

# Tourism and adaptation to climate change: an indicator for a climate-sensitive destination

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## Abstract

Climate change has and will have an increasing impact on a destination's tourism activities in the future. In order to best plan strategies to adapt to the changing conditions, it is necessary to have reliable and easily interpretable data. This is the role of a climate indicator that represents how favorable or unfavorable these conditions are for a tourist.

## Introduction

In recent years, dramatic events have profoundly transformed the world of tourism, affecting the way people travel and choose destinations. Today, climate change poses an even more significant threat to the entire industry. Tourists, who are seeking more environmentally friendly travel options, are increasingly focused on the weather conditions they may find on their itineraries. Meanwhile, many destinations are facing the effects, some already significantly present, of climate change, such as rising sea levels, reduced snow cover or extreme weather conditions. The phenomenon, popular in the media, is often only superficially understood. It is therefore important to clarify some basic concepts.

## Climate and climate change

We summarize the main concepts here.

- *Weather and climate*: weather refers to the atmospheric conditions over a short period, while climate is the average of these conditions over longer periods (typically about 30 years). Climate variations are slow and persistent, while weather can change rapidly.
- *Atmosphere and greenhouse effect*: Earth's atmosphere, composed mainly of nitrogen and oxygen, is crucial for life, protects against harmful external radiations, and regulates climate. The greenhouse effect, due to gases such as carbon dioxide (CO<sub>2</sub>) and methane, retains heat and makes the Earth livable. However, the increase in greenhouse gases due to human activities amplifies the phenomenon causing a global warming, with serious effects such as raised sea temperatures, decreased precipitations, reduced glaciers' extension and snowpacks, or intensified extreme weather events.

- *Climate models*: weather forecasts and climate models help to understand and predict climate behavior. These models, based on mathematical simulations, are critical for studying climate change on global and regional scales, predicting future trends, and assessing the impacts of climate change. The good precision, accuracy, and reliability of modern models has been thoroughly verified (see e.g., Hausfather et al., 2020). A key component of these models are the greenhouse gas emission scenarios, Representative Concentration Pathways (RCPs), that describe the evolution of greenhouse gas concentrations. The most significant scenarios are RCP8.5, the most pessimistic one according to which emissions continue as they do today without substantial reductions, or RCP4.5, an intermediate condition in which emissions are reduced by aiming for global temperatures by the end of the century that are no warmer than 2-3 °C above current levels. To these, the latest models add socioeconomic indicators: projections of population and economic growth, trends in technological and geopolitical development, and progress in counteracting climatic changes. The combination of these produces the Shared Socioeconomic Pathways (SSPs), the basis of the latest report of the Intergovernmental Panel on Climate Change (IPCC, 2021).

Responses to climate change can be strategic or tactical. The strategic approach, known as mitigation, involves implementing measures to reduce or prevent greenhouse gases (GHGs) emissions to reduce the severity of negative impacts. These measures are generally agreed upon at international meetings such as the United Nations climate change conferences (COPs). Many regional, state and individual organizations have developed plans to address climate change through mitigation, although no significant steps have been taken to date.

Mitigation measures involve long-term actions, while immediate effects have already demonstrated an impact on the tourism sector and on the ability of businesses and individuals to operate. Therefore, a tactical approach, known as adaptation, is needed. Adaptation measures are designed to address problems more rapidly and aim to reduce risks, limit impacts, reduce vulnerabilities, and increase the resilience of human and natural systems to climate change. Obviously, addressing these challenges requires a good collaboration among all stakeholders, including local people, tourists, and institutions at the local and national levels.

### **Tourism and climate, a complicated relationship**

Tourism is responsible for a significant share of GHGs emissions, contributing 8 percent of global emissions, mainly from transportation, and is expected to increase significantly in the coming years. Without taking specific actions, tourism could generate a 154% increase in energy consumption, 131% increase in emissions, 152% increase in water consumption, and 251% increase in solid waste disposal by 2050 (UNEP, 2012).

On the other hand, tourism is very vulnerable to climate change, and in recent years we have seen how much it has been affected. In particular, with regard to Europe and the Mediterranean

basin, an area that is particularly sensitive to warming because of its conformation so much so that it is considered a "hot spot," there have been: increases in temperatures, with a reduction in the attractiveness of traditional destinations such as art cities, beaches and ski resorts and a shift of flows to other destinations; rising sea levels, with erosion of coastlines and beaches and a decrease in snow cover, with a significant impact on winter ski resorts at medium and low altitudes. Urgent actions are therefore needed to reduce emissions and adapt to the effects of climate change, especially in the Mediterranean basin.

Climate is a determining factor in tourists' choice of destination. When the climate changes, the attractiveness of the destination changes and its image tends to change with it. But above all, weather (meteorological) greatly affects travel satisfaction. The perception of weather conditions is determined by physiological and psychological factors and can vary according to different situations and activities during the trip.

An analysis of the impacts is crucial to developing adaptation strategies that preserve natural and cultural resources, maintain the competitiveness of destinations and improve the quality of life for residents. The impacts of climate change on tourism can be classified as follows:

- *Direct climate impacts:* increased temperatures, heat waves, extreme events (hurricanes, storms), sea level rise, and decreased precipitation and snowfall, leading, primarily, to reduced attractiveness of traditional destinations (art cities, beaches, and ski resorts).
- *Indirect impacts:* reduced water availability, loss of biodiversity, coastal erosion, damage to infrastructure, and increase in contagious diseases.
- *Impacts on social and economic systems:* influences on economic growth and political stability.
- *Impacts of mitigation policies:* increase in transportation costs and changes in travel patterns.

Climate change impacts vary by season:

- *Summer:* coastal erosion, shifting tourist flows northward, water deficits, and extreme hardship conditions in cities.
- *Winter:* reduced snowfall, loss of alpine biodiversity, and stress on tourism infrastructure.

Adaptation strategies and policies are based on specific, reliable, clear data and information that can be easily interpreted and communicated. Future scenarios produced by climate models are usually represented by providing the main variables: temperature, solar radiation, humidity, precipitation, and wind intensity. These are calculated taking into account possible evolutions in greenhouse gas production.

For a better and clearer understanding these variables can be summarized in a tourist climate index (TCI). This provides a measure of a destination's climate suitability for its visitors. There are different versions of it, adapted to particular situations and conditions, and it can be adjusted by taking into account the different activities carried out in a destination by tourists.

### **Climate indicators for tourism**

A tourism climate indicator (TCI) summarizes how weather conditions are perceived by tourists, indicating whether, and to what extent, the conditions for visiting a location at a certain time are suitable. A number of conditions must be met to calculate a TCI. First, appropriate variables must be identified, focusing on climatic elements relevant to tourist well-being, such as temperature, humidity, precipitation, insolation, and wind. Temperature, in particular, is critical as it affects thermal comfort, a key factor that influences visitor movements and activities, and affects the length of the tourist season, especially in middle and high latitude regions. Second, standardized assessment systems must be developed to provide a common basis of measurement for each variable. Once calculated as a combination of these standardized variables, an indicator is validated with field surveys to verify the correspondence between the calculated levels and tourists' perceptions.

The TCI was initially proposed by Mieczkowski (1985) to assess the climatic suitability of a place for a generic tourist. It has since been revised by several authors, and today there are various proposals ranging from general indices to those adapted to specific circumstances or areas, such as cities, seaside resorts or winter mountain destinations. A TCI includes three main parameters: thermal conditions, aesthetic elements, and physical factors. Thermal conditions reproduce perceived temperature, aesthetic elements include cloud cover and insolation, and physical factors consider precipitations and wind intensity. All values are expressed as standardized scales.

While TCIs represent average conditions, more realistic representations can be obtained by adapting them to specific activities using a different approach (Bafaluy et al., 2014; Turner et al., 2023). This approach redefines thermal conditions using a perceived temperature that represents the feeling experienced by people while performing different activities (walking, running, playing, etc.).

### **An adapted TCI**

A TCI that can be practically used for defining scenarios underlying climate strategies and policies and for public communication can be calculated using the formula:  $TCI_a = 4 \cdot PET + 2 \cdot CD + 3 \cdot PR + WN$ , where each variable (PET = physiological equivalent temperature in °C, CD = cloud cover in %, PR = precipitation in mm/day, and WN = wind speed in m/s) is rated on a scale of 0 to 10, thus giving TCI on a scale of 0 to 100. These values are then reported on a 1-7 scale with the meanings: unacceptable, marginal, acceptable, good, very good, excellent, ideal.

PET, the perceived temperature, is derived by considering the energy expenditure of individuals due to physical activity, their clothing, physical characteristics (age, body mass, etc.), and

climatic variables such as temperature, solar radiation, and wind intensity. The activities considered are those most frequently performed by tourists in the destination of interest.

Once the scenarios have been created, it is possible to use them as a basis for designing actions or strategies that must, inevitably, be dynamic and adaptive. The idea is to prepare for different possible conditions and adopt some kind of continuous measurement system so that, in the event that a defined threshold is exceeded, actions corresponding to that particular scenario can be implemented in due course, also considering the time required for implementation. In addition, a climate index can also be used to provide tourists with reliable and clear information, thereby increasing their appreciation and satisfaction.

## Conclusion

Without objective data or well-designed indicators, it is not possible to create effective adaptation strategies to cope with climate change. As tourists' environmental awareness increases, it becomes essential to have reliable and easily interpretable indicators. Integrated climate information systems are needed to provide real-time data on climate conditions, guide tourists' travel choices, and prepare adaptation strategies. Effective communication and a participatory process involving all local stakeholders are essential for successful adaptation that dynamically takes into account current conditions and future developments.

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