overall number of overnights

are compatible with the TCI results, with increasing comfort levels in winter resulting in increasing tourist numbers and declining TCI numbers in summer having the opposite effect.

Since the case study area covers 98.37% of all international tourist overnights, the averages of these changes can also provide insights into overall shifts in Turkey. According to the results of the model, overall tourist flow will likely decline 37% by 2050, with highest drop observed in August, the most popular tourism month of the reference period. In general, the potential decrease in the summer period is substantial; however, there may be a commensurate rise in overnights in the winter period, especially in January. The largest likely loss of tourist flow will be seen in Muğla, Aydın, Mersin, Kars, and Antalya, where the drop in tourist demand could reach roughly 50%, with the largest dips in the summer season. On the other hand, there could be a rise in tourist numbers in winter, though this potential gain is not as large as the loss. A significant decrease is also observed in Trabzon, Bursa, İzmir, Bolu, Hatay, and Van, which could lose more than 30% of its reference period tourist demand. There are also some cities that will most likely experience rising demand, in particular Nevşehir, Adıyaman, Kütahya, Konya, and Denizli. The tourist flow is likely to increase even in summer in these cities, or decline only slightly. Balıkesir, Sivas, Şanlıurfa, Amasya, Çanakkale, Eskişehir, Adana, Manisa, Ankara, and Mardin all project a less than 10% dip in tourist overnights. Figure 7 shows the overall results of the changing number of overnights per year.

Despite a significant decrease in general tourism demand, Antalya, İstanbul, and Muğla should remain the most popular tourism destinations in Turkey. However, the peak tourism season will likely shift from summer toward winter and spring. The overall number of tourists will presumably decrease in popular destinations; however, the tourism season will be extended throughout the year. On the other hand, the increase in tourism demand in inland regions, while significant, would not match the losses of the coastal destinations. It should be stressed that the rises and declines in tourism demand shown in this evaluation are valid for general tourism activities. Although negative impacts are observed in coastal tourism destinations where beach tourism is dominant, these impacts are unlikely to have such and

adverse effect on beach tourism destinations, where visitors are much more attracted to hot temperatures and therefore more resilient to enhanced warming.

5 Conclusions

The results of this study are consistent with those of others of the mainstream approach in the literature, which predict a shift in tourism demand from summer to winter and a decline in overall tourism demand. However, the results do not indicate a total absence of tourism in the summer, but rather a possible decrease. Although TCI values provide insight into suitable climate conditions for general open air tourism activities, increasing heat may be more tolerable for beach and swimming activities (Rutty and Scott, 2013). On the other hand, the increasing temperatures in winter may prolong the tourism period by lengthening the window of the year in which comfort conditions are suitable. Increasing comfort levels in the inland region and existence of cultural, historical, and natural heritage sites in these regions can generate options for alternative tourism destinations. The most significant outcomes are (i) the shifted peak period, (ii) the prolonged tourism season, (iii) the decreased amount of overall tourism demand, and (iv) the emergence of new alternative destinations.

Tourism investment and development should be governed in accordance with this knowledge. Tourism demand should be managed through adaptation measures in coastal areas, and negative impacts should be eliminated and alternative solutions developed. At the same time, the tourism industry should take advantage of tourism potential in inland areas through infrastructure and superstructure enhancements and the promotion of sustainable values in those regions. Climate change is a threat, but through adaptation and mitigation strategies risk can be diminished and benefits increased. Holistic, comprehensive, sustainable, and climate change-centered master and action tourism plans are needed for the viability of this important economic sector. In the short-term, Turkey's "Tourism Strategic Plan for 2023 and Action Plan for 2007–2013" can contribute to sustainable tourism development and alternative tourism types; however, in the mid- and long term this plan requires revisions that take into consideration climate change impacts on the sector. The 2050s are a critical deadline for the tourism sector in Turkey to take measures and make preparations for the upcoming consequences of climate change.

The TCI is limited by its focus on standard threshold values for comfort rather than on personal perspectives and perceptions of climate; the literature has argued that people from different countries and regions have different perceptions of heat and suitable/comfortable temperatures (Rossello-Nadal, 2014). Another limitation of TCI outlined in the literature is that it is designed for general tourism activities and neglects specific tourism segments such as beach tourism (Scott et al., 2016). Beach tourists might be more tolerant of heat because of their tendency to enjoy the sun and water bathing. The study's results might therefore be reassessed for coastal popular beach tourism destinations in future research using other tourism climate indices designed specifically four beach tourism such as the Climate Index for Tourism (CIT) (De Freitas et al., 2004; 2008), the Holiday Climate Index: Beach (HCI:Beach) (Rutty et al., 2020), the User-Based Beach Climate Index (Morgan et al., 2000), and the Beach Utility Index (BUI) (Georgopoulou et al., 2019).

This study is also limited by its two base assumptions. First, it considers only the direct impacts of climate change, since only the climatic projections of temperature, precipitation, wind, sunshine duration, and humidity were used as variables. However, indirect impacts such as natural degradation, sea level rise, extreme weather events, and global economic

crises will inevitably affect tourism demand in specific destinations. These impacts are excluded in the assessment since the direct effects are more comparable between different geographic, demographic, and social destinations. Secondly, this approach assumes a steady relationship between weather and tourism and holds all other variables constant; however, climate is not the only determinant factor in tourism, and there are other relevant dynamics or external shocks that affect the distribution of tourism demand and spending. The demographic and economic structure of populations, environmental concerns, GHG diminishing policies, new technologies, investment, and global stresses such as wars, epidemic diseases, economic crises, environmental stress, and disasters may alter the preferences of tourists.

In the more specific context of this study, Turkey's location and unstable economic and political situation may affect tourism demand negatively or positively. For example, due to political tensions with Russia in 2015, the number of Russian tourists visiting Turkey decreased in the summer of 2015–2016 (URL-1). Russian tourists comprise the majority of visitors for some cities in Turkey such as Antalya, where the economy is dependent on international tourism and which suffered from a lack of tourist in this period. In addition, bombings and an attempted military coup in 2016 resulted in a significant decline in visitors to Turkey (URL-2). On the other hand, the decreasing value of Turkish Lira against the Euro and US Dollar has made Turkey an affordable destination, especially for European tourists. For this reason, in 2017 and 2018 the number of tourists increased rapidly (URL-3). However, it is not easy to predict the future number of tourists when considering all other non-climatic variables. Moreover, these examples are of instant short-term reactions of tourists to certain situations, while climate change is a long-term, slowly impacting phenomenon that will affect the industry gradually over years. The independent evaluation of climate change will therefore provide clearer future scenarios for decision makers. The emphasis of this study is on climate as one of the important determinants for tourism demand as regards destination choice, time of travel, and engagement in activities. In this way, the strategic requirements for the adaptation of the sector to the ongoing climate crisis can be addressed.

This study is important as a leading document for the future of Turkey's tourism industry under climate change impacts. It fills a gap in knowledge on the interaction between tourism and climate change and its possible impacts on various regions in Turkey. Moreover, it stands as sample research for tourism destinations in the Mediterranean Basin, where similar impacts are expected, serving as a benchmark study for similar climate and tourism regions. The methods of this paper have produced a comparative result among case study regions and can easily be adapted to other regions, countries of different scales, or micro-climate zones within a region to evaluate the relative effects of climate change. In the literature, most studies on tourism demand and climate change are based on national or global comparisons or focused on a specific tourism type. This study compares different climate zones and includes different tourism types within a country in order to help direct the investments and measures adequately on a national level. Its methods can be used by any country with an economy that relies on tourism revenue to manage its resources and determine the risks and opportunities of climate change. The results of this study also highlight the greater negative impacts of climate change in coastal tourism cities, which require special attention. As stated in climate projections, increased temperatures will cause seasonal shifts, changes in tourism peak periods, and declines in overall tourism demand in coastal regions, which will be particularly devastating in southern Turkey. There are opportunities that can be turned to the benefit of tourism at the same time that there are risks in

climate change scenarios. The determination of these risks and opportunities can illuminate the path to climate change adaptation for tourism development.

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