



HOW CLIMATE CHANGE WILL SHAPE DESTINATION IMAGE: A PRELIMINARY STUDY

Abstract

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Purpose – Climate change is set to significantly transform the tourism industry, which is particularly sensitive to variations in weather conditions. As global temperatures increase, the attractiveness of certain destinations may shift, potentially affecting their perceived image and competitive positioning. This study presents an exploratory analysis of the relationship between climate change, specifically rising temperatures, and destination image (DI), a critical component of the tourism system.

Methodology/Design/Approach – The study focuses on the Mediterranean region, one of the regions most affected by climate change, where four major tourism destinations are found: Portugal, Spain, Italy, and Greece. The Climate Index for Tourism (CIT) is applied to assess the relationship between climate conditions and tourism suitability quantitatively. Datasets of climate projections up to 2100 were obtained from the Copernicus Climate Data Store and post-processed with Python scripts.

Findings – Results reveal substantial shifts in the distribution of CIT-rated days (Fair, Good, and Unfavourable) from May to October. These changes likely impact tourists' perceptions and the image of the studied destinations.

Originality of the research – This paper establishes a connection between climate science and tourism marketing by incorporating climate projections within the examination of DI.

Keywords: Destination image; Climate change; Climate index for tourism; Copernicus climate data store

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INTRODUCTION

Tourism is heavily dependent on natural resources, and as a global phenomenon, it influences and is influenced by global environmental change (Gössling et al., 2006). Tourism can have global environmental consequences that can be categorised into physical and psychological effects, with changes in the perception and understanding of the environment being one of several consequences (Gössling, 2002). In the 'Djerba Declaration on Tourism and Climate Change' of 2003, the World Tourism Organization (WTO) acknowledged the intricate connections between tourism and climate change (2003, 1), "having carefully considered the complex relationships between tourism and climate change, and particularly the impacts that the latter are producing upon different types of tourism destinations...". As tourism is highly vulnerable to weather changes and considered a climate-dependent sector, the effects of climate change are set to significantly alter the tourism industry in the near future (Gössling, 2002; Gössling & Hall, 2006). International reports, including the European Commission's report (2022), the Tourism and Climate Change Stocktake report (IPCC, 2023), and the WTTC's roadmap for further industry collaboration and collective advancement in a climate change scenario (WTTC, 2015), emphasise the urgent need to prioritize sustainability issues into tourism corporate governance and executive leadership.

Climate plays a significant role in shaping tourism demand and visitor satisfaction, making evaluating climatic suitability essential for tourism-related decision-making. By assessing climate conditions, tourism planners can more effectively identify appropriate destinations for development and integrate climate considerations into infrastructure planning and program design (De Freitas, Scott & McBoyle, 2008). Different approaches can examine the relationship between tourism and climate change. According to Hamilton et al. (2005), there are two primary perspectives to consider: (1) the perspective of tourists, which focuses on analyzing their preferences, and (2) the perspective of destinations, which evaluates how their attractiveness changes with varying climate conditions and management strategies. Additionally, Hamilton and Tol (2004) identified three main approaches in tourism research that examine the influence of climate and weather: studies on destination image (DI), climate index studies, and daily-use models of recreational sites.

Since climate plays a crucial role in shaping tourism demand and visitor satisfaction, it is essential to evaluate how suitable a region's climate is for tourism to support informed decision-making by both tourists and industry stakeholders. By doing so (De Freitas, Scott & McBoyle, 2008), tourism planners can more effectively assess a destination's potential for development and integrate climate considerations into infrastructure planning and strategic programming. While the relationship between climate change and tourism has been widely explored in terms of demand, seasonality, and destination suitability (e.g. Amelung & Viner, 2006; Scott, Gössling & Hall, 2012), much less attention has been devoted to its implications for DI. Although climate and weather are recognized as influential attributes in DI formation (Beerli & Martín, 2004; Gallarza et al., 2002), empirical research connecting projected climate changes to the perceptual and branding dimensions of destinations remains limited. Addressing this gap, the present study integrates climate projection data with the conceptual field of DI to explore how

environmental transformations may influence the future image and marketing of Mediterranean destinations. In this context, the main research question is: How might projected climate changes impact the key elements of DI that tourists perceive? There is an urgent need for further research to conceptualize and accurately measure climate as a component of DI, especially as global climate variability increasingly influences tourist perceptions and behaviors. This preliminary study aims to explore how climate change projections may shape DI in the future and that is important to consider new directions for promoting tourism destinations and establishing their brands, requiring adaptive marketing strategies.

1. LITERATURE REVIEW

1.1 Climate Change and the tourism system

The relationship between tourism and the changing climate has been discussed and studied for a relatively long time in tourism research (Kaján & Saarinen, 2013; Pang et al., 2013). Climate is simultaneously a 'push' and a 'pull' factor in tourism and for some destinations, it represents the primary attraction on which tourism is grounded (Scott et al., 2004). Nevertheless, according to some in relation to other economic sectors (e.g., agriculture and forestry), "tourism has received far less attention by the climate change impacts research community, irrespective of its current and growing significance to the global economy" (Scott et al., 2004, 106). According to Pang et al. (2013), the first recognised tourism academic to write about the potential impact of climate change on tourism and recreation, particularly in wetlands, was Wall (1998). In this paper, two main groups were considered with the potential to adapt to climate change: tourists (participants) and the tourism industry, where the "former is likely to be much more adaptable than the latter" (Wall, 1998, 371). For this author, destinations that are more dependent on natural resources to attract tourists (such as mountains, coasts, or wetlands) are likely to suffer more from climate change than those that rely more on cultural attractions.

In fact, tourism, being a weather-dependent industry, will be affected by climate change (Pang et al., 2013). For that reason, as argued by (Scott, D., Gössling, S., Hall, 2012a) the notion of complex interrelationships between climate change and the various components of the tourism system is crucial when considering the impacts of climate change. As argued by Hall and Higham, (2005), assessing the relationship between tourism and climate change requires a comprehensive approach that considers the entire tourism consumption and production system rather than focusing solely on specific, isolated components, no matter how significant they may be. As these changes unfold, tourism policymakers are urged more than ever to account for climate impacts when designing resilient and sustainable tourism systems (Zhou et al., 2024).

From a global perspective, climate change will have a significant impact on the tourism industry due to its inherent vulnerabilities (Day et al., 2021). It exerts substantial pressure on the sector by altering environmental and socio-economic conditions that shape tourist behavior and influence the appeal of various destinations. From the supply side, climate change poses risks to tourism infrastructure, natural attractions, recreational activities, and the overall accessibility of destinations. On the demand side, changing climatic conditions affect visitor comfort, increase health risks, and alter the seasonality of destinations. These factors significantly influence tourists' choices regarding where to travel (Tanrisever et al., 2024). In this context, climate can be regarded as a vital tourism resource that can be both measured and utilized (De Freitas, 2001), serving as a valuable asset for the industry that can be quantified.

Climate change is expected to impact travel behavior by altering conditions for holidaymaking at various destinations, as well as by influencing how tourists perceive climate variables in terms of comfort (Gössling et al., 2006). For that, climate plays a crucial role in tourism demand. De Freitas (2003) states that individuals will only engage in tourism activities if they view the climate as suitable. According to him, due to the voluntary and discretionary nature of tourism, participation tends to decline when discomfort or dissatisfaction increases. Consequently, satisfaction significantly influences participation, which can be seen as an indicator of demand for the climatic resource, often referred to as the demand factor.

In 1999, Lohmann and Kaim noted that there was a lack of empirical evidence on the importance of the climate in destination choice decision-making. Nevertheless, the landscape is shifting, with a notable rise in interest regarding tourism's impact on the climate over the past decade (Becken & Wilson, 2013; Chen et al., 2017). Zhou et al.'s (2024) meta-analysis study shows that in the last two decades, several studies have focused on the impact that climate, as a non-price factor, might have on tourism demand by altering destinations' natural attributes, weather events, thermal comfort, and the feasible tourism activities allowed.

1.2 Exploring climate in DI studies

The foundational work of scholars such as Gunn (1972, cited in Rodrigues et al, 2012) and Hunt (1975) was crucial in establishing DI as a distinct research field. Gunn (1972, p. 24, cited in Rodrigues et al., 2012, 135) notably stated, "through traveler's perceptions, we can learn more about how land qualities become tourism resources," emphasizing the importance of perception in shaping tourism experiences. This initial insight generated considerable scholarly interest, leading researchers such as Crompton (1979) and Goodrich (1978) to explore further new frameworks for analyzing DI. The concept quickly gained prominence for its substantial influence on tourist behavior. A review of various definitions of DI (Rodrigues et al. 2017, Rodrigues, 2015) reveals its inherently ambiguous, eclectic, and multifaceted nature, often described as an 'umbrella construct' (Rodrigues et al., 2017) that means different things to different people. One of the most frequently cited definitions comes from Crompton (1979), who characterized DI as a composite of beliefs, ideas, and impressions about a destination. This perspective

was further developed by Phelps (1986), who also focused on impressions and perceptions, and by Gartner (1989), who regarded DI as a 'complex combination of components'. Echtner and Ritchie (1993) reinforced the holistic nature of DI, arguing that it encompasses a wide range of attributes and calling for a more comprehensive conceptualization to fully capture its dimensions. Gallarza et al. (2002) proposed four key characteristics of the DI construct: complexity (it is not straightforward or singular), multiplicity (in both elements and processes), relativism (subjective and often comparative), and dynamism (changing over time and space). These attributes laid the groundwork for the first comprehensive theoretical framework in the field. According to Bigne et al. (2001), DI is the subjective interpretation of reality within the tourist's mind.

Assessing the significance of destination characteristics that have universal importance in influencing tourists' evaluations of the attractiveness of any tourism destination was a key focus of Hu and Ritchie's (1993) study. Reviewing several studies from the 1970s, they found that 'natural beauty and climate' were consistently regarded as essential factors in defining a destination's attractiveness. However, even though several studies advocate that climate change may affect the relative attractiveness of destinations (Beerli & Martin, 2004; Echtner & Ritchie, 1993; Gallarza et al., 2002), the attention devoted by the literature to climate change and tourism has been quite limited (Bigano et al., 2005). Among the 142 DI studies reviewed by Pike (2002, cited by Hamilton & Tol, 2004), only one, by Lohmann and Kaim (1999), specifically addressed weather, highlighting the limited empirical evidence on its influence in destination choice decisions. Based on 25 studies from 1975 and 1999 about DI, Gallarza et al. (2002) identified 12 in which climate appears as an attribute. Nevertheless, not all studies considered it relevant (Bigano et al., 2005). Rodrigues (2015) updated the framework of Gallarza et al.'s with 24 studies about DI from 2000 to 2012, of which 15 included climate as an attribute. In Beerli and Martin's (2004) schema, reference to climate/weather appears in one of the nine categories of DI: "natural resources", wherein the following items are highlighted: temperature, rainfall, humidity, and hours of sunshine.

Although DI studies have been focusing on climate/weather as an important attribute, there is a notable lack of discussion regarding the implications of climate change for destination and place branding and image, particularly in regions experiencing rapid environmental changes or where brand values are especially vulnerable (Hall, 2014). This is an important topic to explore in the future since an increasing preference for sustainable brands is shaping tourists' destination choices (Hedlund, 2011). A destination's environmental and socio-economic aspects are intrinsically connected to the overall image of the destination (De Souza et al., 2014). For that reason, destination management companies (DMO) should explore the best way to develop the image and branding of a destination by using the concept of a sustainable image to enhance their competitiveness (Almeida-Santana & Moreno-Gil, 2019).

1.3 Climate change and the various climate indices

Climate indices are essential for assessing tourism destinations, supporting demand forecasting, and planning tourism activities. Among these are the Climate Index for Tourism (CIT) (De Freitas et al, 2008), the Tourism Climate Index (TCI) (Mieczkowski, 1985), and the Holiday Climate Index (HCI) (Rutty et al., 2020; Scott et al., 2016). These indices have unique characteristics, methodologies, and applications designed for specific tourism contexts and climatic conditions. Climate information for the tourism sector should encompass general climate features and detailed assessments of thermal comfort and aesthetic and physical weather factors (De Freitas, 1990, 2003; De Freitas et al., 2008). Mieczkowski (1985) developed the Tourism Climate Index (TCI) to assess climatic conditions for tourism activities like sightseeing. This marked the first effort to create a numerical index specifically designed to evaluate climates for tourism purposes, integrating seven tourism-related climate variables (Fichett et al., 2016). It has become the most widely used tool for assessing the attractiveness of various tourist destinations and comparing them objectively. Despite the TCI's wide application, it has been criticized substantially (Scott et al., 2016).

To improve upon the limitations of the Thermal Comfort Index (TCI), the Holiday Climate Index (HCI) was created to provide a more accurate evaluation of a destination's climatic suitability for tourism. Unlike the TCI, the HCI is specifically designed to cater to various tourism segments and types of destinations (Scott et al., 2016). It takes into account tourists' stated preferences for different weather elements, including temperature, rainfall, sunshine, and wind. There are different versions of the HCI, such as the HCI: Beach (Rutty et al., 2020) and HCI: Urban (Scott et al., 2016), tailored for specific tourism contexts. The term "holiday" was intentionally chosen to highlight the index's emphasis on leisure tourism. According to Scott et al. (2016), a significant advancement of the HCI is its use of variable rating scales and component weightings, which are based on a growing body of research regarding tourists' climate preferences over the past decade. This approach aligns with the conceptual framework proposed by de Freitas et al. (2008), emphasizing the critical impact of physical factors such as wind and rain. The HCI also uses daily data to evaluate index scores, considering the likelihood of both favorable and unfavorable weather conditions.

A newer index (developed after HCI) aimed to offer a more flexible and comprehensive tool (Climate Index for Tourism-CIT). Verbal expressions of beach users' sensory perceptions of local atmospheric conditions are used to evaluate the physical and aesthetic aspects of the environment (De Freitas, 1990). This scale proved easy to apply in field studies and strongly correlated with more complex assessment methods (Morgan et al., 2020). Gaining insight into climate impacts supports the development of tourism climate indices that encompass multiple climatic dimensions and are grounded in objective evaluation (De Freitas, 2003). For this author, climate information shared with tourists and the tourism industry should go beyond general characteristics, such as monthly and annual averages, to include detailed insights on thermal comfort and aesthetic and physical weather conditions. For that reason, CIT allows for destination-specific customization and can be adapted to different tourism types and climate realities; it often uses monthly data and can be adjusted for regional and seasonal contexts (De Freitas et al., 2008).

2. METHODOLOGY

The Climate Index for Tourism (CIT) was designed to assess tourist perceived satisfaction with climate/weather conditions for “sun, sea and sand” (3S) beach holidays (De Freitas et al., 2008) specifically, beach “sun, sea and sand” (3S). The index is determined by a function of three different type variables: a thermal sensation variable, using the standard ASHRAE thermal sensation scale, an aesthetic variable, reflecting the sky conditions in terms of cloud coverage (ranging from clear to overcast), and a physical variable, defining wind and rain thresholds of intensity and duration. Based on this 3S tourism suitability index, each day is assigned a value from 1 (poor) to 7 (ideal), where days with values 1 to 3 are labelled as unacceptable, 4 as marginal, and 5 to 7 as acceptable (De Freitas et al., 2008) specifically, beach “sun, sea and sand” (3S). The long-term evolution of the number of days in each category within a given region, driven by climate change, serves as an indicator of how tourists’ perceived satisfaction may be impacted. To assess this evolution, the present study considers CIT results derived from projections from a single climate model under two different greenhouse gas emissions and concentration scenarios, and explores how climate, as a component of DI, can shape tourist’s perceived image.

2.1 Study approach

Climate models are representations of the climate system translated into numerical models and solved with the use of supercomputers. According to the incorporated components (atmosphere, ocean, cryosphere and biosphere) the adequate physical equations and principles are implemented in order to provide an approximate representation of the real climate system. The level of detail and complexity in a model is determined by the trade-off between accuracy and computational efficiency required for a particular objective. Long-term forecasts of climatological characteristics such as temperature and precipitation, spanning several decades, are particularly important in the context of the CIT. These simulations require modelling approaches that differ from those used in short-term weather forecasting, which typically operate on a daily scale (Voldoire, 2022). The CNRM-CM5 climate model is an Earth system model designed specifically to run global climate simulations. However, the outcomes of the simulations are highly dependent on the parametrization of certain inputs, referred to as forcings, such as greenhouse gas (GHG) emissions (e.g. CO₂, methane) and land use patterns such as vegetation distribution. Some of these forcings strongly depend on the evolution of human activity (anthropogenic forcings), which is now recognized as a primary driver of climate change by scientific consensus (Lynas et al., 2021). To account for this dependence, several types of evolutions are considered in the simulations, known as Representative Concentration Pathways (RCP) scenarios. Each RCP includes a time series of emissions and concentrations of GHG, aerosols, chemically active gases, and land use/land cover, and represents a possible scenario and path (trajectories over time) to reach a particular change in the atmospheric radiation balance caused by changes in atmospheric constituents (Moss, 2010). Different emission scenarios are projected to produce region-specific variations in climate change. The Mediterranean region, where four major tourism destinations are found, namely, Portugal, Spain, Italy, and Greece, is among the areas most affected by climate change. Projected changes will alter the seasonal weather patterns, leading to increases in heat extremes, heatwaves, and dryness across the region (Orlowsky & Seneviratne, 2011; Ozturk et al., 2015). These climatic shifts are expected to have a significant impact on tourist activities, whether urban (Caldeira & Kastenholz, 2018) or beach-related (Perch-Nielsen, 2009). To quantitatively evaluate the relation between climate change, weather conditions and tourism suitability, the previously described CIT was considered. The index values used in this work were derived from data from two climate projections generated by the global climate model CNRM-CM5 (National Centre for Meteorological Research - UMR 3589, 2023), considering two RCP4.5 and RCP8.5 scenarios. The experiment RCP4.5 assumes that the emissions of GHG start declining beyond 2040, and experiment RCP8.5, is a pessimistic scenario that assumes a continuous rise in emissions throughout the century (Thomson et al., 2011). The CIT results derived from these two possible pathways provide an interesting insight into how different climate scenarios may influence tourist’s perceptions and, consequently, the DI.

2.2. Dataset description & processing workflow

The CIT datasets used in this study were obtained from the Climate Data Store (CDS) provided by the Copernicus programme (European Commission) and implemented by the European Centre for Medium-Range Weather Forecast (Copernicus Climate Change Service, 2019). The data were classified according to the CIT scale, and aggregated into three categories of days, reflecting the index rate: Unfavourable (CIT=1-3), Fair (CIT=4), and Good (CIT=5-7). Eight datasets were requested from the CDS portal corresponding to the periods 2021–2025, 2031–2035, 2041–2045, 2051–2055, 2061–2065, 2071–2075, 2081–2085, and 2091–2095. The dataset associated with each interval of years includes three files corresponding to the number of days per month in each category (Fair, Good, and Unfavourable) for each location (geographic coordinate) in Europe. The data in these files were filtered according to the region of interest (ROI) presented in Figure 1, which was defined by constraining the geographic coordinates of the datasets according to the conditions $-10^{\circ} < \text{lon} < 25^{\circ}$, $45^{\circ} < \text{lat} < 36^{\circ}$. After the filtering process, representative years were selected for further processing to determine the trend in the evolution of the number of days per category throughout the period of study for the ROI.

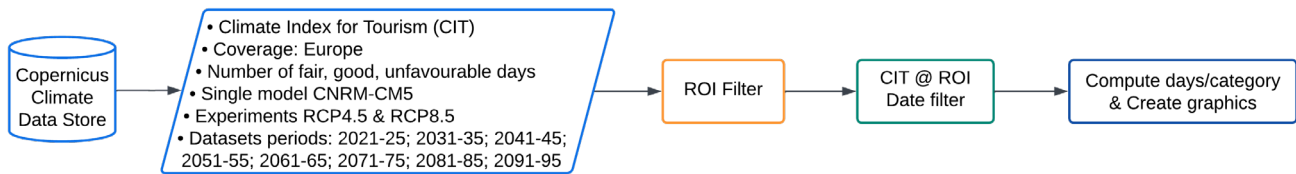
Figure 1: Region of interest (ROI) focusing on Portugal, Spain, Italy, and Greece



Source: OpenStreetMaps (Contributors, 2024).

The datasets containing the CIT values were locally processed on a personal computer (Intel i9, with 64 GB RAM), using scripts written in the Python programming language (Van Rossum & Drake, 2009) and implemented in jupyter notebooks (Kluyver et al., 2016). The Python libraries CliMetLab (Bougeault, 2020), numpy (Harris et al., 2020), pandas (McKinney, 2010), and matplotlib (Hunter, 2007) were used for data processing, basic statistical analysis and chart creation. The workflow is summarized in the diagram presented in Figure 2.

Figure 2: Dataset processing workflow



Source: Own elaboration

For each RCP scenario the final output of the processing workflow provides, for each geographic location within the ROI, the number of days in each category (Fair, Good, and Unfavourable), expressed as both the average per month (for years 2035, 2065, and 2095), and the total average per year (from 2035 to 2095).

3. RESULTS AND DISCUSSION

The goal of the previously described data processing is to assess the impact of climate change, under two different emissions scenarios, on an index that reflects 3S tourism suitability in the region under study. For that purpose, the available data were filtered and combined to create a visual representation of the trends in the evolution of the average number of days per category, per month, at each geographical point, for three representative years distributed over a 60-year period. Figure 3 shows the evolution plots obtained for the years 2035, 2065, and 2095, under RCP4.6 and RCP8.5 scenarios, from which the following observations emerge: (i) there is a distinct “window” of Good & Fair days, from May to October; this is consistent with the expected period more suitable for 3S tourism in the ROI, typically spanning from June to September; (ii) the peak of Good days does not appear to change significantly; (iii) there is a noticeable change in the number of Fair and Unfavourable days inside the “window”; in fact, the data suggest a shift from Unfavourable days toward Fair days, a trend that is even more pronounced under RCP8.5; (iv) under scenario RCP8.5 the number of Good days exhibits a distinct pattern, with an increase observed in the months of May and October. These results suggest that RCP induced climate change may enhance 3S tourism suitability according to the CIT, particularly under RCP8.5, which shows an increase in the number of Good days within the optimal seasonal “window”. The observed decrease in the number of Unfavourable days, accompanied by the increase in the number of Fair days, is also relevant. To better understand the dynamics of these variations, Figure 4 shows plots of the yearly average total number days per category over the period 2035-2095, under RCP4.5 and RCP8.5 scenarios. To assess data trends, linear fits were computed, and the corresponding Pearson correlation coefficient (r) was used to evaluate the Goodness of fit. The slope of each linear fit, representing the rate of change per year, was used to define the rate δ (days/decade). Important findings for both RCP scenarios based on the linear fits:

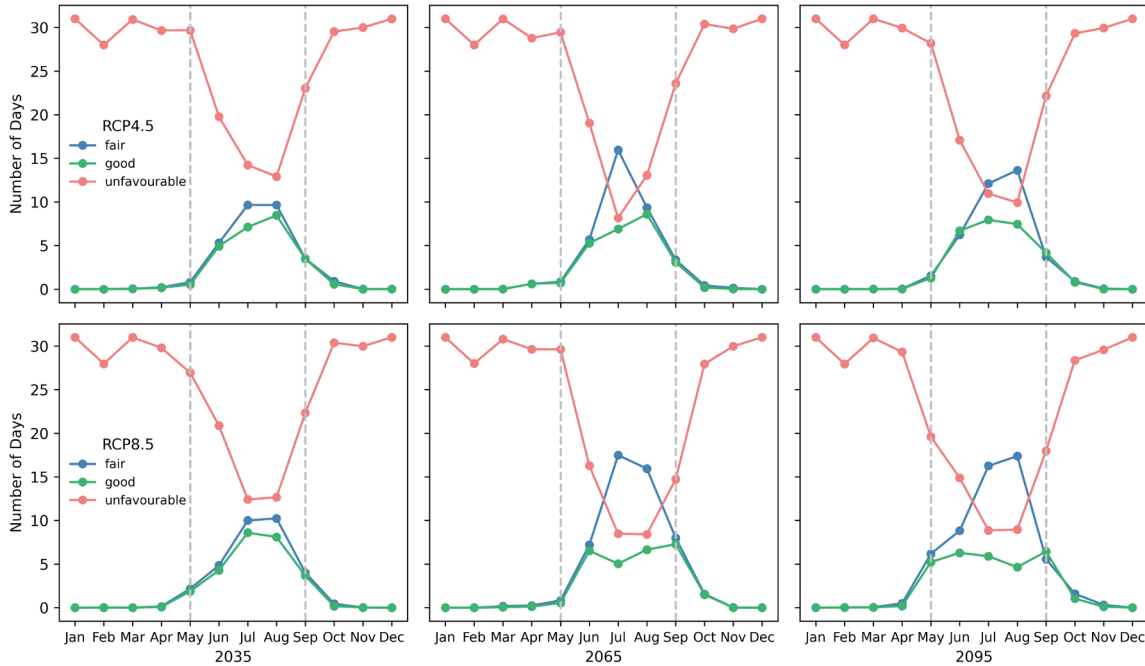
- There is a weak temporal correlation ($r < 0.4$) between the number Good days and the years, with growth rates of 0.5 days per decade, confirming the trend suggested by Figure 3 and indicating that the number of Good days will not change significantly in either scenario;
- The number of Fair days show a positive temporal correlation ($r > 0$), and the number of Unfavourable days a negative temporal correlation ($r < 0$). However, in the case of RCP4.5 both correlations are weak ($|r| < 0.3$) and in the case of RCP8.5 both are strong ($|r| \approx 0.8$). This explains the coupled trends observed in Figure 3 for these two categories of days.

The suggested shift between days from category Unfavourable to Fair is now evident. In fact, as showed below, for both RCP, the rate of change of Unfavourable days (in absolute value) is (approximately) equal to the sum of the rate of change of Good and Fair days ($|\delta_{unf}| = \delta_{Good} + \delta_{Fair}$):

$$\begin{aligned} \text{RCP4.5: } & \delta_{unf} = -0.8; \delta_{Good} = 0.5; \delta_{Fair} = 0.5; |-0.8| \approx 0.4 + 0.5 \\ \text{RCP8.5: } & \delta_{unf} = -4.7; \delta_{Good} = 0.4; \delta_{Fair} = 4.3; |-4.7| = 0.4 + 4.3 \end{aligned}$$

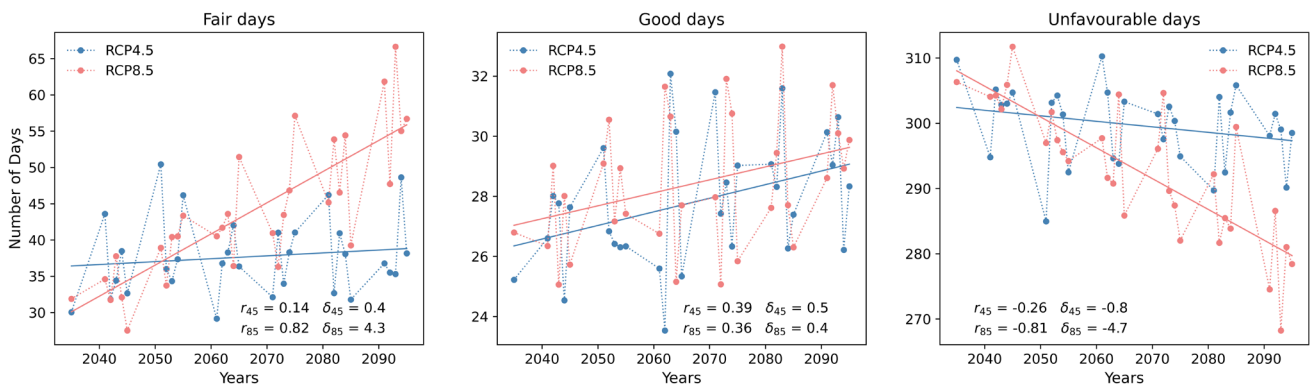
This numerical evidence clarifies the coupled variation of Unfavourable and Fair days observed in Figure 3 and reinforces the conclusion that, according to the CIT criteria, countries in the ROI are likely to benefit from the projected average temperature increase. Overall, for the period of 60 years, the number of Good days doesn't show a significant variation ($\approx +3$) under both RCP. However, under RCP8.5 the Fair days show an increase of 26 days, for the same period.

Figure 3: Average number of days per category for the points within the ROI for RCP4.5 & RCP8.5 scenarios. The window of Good & Fair days is identified by the vertical dashed grey lines.



Source: Own elaboration

Figure 4: Trends of the yearly average of total number days per category over the period 2035-2095 under RCP4.5 and RCP8.5 scenarios. Solid lines represent the linear fit, r and δ are the Pearson correlation coefficient and the rate of variation of days per 10 years, respectively.

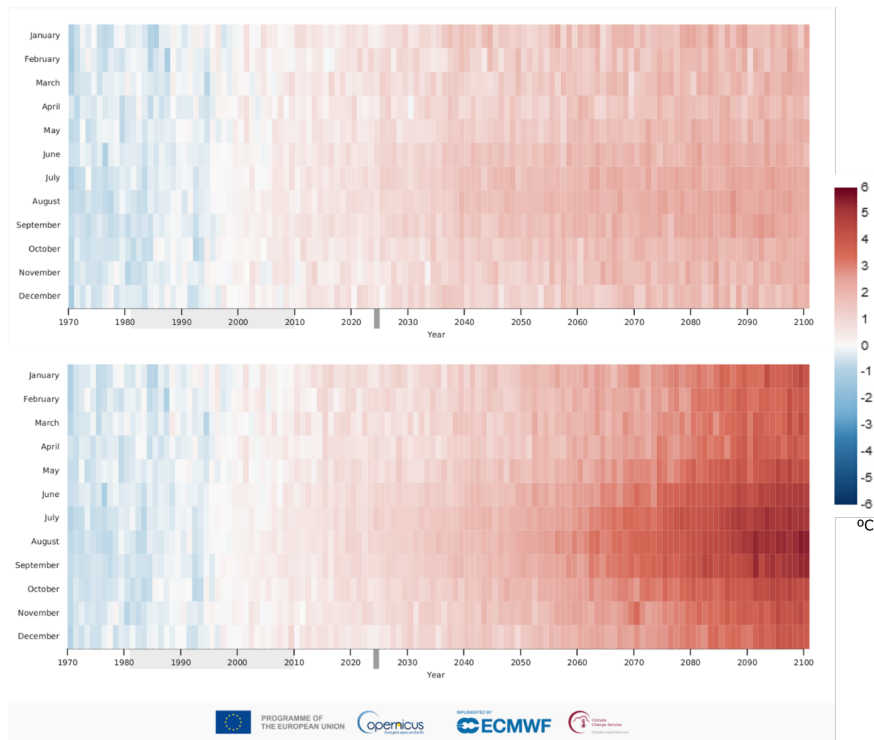


Source: Own elaboration

These results should be interpreted in the context of climate change and, in particular, the projected increase in temperature. The charts in Figure 5 corresponding to the intra-annual variability across the months for the period 1970-2100 for the Mediterranean region. The seasonal stripes show the projected change in the monthly mean of daily mean near-surface (2 m) air temperature values relative to the baseline period 1981-2010. mean monthly temperature values relative to the baseline period 1981-2010, and the mean of daily mean near-surface (2 m) air temperature. Each coloured cell represents the median of the EURO-CORDEX ensemble model output (Copernicus Climate Change Service, 2022), for the mean spatial values of the

region under study. As expected, the RCP8.5 scenario shows higher values for the change in temperature due to the continuous increase in GHG emissions after 2040, whereas in the case of RCP4.5, the emissions start to decrease after 2040 and, therefore, the temperature increase is lower. Under scenario RCP8.5, after 2060, the increase in the temperature is more pronounced as indicated by the concentration of dark red cells, particularly from May to October (the previously identified window), with an average increase of +4.9 °C for this period. On the other hand, the RCP4.5 scenario shows an average temperature increase of +2.3 °C over the same period, which is less than half of the corresponding value in the RCP8.5 scenario, and reflects the impact of the decrease in GHG emissions after 2040. Table 1 summarises the values for the year 2095 (the last year of the study period) for both scenarios. The projections indicate a greater increase in temperature during the May-October window, particularly under the RCP8.5 scenario. It is therefore plausible that these changes, especially during the summer months, will influence the perceived suitability for 3S tourism.

Figure 5: Seasonal stripes - Mean of daily mean temperature (°C) - CORDEX-EUR-11 Change relative to 1981-2010 - RCP4.5 (Top) RCP8.5 (Bottom)



Source: C3S/ECMWF

Table 1: Mean temperature (°C) for 2095 from CORDEX-EUR-11 (relative to 1981-2010) - Monthly for Mediterranean

Scenario	Quantity	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
RCP4.5	Change	1.69	1.83	1.91	1.71	2.11	2.38	2.43	2.47	2.38	2.13	2.34	1.44
	Climatology	9.92	10.8	12.85	15.40	19.03	23.26	26.44	26.73	23.70	19.28	15.09	10.99
RCP8.5	Change	3.75	3.51	3.38	3.86	4.62	4.87	4.96	5.32	4.78	4.58	4.52	4.19
	Climatology	12.15	12.66	14.49	17.69	21.65	28.53	29.03	29.58	26.09	21.75	17.36	13.90

Source: own elaboration (extracted from seasonal stripes, Change & Climatology): <https://atlas.climate.copernicus.eu/atlas>

Due to CIT's dependence on temperature through the thermal sensation parameter of the ASHRAE scale (De Freitas et al., 2008) specifically, beach "sun, sea and sand" (3S), changes in this parameter due to temperature increase are expected to cause changes in the distribution of days across the index categories. The increase in temperature, particularly during the months of May and October, may be responsible for the rise in the number of Fair days observed in 2065 and 2095 for those months, especially under the RCP8.5 scenario (Figure 3). On the other hand, it is understandable that the overall change in Good days remains low ($\delta_{8.5} = 0.4$ days/decade, $\delta_{4.5} = 0.5$ days/decade). The temperature increase induced by climate change may contribute to extreme values on the ASHRAE thermal sensation scale in some locations within the ROI, thus decreasing the CIT rating for those locations. Table 2 shows the projected increases in temperature for Portugal, Spain, Italy and Greece during the May-October window, under RCP8.5. The expected increases in the average temperatures ranges from 4.92 °C to 5.47 °C. Notably, during the summer months, the rise may reach up to 6.29 °C, as observed in Greece during August. Such elevated temperatures are not expected to contribute to an increase in the number of Good days during this period, as they negatively impact the index values, pushing them beyond the optimal range for 3S tourism suitability.

Table 2: Mean temperature (°C) for 2095 under RCP8.5 from CORDEX-EUR-11 (relative to 1981-2010) – Monthly for Portugal, Spain, Italy and Greece

	Quantity	May	Jun.	Jul.	Aug.	Sep.	Oct.	Average
Portugal	Change	4.58	4.59	4.70	5.51	5.35	4.81	4.92
	Climatology	19.20	23.05	26.49	27.52	24.48	19.50	23.37
Italy	Change	5.13	5.22	5.19	5.98	4.81	4.83	5.19
	Climatology	18.81	23.45	26.60	27.07	21.81	17.09	22.47
Spain	Change	5.25	5.20	5.19	6.07	5.82	5.07	5.43
	Climatology	18.52	22.87	26.43	27.22	23.17	17.55	22.63
Greece	Change	5.30	5.43	6.02	6.29	4.98	4.81	5.47
	Climatology	21.07	25.86	29.92	29.86	24.37	19.22	25.05

Source: own elaboration (extracted from seasonal stripes, Change & Climatology): <https://atlas.climate.copernicus.eu/atlas>

Despite the overall temperature increase, climate change appears to “promote” days within the ROI from Unfavourable to Fair, particularly within the May–October window and under the RCP8.5 scenario. A deeper understanding of the “promotion & demotion” dynamics would require a granular analysis of sub-regions within the ROI, focusing on location-specific changes in the number of days per category to identify local trends. Nonetheless, the current results confirm a clear relationship between climate change and tourists’ perceived satisfaction with a 3S tourism destination, as evaluated by the CIT. This is evident from the observed changes in the number of days per category resulting from the climate projections. Such local-level shifts will have implications for DI management and may require the recalibration of operational strategies.

CONCLUSION

The CIT datasets used in this study were derived from a single climate model under two RCP scenarios (4.5 and 8.5). As such, the discussion focused on trend analysis and the differences between the two projections. To overcome this limitation, future research should incorporate data from an ensemble of climate models to better estimate uncertainties and provide a more robust understanding of CIT dynamics. Nonetheless, based on the observed trends, the following considerations can be made:

- (i) Over the 60-year study period (2035-2095) under RCP8.5 scenario, the distribution of days across CIT categories Fair and Unfavourable shows significant shifts between May and October, with pronounced changes during the Summer months. Additionally, by 2095, the number of Good days in May and September increases to levels comparable to those observed during the summer months.
- (ii) These trends during the high-season period for 3S tourism in the Mediterranean region are likely to impact the tourism system, as the push-pull climate factors influencing international destination choice will be affected. This will require a more versatile and adaptive sector. In this context, it will be essential to further explore how the climatic conditions of tourism destinations can be effectively communicated to potential visitors. Appealing weather patterns should be emphasized, while less favourable conditions must also be conveyed transparently to manage tourists’ expectations and minimize potential dissatisfaction. As such, the DI, serving as a dynamic tool in marketing communication, should be continuously adapted and refined to reflect these evolving scenarios.
- (iii) The index outputs should be presented in a format that is easily understandable for both tourists and the industry. In the future, it will be essential for destinations to provide more detailed information about climate conditions on their websites, as these changes will influence tourists’ perceptions and the overall image of the destination. As a result, we can expect shifts in temporal and geographical trends in tourism demand, which will affect the competitiveness of various destinations.
- (iv) As noted by Scott, Gössling, and Hall (2012), it is crucial to understand the tourism system as a whole when evaluating the impacts of climate change. This preliminary study aims to focus on DI, which is a central aspect of the tourism system affected by the consequences of climate change. It is likely to see a geographic and seasonal redistribution of climate resources, and the way this aligns with tourist demand will have diverse implications for international tourism.
- (v) The possibility that the CIT scale is biased due to the non-representative sample of tourists (young adults from one country) used during its development, should be considered. This limitation, acknowledged by the index authors, may distort the results when assessing the 3S tourism suitability for a different population (e.g. from the region under study). The anticipated changes in the index scale are expected to become apparent once thorough validation processes are applied, taking into account factors such as cultural differences, variations in age groups, and gender considerations. This comprehensive approach will ensure that the scale accurately reflects the diverse experiences and perspectives of all individuals.

- (vi) Destination Management Organizations (DMOs) must adopt a sustainable branding approach that reflects the impacts of climate change. By integrating insights from environmental shifts, DMOs can adjust their marketing campaigns to promote eco-friendly practices, local culture, and sustainable tourism. This strategy enhances the destination's appeal while encouraging responsible travel.

Tourism is a multisectoral industry that significantly impacts both the economy and society. However, as previously mentioned, climate change is expected to reshape the landscape of tourism. The dynamics of supply and demand on the destination side will be influenced by these changes, especially regarding how tourists perceive different locations. This preliminary study aims to explore how climate change may shape DI in the future and that is important to consider new directions for promoting tourism destinations and establishing their brands, requiring adaptive marketing strategies. A new climate change communication in destination branding should be considered in the future (Stankov et al., 2023).

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Statement

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