



HAL
open science

Climate and carbon risk of tourism in Europe

Robert Steiger, O. Cenk Demiroglu, Marc Pons, Emmanuel Salim

► **To cite this version:**

Robert Steiger, O. Cenk Demiroglu, Marc Pons, Emmanuel Salim. Climate and carbon risk of tourism in Europe. *Journal of Sustainable Tourism*, In press, 10.1080/09669582.2022.2163653 . halshs-03932019

HAL Id: halshs-03932019

<https://shs.hal.science/halshs-03932019>

Submitted on 10 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

Climate and carbon risk of tourism in Europe

Robert Steiger^a , O. Cenk Demiroglu^b , Marc Pons^{c,d} and Emmanuel Salim^{e,f} 

^aDepartment of Public Finance, University of Innsbruck, Innsbruck, Austria; ^bDepartment of Geography, Umeå University, Umeå, Sweden; ^cAndorra Research and Innovation Institute, Andorra la Vella, Andorra; ^dSustainability Institute, Universitat Politècnica de Catalunya, Barcelona, Spain; ^eUniversity of Lausanne, Institute of Geography and Sustainability, Interdisciplinary Centre for Mountain Research, Lausanne, Switzerland; ^fUniversité Savoie Mont Blanc, Edytem, France

ABSTRACT

Europe accounts for 51% of international tourist arrivals and the tourism industry provides about 10% of workplaces in Europe. Tourism will be impacted by climate change in a diverse number of ways. At the same time, tourism is also a significant contributor of greenhouse gas emissions. The aim of this article is, therefore, to provide an assessment of climate and carbon risks for the European tourism industry based on a systematic literature review. Climate risk is the dominant category with 313 papers (74%), while 110 papers (26%) were on carbon risks. The following gaps were identified: geographical gaps, especially in countries of the former Soviet Union and former Yugoslavia; a lack of coherent studies on national tourism's and its sub-sectors' emissions; research addressing how climate policies might affect tourism demand; assessments of the integrated carbon and climate risks; lack of evidence on the link between tourism climate indicators and tourism demand; lack of climate change and tourism studies addressing policy and institutional tools for adaptation and implementation of adaptation measures in destinations; and research on rising sea levels and coastal erosion and its impacts on tourism destinations and demand.

ARTICLE HISTORY

Received 27 June 2022


Accepted 23 December 2022

KEYWORDS

Climate risk; carbon risk; tourism; Europe; systematic review; adaptation; mitigation

Introduction

Climate change is an immense challenge for society. More than a decade since the publication of the UNWTO/UNEP/WMO (2008) report on climate impacts on tourism, it is clear that tourism worldwide has to adapt to numerous climate-related changes and increase its efforts to reduce greenhouse gas (GHG) emissions. Due to the intensity of its economic development and because tourism is highly climate-sensitive—e.g. the appeal of a landscape, weather/climate as pull and push factors and natural resources required for outdoor activities (UNWTO, 2021)—tourism in Europe is confronted with numerous challenges related to climate change impacts, adaptation and mitigation (Scott, 2021). Together with a high economic relevance of tourism in many European countries, especially in the Mediterranean (World Bank, 2022), these challenges highlight the need for a comprehensive assessment of available research.

CONTACT Robert Steiger  robert.steiger@uibk.ac.at  Department of Public Finance, University of Innsbruck, Innsbruck 6020, Austria.

© 2023 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivatives License (<http://creativecommons.org/licenses/by-nc-nd/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited, and is not altered, transformed, or built upon in any way.

The IPCC AR6 summary of the observed changes over the European continent since 1950 shows an increase in hot extremes in all regions (AR6 WG1 reference regions), an increase in heavy precipitation in all regions except the Mediterranean and an increase in drought in Western and Central Europe (Masson-Delmotte et al., 2021). For the future, projected warming (median of climate model results relative to 1850–1900) is 2.3 °C–2.5 °C for 2021–2040, 2.6 °C–3.7 °C for 2041–2060 and 2.6 °C–6.7 °C for 2081–2100 (Gutiérrez et al., 2021). There is high confidence that extreme heat events will increase throughout the 21st century across all areas extending from the Mediterranean (MED) to Eastern (EEU), Northern (NEU) and Western and Central European (WCE) regions—at a rate above that of the global average (Arias et al., 2021). In terms of precipitation, there is high confidence that there will be a future decrease in the MED, along with increases in aridity, droughts and fires, as well as increases in heavy precipitation and pluvial floods in the EEU, the NEU and the WCE. The entire continent will also face an increase in severe windstorms (medium confidence). The cryosphere (snow cover, glaciers) is also significantly affected: for example, snow cover in the Alps will decrease below 1500–2000 masl (high confidence) and periglacial processes in the Nordic countries are likely to disappear by the end of the century (medium confidence) regardless of the warming rate. Glaciers in the European Alps are projected to lose two thirds of today's ice mass in a low emission (RCP 2.6) late century or might be mostly ice-free in a high emission scenario (RCP 8.5) (Zekollari et al., 2019). Last but not least, the European coastline is open to increasing risks (high confidence) from rising sea levels, coastal floods and erosion, marine heatwaves and acidification (including lakes) (Arias et al., 2021). The consequences of such physical changes undoubtedly imply further impacts on the vulnerability of the European tourism market.

In addition to the effects of climate change on tourism, the urgent need to reduce greenhouse gas (GHG) emissions, endorsed by the Paris Agreement, implies the implementation of a carbon reduction policy that constitutes another challenge for the tourism industry and tourism-related transport sector (Scott & Gössling, 2022), which accounts for more than 8% of GHG emissions worldwide (Lenzen et al., 2018). As the latest UNEP report shows, current climate change mitigation policies are estimated to result in a warming by 2.8 °C by the end of this century (UNEP, 2022), notably still far off the Paris Agreement goal of limiting global warming to well below 2 °C. According to UNWTO and the International Transport Forum (ITF), the tourism sector is not at all on the path of reducing emissions but is predicted to even increase its CO₂ emissions by at least 25 percent by 2030 (UNWTO & ITF, 2019). Yet climate does not seem to be a priority for tourism policy makers (Becken et al., 2020), and it seems imperative to provide a clear view of the situation in the European tourism market.

Accordingly, the aim of this article is to provide an assessment of the climate and carbon risk (Scott & Gössling, 2022) with a specific focus on the tourism industry on the European continent. To this end, we conducted a systematic literature review with an emphasis in results presentation on contributions published since the IPCC's Fifth Assessment Report (IPCC, 2014). To our knowledge, this is the first review that includes both climate and carbon risks of the tourism industry on the European continent and that is not limited to specific forms of tourism. A research agenda is derived from the state of the art of research and highlights urgent knowledge gaps that need to be addressed to better inform the tourism industry on potential climate risks and the needs and options for adaptation and mitigation.

Methods

The literature search was conducted in the Web of Science database (Clarivate, 2022). The search terms 'climat* chang* AND touris*' were used in combination with all countries on the European continent (Figure 1). We also included countries (Azerbaijan, Armenia, Georgia, Kazakhstan, Russia and Turkey), where only parts lie on the continent according to Ural mountains and river delineation.

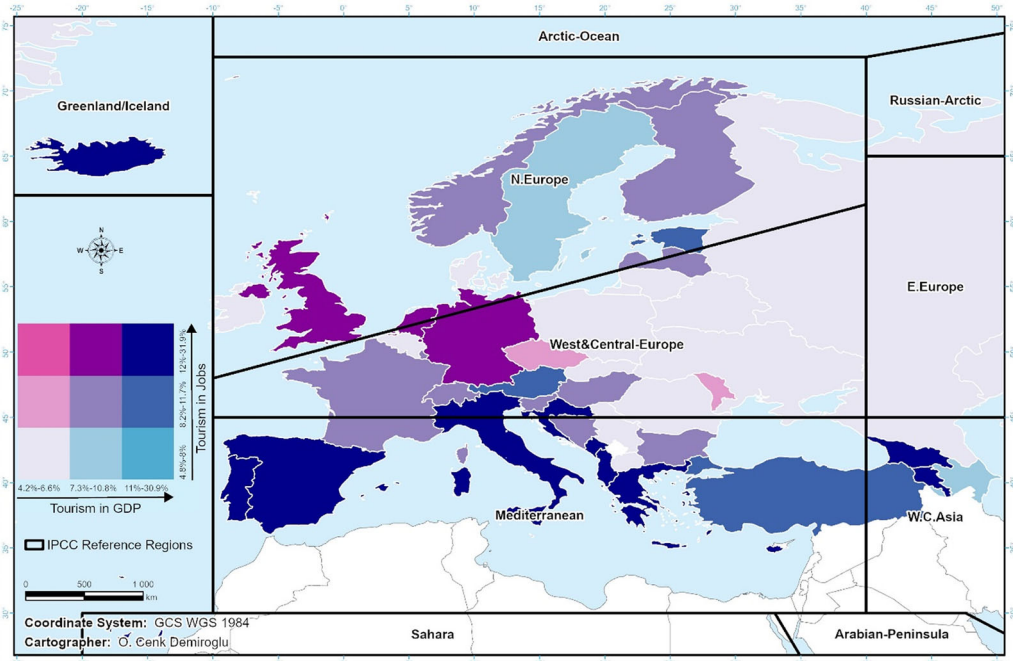


Figure 1. Total Contribution of Tourism to GDPs and Employment in Europe in 2019. Data source: WTTC, 2021 (detailed data see Table A1 in the Appendix)

Furthermore, we also used the following search terms: Euro*, Mediterranean, Balear*, Scandinavia* and major mountain regions (Alp*, Apennin*, Carpath*, Caucasus*, Pyrenees*). As literature on tourism’s contribution to climate change was underrepresented in this research, we conducted an additional search with ‘CO2 AND tourism*’ in combination with the above-mentioned terms. The search was limited to publications in English language mainly because of two reasons: an initial review of a random sample of publications in French, German, Spanish and Turkish revealed only little additional value to English publications. Furthermore, as the author team could only cover a small fraction of languages in Europe, there is a risk of getting skewed results towards these countries, whereas English language is open for the international academic community.

Using the above-mentioned search strings, we found 1340 articles. The title and abstract of these articles were screened to identify whether the article investigated climate and/or carbon risk to the tourism industry. We excluded papers, if one of the following criteria were met:

Articles where tourism or climate change were not the focus: For example, where tourism is mentioned in the introduction or discussion section, e.g. that tourism is an important source of income in the studied region (introduction), but no further analysis of tourism is made; or that tourism could be affected by climate change (discussion) without specifying how it would be affected. The same applies to climate change: sometimes climate change is mentioned as one of the big challenges for tourism in the introduction; but, the actual paper is not about climate or carbon risks to the tourism industry.

We also excluded articles investigating the sensitivity of tourism indicators to weather variables. We acknowledge that this is important work to understand the type and magnitude of relationships between weather/climate and tourism. However, in this article, we focus on potential future impacts including research on the type and severity of expected impacts as well as the industry’s contribution to climate change and options for adaptation and mitigation.

According to these criteria, we reviewed 423 articles. A data base with the following information for each article was created: research objectives, methodology, investigated region and key findings. Based on this data, the content structure of this article was jointly developed by all

authors. Climate risk was the dominant category accounting for 313 papers (74%), while 103 papers (24%) were on carbon risks and seven papers (2%) illustrated both climate and carbon risk. For the sake of readability, we did not cite each and every one of these 423 papers. Especially in sub-fields with a high number of papers, e.g. change in the climatic suitability for tourism in Europe or climate change impacts on ski tourism, fewer studies are cited in the text than were reviewed. Where more papers were available than were citable in the text, the aim was to cite more recent work, especially work published after the IPCC's Fifth Assessment Report (IPCC, 2014) and from different geographical areas.

Tourism in the European region

According to data from the World Bank (World Bank, 2022), Europe accounted for 51% of international tourist arrivals in 2017. France, Spain and Italy top the list with a market share of 37% within Europe. However, the relative importance of the tourism industry for national economies, exemplified by the direct, indirect and induced contributions, shows a distinct pattern (Figure 1). According to this pattern, many of the Mediterranean and Caucasian countries, as well as Iceland, benefit from, but also depend upon the travel and tourism sector, in terms of GDP and employment. By contrast, many Eastern and Central European countries fall into the category where the relative total contributions of tourism to both GDP and employment are at the lowest. In special cases such as Andorra, where the direct and direct + indirect contributions of tourism to GDP are 40% and 61%, respectively, the national economy's dependency on the tourism sector can be very critical (Pons et al., 2013). This is also true from a labor perspective, as in the EU27, some 13 million people are employed in the tourism industry, representing a share of 9.4% of the workforce (Eurostat, 2018).

Data on the importance of specific tourism products or types of destinations are not available on the continental level. However, Eurostat 2022 data for the EU27 shows that the volume of overnight stays is considerably higher in the summer half (May–Oct.: 70%) than in the winter half (Nov.–Apr.: 30%) and that 47.4% of overnights occur in coastal municipalities (Eurostat, 2022). This suggests that there is higher demand for summer than for winter activities for the whole of Europe. Nevertheless, it needs to be acknowledged that at national or sub-national level the tourism industry can be highly specialized, e.g. for ski tourism in many mountain regions (e.g. Austria or Andorra) or for cultural tourism in historical cities e.g. in Italy or France.

The most important source market for tourism in the EU is the domestic market (52.7% of overnights), followed by other EU27 states (28.3%) and from outside the EU27 (19%) (Eurostat 2022). For non-domestic overnights, Germans represent the largest group (20.3% of total non-resident nights), followed by the British (13.5%) and Dutch (6.4%) (Eurostat, 2022, 2019 data). Europe accounts for 36% of tourist departures (World Bank, 2022, 2019 data) but represents only 11.5% of the global population. This underlines the disproportionately high responsibility resting on the shoulders of European tourists to reduce their GHG footprint when traveling.

In an outlook for future development published in 2019, a growth of arrivals between 2% and 4% was expected for the period from 2019 to 2022 (Weston et al., 2019). However, the COVID-19 pandemic caused a dramatic 70% drop in international arrivals in 2020 (CCSA, 2021). The recovery after the pandemic has started, reaching 71.5% of international arrivals (and 64% of overnight stays) between Jan-Aug 2022 compared to 2019 (Tourmis, 2022).

Climate risk

The majority (74%) of reviewed papers (423) aim to assess the climate change risk for tourism. The following studies address the concept of vulnerability whereas the remaining papers in the climate risk section focus on the impacts of temperature and precipitation changes; extreme

weather and natural hazards; sea level rise and coastal erosions; ecosystem and biodiversity change; and the implementation of climate change adaptation strategies.

Santos-Lacueva et al. (2019) revealed five socio-political factors that influence the vulnerability of destinations to climate change: past evolution of destinations, evolution of tourism policy, occurrence of extreme meteorological events, dependence on tourism activity and the characteristics of the tourism offering.

Some studies apply the vulnerability concept and use indicators to assess the destinations' exposure, sensitivity and adaptive capacity to climate change. Perch-Nielsen (2010) used 12 indicators to assess the vulnerability of beach tourism. Most European beach destinations have a comparably low vulnerability, with Cyprus and Ireland ranked as least vulnerable globally. Within Europe, Turkey and France rate as most vulnerable to climate change. Koutroulis et al. (2018) used 16 indicators and show that southern European destinations despite high and increasing exposure might be able to reduce their vulnerability due to their high adaptive capacity in two shared socioeconomic pathways (SSP 1—sustainable pathway and SSP 5—fossil-fueled development). However, vulnerability would increase in SSP3, a scenario of regional rivalry. In the to-date most comprehensive assessment of tourism's vulnerability to climate change, a Climate Change Vulnerability Index for Tourism (CVIT) was developed consisting of 27 indicators (Scott et al., 2019). Here, Mediterranean countries have a low vulnerability, except for Turkey, Cyprus and Montenegro, while the rest of Europe has very low vulnerability scores.

Temperature and precipitation changes

Thermal comfort for outdoor activities

Increasing temperature and altered precipitation patterns are expected to affect tourism throughout Europe. Studies investigating thermal comfort of the human body find that cold stress will decrease while conditions with heat stress and sultriness will increase (Endler & Matzarakis, 2011; Matzarakis et al., 2013; Katavoutas et al., 2021). Consequently, tourism in cooler regions and/or seasons might benefit from climate change (Matzarakis et al., 2012; Pröbstl-Haider et al., 2021), while in hot regions/seasons, declining thermal comfort might have negative impacts on tourism (Matzarakis et al., 2007; Nastos & Matzarakis, 2019).

A frequently applied method to analyze impacts on tourism is indices, where different weather variables are weighted/fuzzified and combined to represent the climatic suitability of a location for tourism. The indices differ in the number of weather variables that are included, weighting/combination of the individual variables and incorporation of potential overriding effects (e.g. of rain) thus providing an inconsistent picture. An application of the Tourism Climate Index (TCI) shows a northward shift of good climate conditions (Perch-Nielsen et al., 2010b) until the end of the 21st century in a high emission scenario. A line approximately spanning Brittany (France), the Southern Alps and Czechia demarcates northern regions with an improving climate index (including the above-mentioned regions) from southern regions where more frequent hot conditions lead to deteriorating conditions in the summer months. In spring and autumn, TCI values improve across Europe revealing a potential to reduce tourism seasonality (Grillakis et al., 2016; Köberl et al., 2016; Pretenthaler et al., 2016; Suto & Fejes, 2019).

Other tourism climate indices have been developed to address limitations of the TCI (see e.g. Scott et al., 2016), such as that different forms of tourism have different climatic requirements that climate indices need to account for. Using the climate index for tourism (CIT), Amengual et al. (2014) note the split between climate winners and losers for beach tourism in northern and southern Europe. Other studies most often find that the effects of near future climatic conditions on the summer seasons of coastal destinations remain positive (e.g. Moreno & Amelung, 2009; Lemesios et al., 2016; Scott et al., 2016; Čavlek et al., 2019; Demiroglu et al., 2020b). For a high emission late 21st century scenario, Demiroglu et al. (2020b) projected unfavorable

conditions with great climatic discomfort and potential health risks for southern Spain, Italy and large parts of southeastern Europe.

In a study for Mallorca (Spain), the CIT was adapted and specified for seven different activities to identify which activities become suitable/unsuitable in the future (Bafaluy et al., 2014). In summer, CIT values increase for motor boating and sailing and decrease for cycling, football, golf, hiking and cultural activities. Until the end of the century, sailing becomes climatically suitable in spring and autumn and hiking in autumn. Thus, these activities hold future potential for tourism in the shoulder seasons. However, it is important to note that weather perceptions and evaluation can differ between seasons, as shown in a study in Hungary (Kovacs et al., 2016) and perceptions are heterogeneous between individuals, which, in turn, is likely to alter climate attractiveness of locations for specific activities and target groups.

Tourism in mountain regions during the summer season might benefit from warmer and more stable weather conditions, as the Alps are currently perceived as rainy and cold (Pröbstl-Haider et al., 2015). For South Tyrol (Italy) for example, demand is predicted to increase by 10% by the 2050s (Cavallaro et al., 2017a). Mountain tourism might also benefit from increasing heat stress in urban areas, by providing heat escapes at higher altitude (Juschten et al., 2019).

For Nordic countries, studies reveal some unique climate risks related to the cold climate and high latitude. Outdoor tourism in the summer season at the low and the high Arctic (see also Polar Regions article in this issue) is less dependent on weather and climate conditions from both supplier and consumer perspectives, yet a clear sky is still critical especially for attractions such as the Midnight Sun. Other perception studies with tourist actors show that positive aspects of climate change are emphasized (Kietavainen & Tuulentie, 2013) and potential benefits (e.g. more favorable weather) are expected to exceed the costs (Tervo-Kankare et al., 2018).

Cultural heritage and urban tourism is also projected to be negatively affected by increasing temperatures in the summer months (Rutty & Scott, 2010; Matzarakis et al., 2014). In a study on the medieval city of Gubbio (Italy), indoor temperatures are projected to increase from 29 °C to 32 °C, while outdoor temperatures could increase by up to 10 °C due to the microclimatic conditions, posing a serious threat to human health and potentially negatively affecting heritage tourism (Pioppi et al., 2020). This is supported by Cellini and Cuccia (2019) who show that museum visits are negatively influenced by increases in temperatures during the summer months (Jun to Sep). However, they also find that visits are positively influenced by rain in the summer months and by increasing temperatures during the non-summer months (Oct to May). By surveying visitors and tracking their activity behavior via GPS devices in Lisbon (Portugal), it was found that higher maximum air temperature leads to fewer visited attractions per day. Furthermore, overall satisfaction decreases in higher air temperatures (Caldeira & Kastenholtz, 2018). Lopes et al. (2021) analyzed the perceptions of human thermal comfort in the urban destination of Porto (Portugal) showing that tourists prefer warmer conditions than they are used to experiencing at home even in often-hot summer months.

Sottini et al. (2021) studied the comfortable climatic conditions for wine tourists and show that climate change could lead to an increase in tourist presence and a deseasonalization of wine tourism in the five regions studied. Conversely, a projected decline of quality wine areas in Tuscany (Italy) is projected to reduce tourism revenues by up to 20 million euros per year until the 2050s (Nunes & Loureiro, 2016).

Snow and ice

Longer autumns and delayed snow cover are reported to have a negative impact on people's mood, as less light is available due to the missing reflection of the snow surface. Access to the wilderness is negatively affected due to shorter winters and less reliable snow conditions (Kajan, 2014). Cross-country skiing, deemed a national sport in Nordic countries, is affected by deteriorating snow conditions as well (Landauer et al., 2012). Pouta et al. (2009) projected a 39% decline

in demand in a high emission late-century scenario for Finland. Adaptation behavior (e.g. switching to other destinations and/or activities) and acceptance of potential adaptation measures (e.g. ski tunnels, snowmaking) were found to be heterogeneous among cross-country skiers (Landauer et al., 2009; Landauer et al., 2014). More frequent days with temperatures near freezing point have led to an increase in injuries caused by slippery conditions due to more freeze/thaw processes (Lepy et al., 2014) and an increase in the number of such days is projected for high latitudes (Lepy et al., 2016). A very special topic is Santa Claus that some places use for place branding (e.g. Rovaniemi in Finland). If snow conditions continue to become less reliable during the Christmas period, place authenticity and consequently attractiveness may be affected (Hall, 2014). Tervo-Kankare et al. (2013) find that a snow landscape is very important for tourists in Rovaniemi and the majority would not visit the place in the absence of snow. Therefore, a repositioning of the destination may be necessary in the future.

During the winter half-year, tourism in mountain regions is expected to be negatively affected due to less snow and declining snow reliability affecting snow-dependent winter sports (Tervo, 2008; Spandre et al., 2019a). Snowmaking will be able to offset deteriorating natural snow conditions for alpine and Nordic skiing in many regions in the upcoming decades (Spandre et al., 2019b; Steiger et al., 2021). However, climatic conditions (Steiger & Mayer, 2008; Demiroglu et al., 2016a; Willibald et al., 2020), available water resources (Vanham et al., 2009; Soboll & Schmude, 2011; Soboll & Dingeldey, 2012; Gerbaux et al., 2020) and costs (Damm et al., 2014; Steiger & Scott, 2020) may limit the long-term suitability of this technique. Studies for the European Alps show that snow reliability of ski areas will decline despite snowmaking (Steiger & Abegg, 2018). Lower altitude ski areas often located at the fringe of the Alps will be the affected first, while after 2050 also higher elevated ski areas might be affected depending on the emission scenario (Steiger & Abegg, 2013; Steiger & Stötter, 2013). For the Pyrenees, a warming of 2°C could be compensated by snowmaking, while a warming of 4°C in the second half of the century exceeds the capacities of snowmaking (Pons et al., 2015). A study for a low mountain range Germany shows that the upper part of the ski area could still be considered snow reliable in a low emission late century, whereas in a high emission scenario projected ski season is too short to be considered as reliable (Schmidt et al., 2012). Two studies assessed the combined effects of climatic and demographic change. While for Tyrol (Austria) the effects of demographic change were found to have a higher (negative) impact until the middle of the century, accelerating climate change in the second half of the century is projected to have a higher negative impact than demographic change (Steiger, 2012). For a ski area in Southern Germany, demographic change could lead to a small increase of demand in the 2030s and 2040s in an optimistic demographic scenario (Witting & Schmude, 2019).

Studies on ski tourism in the Nordic countries reveal a competitive advantage in terms of snow reliability over the European Alps (Scott et al., 2020; Dannevig et al., 2021; Rice et al., 2022). However, this potential advantage might be impaired by accessibility and limited daylight (Demiroglu et al., 2020a). For ski tourism in Turkey, Demiroglu et al. (2016a) find deteriorating snow and temperature conditions, but fewer days with strong winds which could lead to fewer closure days. In a recently developed Ski Climate Index, other factors besides snow reliability like aesthetics and thermal comfort are included to better represent the variety of factors relevant for tourism demand (Demiroglu et al., 2021).

Tourists still consider natural snow as the most important factor for destination choice (Steiger et al., 2020) even for snow-independent winter activities (Bausch et al., 2021). If expectations are not met this can lead to dissatisfaction (Bausch et al., 2019). Nevertheless, the perceived importance was also found to decrease with increasing age (Bischof et al., 2017). Tourism demand has been found to be highly adaptable with tourists changing travel plans (Pröbstl-Haider & Haider, 2013; Landauer et al., 2014; Schwirplies & Ziegler, 2017). In a case study approach in alpine and low mountain range destinations, overnight guests were more likely to switch to alternative activities than day guests. However, substitution behavior was also found to

differ between presumed similar case studies suggesting that yet unknown factors also influence substitution behavior (Witting et al., 2021).

Economic impacts

Potential economic impacts have been assessed using regression models in combination with tourism climate indices or single weather variables. Amelung and Moreno (2012) estimate a positive net effect on annual overnight stays for the EU28 and Norway of up to 8% for a high emission late century compared to 2005. Conversely, Barrios and Ibanez (2015) found a very low net impact on GDP in the EU until the end of the century. For the summer months and a temperature increase of 2 °C, Jacob et al. (2018) projected a change of overnight stays from –8% (Cyprus) to 20% (Sweden). Conversely, Hein (2007) projected a 20% loss in tourists for Spain in a high-emission late-century future. Using a gravity model (Priego et al., 2015) and a discrete choice model (Bujosa & Rossello, 2013), results are more nuanced for Spain, with a decreasing number of domestic tourists in southern regions and an increase in (mostly coastal) regions in the North-West. For Portugal, a gravity model projects tourist arrivals to decline by 2.5%–5.2% by the 2080s, compared to 2008 (Pintassilgo et al., 2016).

Deteriorating snow conditions might change the geographical distribution of winter tourists (Pons et al., 2014). For South Tyrol (Italy), Cavallaro et al. (2017a) projected a decline of 13%–18% in overnight stays in a low and high emission scenario for the 2050s. Regression results for a ski area in Slovakia show a decline of 6% (+1 °C) to 19% (+3.2 °C) (Demiroglu et al., 2015). However, when also accounting for climate risk relative to competing markets, economic impacts could also be positive even if snow reliability is on the decline, as shown for Switzerland (Gonseth & Vielle, 2019). Despite these predominately negative impacts on winter tourism, studies for Croatia (Grdic & Nihe, 2016; Nizic & Grdic, 2018) and Romania (Surugiu et al., 2011) also show some potential for increasing tourist numbers due to improving conditions for non-snow activities. Conducting a cost-benefit analysis of climate change adaptation measures, Cupac et al. (2020) find that an investment of 1 euro could lead to a benefit of 14.15 euros for tourism in Bosnia-Herzegovina. For summer tourism in Switzerland a moderate welfare gain (+0.21%) is modeled using a general equilibrium model (Vohringer et al., 2019).

Extreme weather and natural hazards

Longer and more frequent dry spells, as projected for the subtropical part of Europe with a steppe climate (BSh and BSk in Köppen-Geiger classification), increases the risk of water shortages according to research on Spain (Rico-Amoros et al., 2013; Sauri et al., 2013; Martin-Arias et al., 2020), Greece (Klein et al., 2015; Michailidou et al., 2016; Katirtzidou & Latinopoulos, 2018; Skrimizea & Parra, 2019; Alamanos, 2021), Cyprus (Zachariadis, 2010) and Turkey (Demiroglu et al., 2018). Activities might be negatively affected such as mountain biking by more frequent heat waves and water sports by droughts with lower water levels and water flows (Auvergne-Rhône-Alpes Tourisme, 2021).

As the temporal population in tourist regions can increase by a multiple in the high season, water demand can also vary substantially between high and low season. In a study covering several regions in Belgium and the Netherlands, peak water demand was modeled to increase by 6.5% by 2050, while net model water demand would only increase slightly by 0.8% (Vonk et al., 2019). A study for the tourism-intense region of Costa del Sol (Spain) shows that, due to future population growth and climate change, water pumping capacity will become insufficient as soon as the early 2030s (Martin-Arias et al., 2020). Potential adaptation measures to cope with future water shortages include an exchange of water of differing qualities, e.g. the use of treated wastewater in agriculture, or improved demand management in the tourism sector (Rico-Amoros et al., 2013; Dinares & Sauri, 2015). Investigating the potential for water-saving practices among tourists,

Torres-Bagur et al. (2020) find that travel motivation of tourists (especially nature motivation) explains the visitors' efforts to save water. The results of their case study also stress the need to increase knowledge and awareness of the impact of climate change on water supply among accommodation managers and visitors. This is supported by Kennedy et al. (2022) who stress the need to raise awareness of natural hazards and to develop hazard management plans for tourism in Malta where floods, drought and storms represent the most important hazards.

Fire risk is also likely to increase, potentially affecting tourism regions, particularly in the Mediterranean (Varela et al., 2020). For Portugal, declines in tourist arrivals are projected to be between 1.2%–2.2% in the 2030s and 4.4%–21% in the 2050s, based on an econometric model considering past fires and effects on tourist arrivals (Otrachshenko & Nunes, 2022). Tourist actors expect an increase in production costs related to a higher incidence of forest fires (Gonçalves et al., 2022).

In mountain regions, melting permafrost and retreating glaciers increase the risk of natural hazards, such as rock falls, debris flow, ice collapse and glacier lake outburst floods (Mourey et al., 2019). Such hazards have already affected access to mountain huts in the French, Italian and Swiss Alps (Mourey & Ravel, 2017; Mourey et al., 2019) and also access to glacier tourism sites (Welling et al., 2020; Welling & Abegg, 2021). This has already led to a decrease in tourism numbers on glaciers in Norway (Furunes & Mykletun, 2012).

The degree of difficulty posed by high alpine routes (Mourey et al., 2020) increases and alpine routes sometimes disappear because of deglaciation or rock collapse (Mourey et al., 2019). Experienced mountaineers were found to be more exposed to an increased risk of natural hazards as higher risks are accepted in this group (Pröbstl-Haider et al., 2016). These impacts have consequences for mountain guides who need to adapt, principally by focusing on spatial and temporal substitution (change of itineraries, deseasonalization) (Salim et al., 2021a), but also by diversifying their activities (mountain biking, sports climbing and not just alpinism) (Salim et al., 2019) or by expanding their winter activities (Salim et al., 2019; Mourey et al., 2020).

Sea level rise and coastal erosion

Rising sea levels increase beach erosion and can lead to a decrease or complete loss of beach areas reducing attractiveness for tourism purposes (Rizzo et al., 2020; Mooser et al., 2020) and thus reducing the capacity for recreational activities and coastal protection (Jimenez et al., 2017; Sousa et al., 2018). This also has the potential to affect primary resources for tourism such as wetlands (Lefebvre et al., 2019), generally increasing the erosion of coastal zones (Royo et al., 2016; López-Dóriga et al., 2019) or more specifically, the Ebro Delta River in Catalonia (Spain) where current event tourism facilities would be affected (Garriga Sala, 2008).

Coastal erosion can be managed with engineering methods. Studies have been conducted for Croatia (Peric & Grdic, 2015), Greece (Tzoraki et al., 2018; Andreadis et al., 2021; Vandarakis et al., 2021), Turkey (Karaca & Nicholls, 2008), Lithuania (Bagdanavičiūtė et al., 2019), Estonia (Tonisson et al., 2019) and Sweden (Ebert et al., 2016). These studies aim to identify the most affected coastal stretches and show that in all of these cases, tourism beaches would be affected by sea level rise. However, no information on potential impacts on tourism is given. Using the hedonic price method, Hamilton (2007) revealed that dikes have a negative impact on accommodation prices. In a review of approaches to beach erosion in Portugal, Spain and Italy (Semeoshenkova & Newton, 2015), the implementation of hard structures (e.g. groynes, seawalls, artificial headlands) is considered insufficient from a tourism point of view, due to decreasing beach quality and human welfare. Soft methods, such as beach nourishment, dune stabilization or bioengineering, are deemed more suitable for preserving the natural value and tourism quality of beaches.

It is important to understand how beach users evaluate measures to adapt to rising sea levels in order to anticipate potential impacts of such measures on landscape attractiveness and recreational value. In a choice experiment with tourists in Mallorca (Spain), their willingness to pay for the implementation of adaptation policies to mitigate three different impacts of climate change was investigated, namely beach retreat, beach closure due to jellyfish outbreak and seagrass loss. Results show that adaptation to beach retreat is rated highest (Enriquez & Bestard, 2020). Likewise, Lam-Gonzalez et al. (2020) highlighted how certain market segments would avoid travel in cases such as beach loss and extreme events. In a study in Cyprus, Leon et al. (2021) found that tourists tend to prioritize solutions to issues such as beach protection, heat waves, water supply and prevention of infectious diseases. More integrated impact assessment models going beyond only considering temperature and precipitation changes (like in the tourism climate indices) are, therefore, needed to present the overall future climate risks of coastal tourism destinations.

In a study on the Atlantic Coast in France, residents and tourists sometimes did not understand the adaptation strategies (e.g. sand recharging, seawall construction and relocation of property), developed to counteract to rising sea levels (Rey-Valette et al., 2015; Rey-Valette et al., 2019). A survey among property owners revealed a utilitarian concern about preserving real estate values (Rulleau & Rey-Valette, 2017). Interestingly, the acceptance of managed relocation measures shows an awareness of the necessity for long-term changes. However, owners who would be directly affected show strong opposition to such measures.

Ecosystem & biodiversity change

A change of marine biodiversity might affect sea-based tourism activities as well. An increase in algal bloom as a result of warming waterbodies might have potential negative impacts on water-based tourism. In a survey, respondents stated that they had either shortened or cancelled their holidays in regions affected by algal blooms (Nilsson & Gössling, 2013). In a study featuring camping tourists in Sweden, Foghagen (2014) found that sunnier conditions are rated higher than a lower risk of algal bloom, while warm temperatures are less important than algal bloom. A loss of marine biodiversity might affect the attractiveness of tourism activities such as diving around the Medes Isles in Catalonia (Rodrigues et al., 2016) or recreational fishing (Townhill et al., 2019).

Little research is available for outbreaks of infectious diseases. For the Camargue (France), model simulations show that a risk of the re-emergence of Malaria is quite low and subject not only to climatic but also to land-use changes (Linard et al., 2009). In a choice experiment with frequent travelers from the UK, Germany, France and Sweden, an increased risk of infectious disease outbreaks (Malaria and Dengue fever) turned out to be the greatest deterrent to visiting an island destination (León et al., 2020).

Attractiveness of landscapes could also be affected by climate change. Retreating glaciers have a negative impact on visitors' perception of landscape (Moreau, 2010; Salim et al., 2021b). Studies also show that glacier retreat in the Alps leads to the development of Last Chance Tourism (Salim & Ravel, 2020) and that stakeholders in glacier tourism need to adapt to the impacts of climate change today (Salim et al., 2021a). Some national and regional reports, such as the IPCC (2019), have also identified the loss of glaciers as a risk to tourism attractiveness in these mountains. The Aragon (Spain) Government, for example, passed an act in 1990 enshrining glaciers as natural monuments in law (vLex, 1990). In Nordic countries, warmer conditions throughout the year and shorter winters will lead to an increase in insects, affecting tourist comfort from insect bites and, in the long term, also landscape attractiveness as some species cause severe tree damage (Kajan, 2014).

Knowledge and implementation of climate change adaptation strategies

The tourism industry has been repeatedly described as being insufficiently prepared (Scott, 2021). Therefore, an important question for sustainable and climate resilient tourism development is the state of knowledge and implementation in the tourism industry. According to Klein et al. (2017) framework of adaptation research, four generations of adaptation research can be distinguished (Table 1). We assigned the reviewed papers to these generations to identify the most visible ones and draw conclusions as to where more adaptation research are needed. From the 320 reviewed climate risk papers (including papers addressing both climate and carbon risk), six could not be assigned to any category as these were review or assessment papers that summarized existing knowledge. As illustrated in Table 1, first and second generation studies still represent the majority of reviewed papers.

While earlier studies on climate change perception among tourism actors found some skepticism about climate projections and doubt about the impacts on the tourism industry (Saarinen & Tervo, 2006; Wolfsegger et al., 2008), more recent studies show that the majority of tourism stakeholders accept that climate change is happening and could have far-reaching consequences for their business (Serquet & Rebetz, 2013; Grdic et al., 2019). However, several barriers to adaptation are identified in the reviewed literature: Carlsen et al. (2013) note that it was difficult for participants in a workshop to relate to a time perspective of 20 years into the future. Structural barriers, such as a lack of long-term planning, funding sources and support (Jenkins & Nicholls, 2010; Csete & Szecsi, 2015) are hard to overcome, slowing down adaptation processes (Wyss, 2013) and leading to a common strategy of maintaining the current business model (Haanpaa et al., 2015). Furthermore, high confidence in the survival of one's own business was found to influence adaptation behavior, potentially leading to more reactive than proactive behavior (Trawöger, 2014; Tervo-Kankare, 2019). Responsibilities are perceived to lie with government bodies (Torres-Bagur et al., 2019) because they are regarded to have better information and more power to initiate and enforce change (Wyss et al., 2014). In a mountain destination in Switzerland, Luthe and Wyss (2016) find that action at the municipal level is more effective for implementing abrupt changes (e.g. hazard events) while the regional level tends to be more suitable for gradual climate-related change.

Table 1. Description of Klein et al. (2017) four generations of adaptation research and examples of reviewed papers.

Klein et al. (2017) framework	Description	Examples in the reviewed literature
First generation (103 papers, 33%)	Descriptive questions related to the potential impacts of climate change, their consequences for the population and the potential costs (or benefits) of such changes.	Studies investigating the evolution of climate conditions and their potential influence on tourism, destinations or activities (Mourey & Ravel, 2017; Demiroglu et al., 2018; Nastos & Matzarakis, 2019)
Second generation (151 papers, 48%)	Descriptive questions about the social factors that influence vulnerability to climate change and normative questions aiming to evaluate and build on successful adaptation and to find a balance between adaptation and mitigation.	Studies aiming at identifying the adaptive capacity of certain destinations (Dannevig et al., 2021; Rice et al., 2022), the adaptive behavior of the supply side (Spandre et al., 2019a; Salim et al., 2021a) and the perception and adaptive behavior of the demand side (Steiger et al., 2020; Leon et al., 2021).
Third generation (37 papers, 12 %)	Policy and finance questions are introduced.	Studies seeking to identify which policy and institutional tools are needed to support adaptation efforts development (Rech et al., 2019; Welling & Abegg, 2021).
Fourth generation (23 papers, 7%)	Questions related to the technical knowledge that is needed to implement adaptation; lessons that can be learned from maladaptation and failure.	Acceptability of the adaptation measures (Rey-Valette et al., 2019), barriers to adaptation (Matasci et al., 2014) or the reasons for the success of adaptation strategies (Mourey et al., 2020).

The majority of studies involving tourism stakeholders in the research process focus on extracting information from the practitioners, e.g. on their perception of climate change and its impacts (e.g. Kundzewicz et al., 2008; Jarvis & Ortega, 2010), which is an important first step to identifying the willingness and perceived urgency to act and prepare for change. Provided a common understanding exists among practitioners that climate change is a challenge for tourism, participatory research settings can be a useful tool for fostering local adaptation processes. In a Swedish case study (Carlsen et al., 2013), three local level socioeconomic scenarios constructed by the research team were used in a stakeholder workshop to identify challenges and adaptation options for tourism in their region. In an alpine destination, an agent-based model was used to simulate changes in the tourism system based on scenarios and adaptation strategies jointly developed with local tourism stakeholders (Balbi et al., 2013; Bonzanigo et al., 2016). Welling et al. (2019) set up a four-stage participatory scenario planning process in South-Eastern Iceland with glacier tourism as the main product. Modeled glacier retreat was used as input in three stakeholder workshops. In the first workshop, participants identified the elements of the tourism system, important interconnections and exogenous factors and relevant drivers of land-use change by cognitive mapping. In the second workshop, participants developed plausible future scenarios of land-use change within the study area. In the third and final workshop, stakeholders developed adaptation options to main threats and opportunities along with their practical applicability considering the previously developed land-use change scenarios.

Carbon risk

Carbon emissions and tourism's footprint

Only 26% of reviewed papers address carbon risks for tourism on the European continent.

In an analysis of global tourism-related carbon flows between 160 countries in 2013, Germany is ranked 3rd worldwide in terms of resident-based carbon footprint (Lenzen et al., 2018). The highest carbon footprint (CO₂ equivalent) to/from Europe is accounted for by travel between the UK and the US (12 Mt), followed by Russia/Ukraine (7.8 Mt) and Germany/France (6.2 Mt).

A number of studies investigate tourism's contribution to national GHG emissions. However, the results are hardly comparable as the analyses took place at different points in time and employed different methods, e.g. in- or excluding emissions related to international travel beyond national borders. One of the earliest studies (Peeters et al., 2007) carried out an EU-wide (the then EU-25 plus Switzerland, Norway, Bulgaria and Romania) environmental assessment of tourist transport and concludes that climate change is the most important externality, when compared to other factors like noise, air quality, landscape and accidents. The main problem lies not in intra-European transport but rather intercontinental, long-haul air travel, which was expected to grow back then. On a national level, tourism-related emissions range from 2.5% in Romania (Surugiu et al., 2012), 5.2%–5.3% in Switzerland (Perch-Nielsen et al., 2010a) and Austria (Neger et al., 2021), compared to 10%–11% in Portugal (Robaina-Alves et al., 2016), Spain (Cadarso et al., 2015; Cadarso et al., 2016), Sweden (Gössling & Hall, 2008), France (ADEME, 2021) and the Netherlands (CBS, 2017). On a sub-national level, 9.2% is reported for Wales (UK) (Jones, 2013) and 12% for Galicia (Spain) (Roibas et al., 2017). Isolating tourism-related emissions generated by air transport, Antequera et al. (2021) estimated international air transport CO₂ emissions to be 54.3% of total emissions of the Canary Islands (Spain). This shows that the carbon intensity of island tourism is considerably higher due to the high share of air transport and in this case also due to larger travel distances from the main source markets compared to other European destinations.

In most of the studies, tourism transport has the highest share of tourism-related emissions (e.g. Unger et al., 2016; Gössling et al., 2017; Neger et al., 2021). Consequently, the distance and transport mode from origin markets to a destination have a huge impact on CO₂ emissions per

tourist (Gössling et al., 2005; Gössling et al., 2015). In the UK's South West region, CO₂-equivalent emissions per day for visitors from overseas (196 kg) are about four times higher than that of domestic visitors (49 kg) (Whittlesea & Owen, 2012). In Barcelona (Spain), the carbon footprint of overnight tourists (mainly arriving by plane) is 111.6 kg, while for day-trippers it is 43 kg per day (Rico et al., 2019). For the island of Menorca (Spain), Sanye-Mengual et al. (2014) show that the carbon footprint of an average stay is comparably low with 277 kg, which is mainly due to a long average length of stay of 20 days. For cruise tourism in Norway, average emissions are 589 kg CO₂ per passenger (Simonsen et al., 2019). Adamiak et al. (2016) studied travel behavior and related emissions of second home owners in Finland and found that owners have fewer trips per year than non-owners. However, their footprint is considerably higher than that of non-owners, as the number of long-haul trips is not different but the flown distance is higher for owners than for other groups. Wicker (2019) investigates the carbon footprints of sports activities in Germany based on the number of trips and distance and finds that nature sports (1455 kg CO₂ per year) cause more emissions than individual (1006 kg) or team sports (514 kg). All these studies reveal a high heterogeneity of GHG emissions between tourists. For Austria, emissions from holiday air travel were found to be higher for people with university degrees, young adults without kids and residents from the capital city (Falk & Hagsten, 2021).

Econometric studies on the carbon risk of tourism analyze the relationship between tourism-related emissions and economic growth. On the global level, using long-term panel data of multiple countries, including those of Europe, several studies (Zaman et al., 2016; Pablo-Romero et al., 2017; Kocak et al., 2020; Pala, 2020; Simo-Kengne, 2022) substantiate how tourism growth leads to increased emissions. Similar evidence is also found for cases on a country scale such as for Cyprus (Katircioglu et al., 2014), Turkey (Pata & Balsalobre-Lorente, 2022; Katircioglu et al., 2014; Eyuboglu & Uzar, 2020), Romania (Surugiu et al., 2012; Ioncica et al., 2016), Greece (Işik et al., 2017) and Latvia (Grizane et al., 2019). However, others highlight the validity of the environmental Kuznets curve, which asserts that tourism growth could amplify emissions in the short run but that these emissions, and other environmental degradation indicators, would eventually be reduced as the growing economies of such countries could help advance their environmental sustainability (Lee & Brahmasrene, 2013; Grizane & Jurgelane-Kaldava, 2019; Leitão & Lorente, 2020; Gyamfi et al., 2021). Alam and Paramati (2017), for example, showed that a 1% increase in tourism investments reduces CO₂ emissions by 0.098%. However, a recent review paper finds contradictory results concerning the validity of the Kuznets curve related to tourism (Dogru et al., 2020).

Carbon emission reductions

The reviewed literature provides technical showcases on the supply side about how the industry could reduce its emissions in the future. This includes improved financial viability and environmental sustainability through the use of renewable energies at hotels and other touristic facilities in Croatia (Nizic et al., 2017), Cyprus (Michopoulos et al., 2017), Serbia (Ristic et al., 2019), Italy (Comodi et al., 2014), Spain (Moià-Pol et al., 2014) and some Alpine ski resorts (Polderman et al., 2020) and reduction in intra-destination transport emissions through a modal switch from cars to public transport (Cavallaro et al., 2017b, 2021), optimal site selection for a hotel location in Greece (Pieri et al., 2016) or the renewal of car fleets used for recreational fishing trips in Latvia (Grizane & Blumberga, 2020). In an analysis of accommodation providers in the UK, only weak responses of these actors to current mitigation policy were found (Coles et al., 2013). A cluster analysis in the same region revealed three different mitigation behavior types (early adopters, early/late majority and laggards) and the authors concluded that policies should be tailored to these types to improve mitigation efforts (Coles et al., 2014). Pace (2016) examined how tourism operators innovate for energy consumption in Malta and showed that energy management

capabilities (e.g. technology replacement, internal knowledge, seizing) increase the potential to reduce consumption. Perfetto et al. (2018) study energy efficiency in hospitality in the south of Italy, showing that building information modeling, i.e. including different stakeholders (e.g. architects, owners, managers) in a collaboration network when designing a new hotel building, can be an effective approach.

For transport-related tourism emissions, an agent-based model for inbound and outbound tourists of Austria was used to investigate different travel demand scenarios (Kapeller et al., 2019). In a business as usual scenario (extrapolating current travel behavior trends), an emission increase of 26% was modeled for 2018–2030. Remarkable emission reductions could be reached in a ‘green transition’ scenario, with an assumed annual increase of airline ticket prices and a higher share of public transportation (25% instead of 18%) leading to a modeled emission reduction of 38% (Kapeller et al., 2019). However, the realization of such green scenarios requires a change in traveler’s behavior.

Consumer behavior research has revealed little willingness of travelers to change their behavior (Barr & Prillwitz, 2012). Common reasons for non-action are denial, limited knowledge, scientific skepticism, necessity and that responsibility lies with others (Dickinson et al., 2010; Hares et al., 2010). Applying the norm activation model, Vaske et al. (2015) show that 44% of variance in reported behavior is explained by environmental attitude, feeling responsible and awareness of the consequences. Others identified an attitude-behavior gap (Kroesen, 2013) and show that ‘deservingness’ is used as legitimation (Hanna & Adams, 2019). Studies note a higher concern for short-haul, rather than long-haul trips in the case of Norwegian outbound tourism, especially regarding discretionary travel (Higham & Cohen, 2011), while in-depth research among students from Sweden highlights the subjectivity of what is ‘discretionary’ (Gössling et al., 2019). In Poland, an earlier study (Dickinson et al., 2013) finds that, despite strong concern for climate change, the main contributors, such as international air travel, are not well-acknowledged, while a couple of later studies show the significance of national cultures in determining pro-environmental behavior (Filimonau et al., 2018a) as well as the need for knowledge reinforcement for the uptake of contemporary mitigation measures such as aviation biofuel technology (Filimonau & Hogstrom, 2017; Filimonau et al., 2018b). Regarding such barriers to mitigation, Juvan and Dolnicar (2014) show how confusing carbon calculators can be for users (tourists from Slovenia and Australia) and that they are possibly not useful for people wanting to reduce their carbon footprint.

Nevertheless, a positive general attitude of tourists toward mitigation is also reported. In a tourist survey in alpine destinations, a high acceptance of wind parks at these destinations was found, although concern about climate change was no predictor variable for acceptance (Brudermann et al., 2019). Other examples are a strongly engaged consumer activism as in the case of the nonprofit organization Protect Our Winters (POW) (Demiroglu & Turhan, 2021) and a high preference or willingness-to-pay for green facilities and destinations (Tsagarakis et al., 2011; Navratil et al., 2019; Saseanu et al., 2020).

Blanc and Winchester (2013) model the impact of a price of 10 euros/t CO₂ on arrivals to range between –1.4% and –2% within the EU and –0.4% on all arrivals. A choice experiment with skiers in Norway reveals that consumers are willing to pay 11.5% more for a ski season pass that includes CO₂ compensation (Haugom et al., 2021). Carbon labels were found to improve the perceived environmental sustainability of a holiday package, but they did not affect the intention to book in a study with Dutch travelers (Eijgelaar et al., 2016).

Despite its relatively high accountability for global emissions (UNWTO/UNEP/WMO, 2008; Lenzen et al., 2018), the tourism industry is often neglected in the highest level climate policy documents such as the Nationally Determined Contributions (NDCs) (UNFCCC, 2021). The NDCs (UNFCCC, 2022) created by the EU and its member states, for instance, do not specifically refer to the tourism industry, even when it comes to the suggestions on yielding mitigation co-benefits through economic diversification where tourism could play a vital role. Few other European

countries such as Armenia, Bosnia-Herzegovina and San Marino mention tourism as a climate risk focus, while Albania, Georgia and Montenegro are the only countries with specific mitigation perspectives relating to tourism. In the case of Albania's Updated First NDC, hotels, restaurants and travel agencies are acknowledged as part of the service sector accountable for future energy demand. Georgia and Montenegro, on the other hand, clearly highlight the need to pursue a low carbon approach to future tourism development, e.g. by erecting energy-efficient buildings, but also, in the case of Georgia, by promoting agritourism to mitigate agricultural emissions (UNFCCC, 2022).

Climate change is also addressed in several tourism strategy papers. On the EU level, climate change adaptation and mitigation is included as one of the ten points of action toward sustainable and responsible tourism (TSG, 2012). In a more recent study commissioned by the European Parliament, the need for more climate action is stressed and references to EU funding schemes to finance climate mitigation action are made (Weston et al., 2019). On the national level, there is a broad range of ways in which climate change is addressed, if at all. For the Nordic countries, Landauer et al. (2018) conclude that national tourism strategies do not present actions that actors should consider. Most of the climate actions in national tourism strategies are demands directed at governments to invest in sustainable mobility, e.g. by improving train connections in a 500 km radius around the Netherlands (NBTC, 2019). A notable exception is the tourism strategy of the federal state of Tyrol (Austria) (Land Tirol, 2020). Here, goals for 2035 include an increase in the share public transport used by tourist arrivals from 10% to 20%, a 100% use of renewable energies for local public transport at the destinations and climate-neutral ski areas.

Discussion and conclusion

In this study, a total of 423 papers were identified to reflect climate (n: 313) and/or carbon (n: 110) risks of tourism in European countries and reveal a clear lack of studies in the carbon risk domain. This uneven split between the two main themes is even more evident from a spatial perspective (Figure 2), as many Western European and Mediterranean countries receive the most coverage under each theme while many former Soviet Union and former Yugoslavian countries and Albania lack research on both fronts. This research gap is, however, somewhat consistent with the limited economic contribution of tourism (Figure 1) in the said countries, that is, with the exception of Albania and Montenegro, where tourism dependency is among the highest. It should also be noted that this gap indicator is aggregated at the national level and does not necessarily point to the situations in all critical subnational regions.

The reviewed literature shows that tourism's share of greenhouse gas emissions is remarkable, with values on the national level between 5% and 11% of total emissions. The greatest potential for emission reduction lies in the transport sector (Gössling et al., 2015; Lenzen et al., 2018). European destinations are characterized by potent domestic or nearby international source markets. This represents a large potential for a shift to less carbon-intensive transport modes like the train. After two decades where night train connections were ceased, new night train connections have been established more recently (Energiezukunft.eu, 2022). In this context, the Trans-European Transport Network (TEN-T) is important as a political framework. The TEN-T consists of a core and a comprehensive network which should be finalized by 2030 and 2050, respectively (European Commission, 2022). Although it includes the construction and better integration of all transport modes, an improvement and expansion of the rail network in Europe is an important part of this plan.

This review identifies a number of research gaps that urgently need to be filled in order to provide better knowledge to reduce this sector's emissions and improve its preparedness and adaptive capacity. The following research agenda summarizes the key points this review revealed:

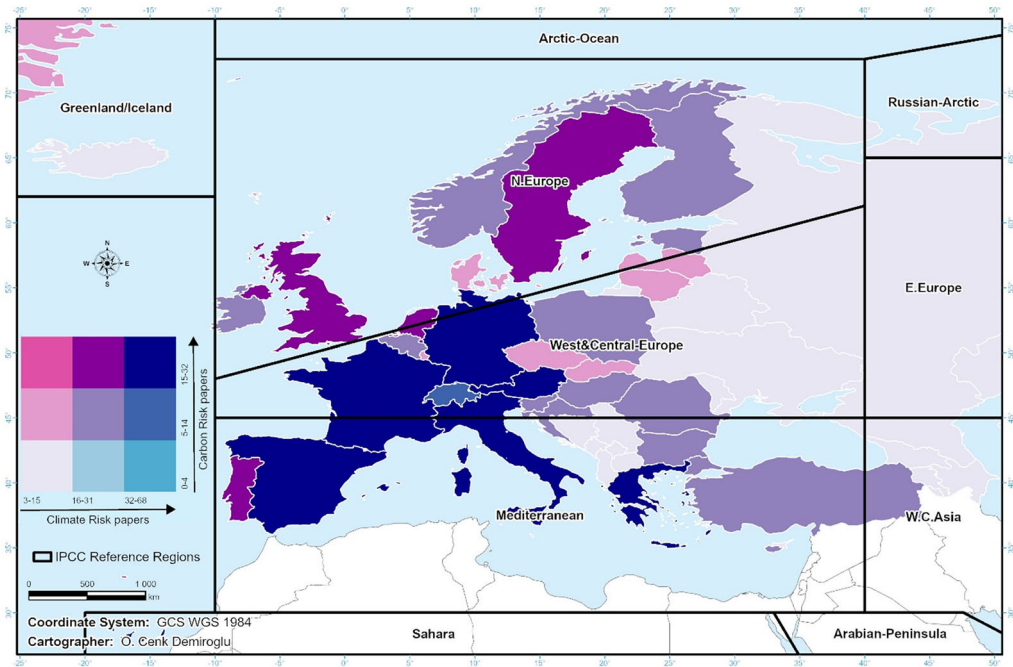


Figure 2. Research coverage on climate and carbon risks of tourism in Europe. For detailed data, see [Table A1](#) in the Appendix

The lack of coherent studies on national tourism and its sub-sectors' emissions call for better methods to accurately measure emissions and monitor progress towards achieving emission reduction targets. To achieve the aim of the Paris Climate Agreement (United Nations, 2015), CO₂ emissions would need to be reduced by approximately 50% by 2030 and reach net-zero by mid-century (IPCC, 2021). As shown in this review, tourism is almost not mentioned in NDCs and even in national tourism strategy papers, little ambition defining clear reduction targets could be found. Therefore, the research community needs to provide information on how tourism could achieve the required emissions reductions, also considering the projected growth rates in tourism. This also includes better knowledge of options to influence travelers' behavior reducing their emissions.

Given these very ambitious reduction targets, it is likely that national and international climate policies will affect tourism at all spatial scales (from global to regional). More research is needed addressing how climate policies might affect tourism demand (e.g. number and length of trips, spending), if and how the distribution of tourists could be affected (e.g. destination choice) and what impacts such changes might cause at the destination level, e.g. increase/decrease of demand, changing expectations and needs.

On the one hand, carbon risks are likely to increase if policies are implemented to achieve the required emission reductions to slow climate change. On the other hand, climate risks in the upcoming decades are expected to increase due to accelerating climate change regardless of emission paths (IPCC, 2021). Therefore, the integrated carbon and climate risks deserve more attention by the scientific community as it increases complexity. This complexity represents an important constraint concerning tourism planning and climate policy development.

In the climate risk theme, there are many studies using e.g. indices to assess changes of climatic conditions for tourism, but there are comparably few studies investigating the impact of such changes on demand and the local-regional tourism system. Questions such as how important climate is in comparison to other destination choice factors or what a change of

10% in a climate suitability indicator would mean for visitor numbers or spending remain unanswered. From a conceptual point of view, a clearer distinction is required between tourism activities being dependent on resources affected by the weather, like snow, ice, waves and wind, on the one hand, and tourism activities where weather is only relevant for comfort (e.g. temperatures) and attractiveness (e.g. visibility) on the other hand. A potential gap between stated preferences and behavior in hypothetical situations and real behavior when such conditions occur is often mentioned, but rarely addressed. The increasing occurrence of formerly unusual conditions (hot, lack of snow, drought and wildfires) could be used as natural experiments where tourists' real perception (e.g. through interviews, surveys) and impacts on demand can be investigated.

The present review revealed a clear lack of climate change and tourism studies that can be assigned to Klein et al. (2017) third and fourth generation of adaptation research. Third-generation studies would identify policy and institutional tools that support the industry's adaptation to climate change. Considering this research gap, it is not so surprising that the tourism industry is considered insufficiently prepared (Scott, 2021). More research is urgently needed to address these questions to support the industry in preparing for the (uncertain) future. Fourth-generation studies would address the implementation of adaptation measures at the destination level. Furthermore, limits to adaptation (e.g. physical, economic or social) as well as if adaptation can be considered as maladaptive or successful adaptation (Scott et al., 2022) are rarely assessed. Although there is a rich body of literature on climate change impacts also on the destination level, there is a lack of studies addressing the interactions between different impacts on the destination or market level (Scott, 2021). Tourism can inherently be seen as a complex and multidimensional system. Even these different dimensions interrelate and have strong interdependencies. However, to date, most studies focus on one interdependency, for example the link between a climatic resource/variable (i.e. temperature and snow availability) and tourist attendance. A better understanding and further research between these crossed-interdependencies, for example between climatic changes with feedback on the health, energy or biodiversity dimensions of destinations, are one of the big challenges academia has to face in the coming years. Such complex interrelationships require interdisciplinary research teams.

It is surprising that so little research exists on rising sea levels and coastal erosion, given that about half of tourism volumes in Europe is generated in coastal municipalities (Eurostat, 2022). There is a substantial body of literature on coastal erosion, but obviously tourism is not or hardly mentioned in these studies. Therefore, a possible research avenue could be to link this body of research with tourism aspects or to analyze existing results through the lens of tourism. Furthermore, more local integrated assessments are needed to investigate the cost effectiveness of potential adaptation measures, the magnitude of potential beach loss and infrastructure damage and the resulting impacts on tourism. Important but so far unanswered questions include: How can revenues from tourism be used to (co-) finance expensive protective measures? Are alternative adaptation options to rising sea levels (e.g. relocation) available and suitable from a tourism perspective?

As shown in this review, tourism in Europe urgently has to prepare for diverse climate and carbon risks and at the same time increase its efforts to reduce tourism-related GHG emissions. A decarbonized and better prepared tourism industry can benefit from higher quality natural resources and provide more sustainable benefits for regional economies that are dependent on tourism.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Robert Steiger  <http://orcid.org/0000-0002-1752-6450>
 O. Cenk Demiroglu  <http://orcid.org/0000-0001-7012-4111>
 Emmanuel Salim  <http://orcid.org/0000-0003-4182-9395>

References

- Adamiak, C., Hall, C. M., Hiltunen, M. J., & Pitkanen, K. (2016). Substitute or addition to hypermobile lifestyles? Second home mobility and Finnish CO2 emissions. *Tourism Geographies*, 18(2), 129–151. <https://doi.org/10.1080/14616688.2016.1145250>
- ADEME. (2021). Greenhouse gas inventory of the tourism sector in France. <https://bibliothec.ademe.fr/changement-climatique-et-energie/4782-greenhouse-gas-inventory-of-the-tourism-sector-in-france.html>.
- Alam, M. S., & Paramati, S. R. (2017). The dynamic role of tourism investment on tourism development and CO2 emissions. *Annals of Tourism Research*, 66, 213–215. <https://doi.org/10.1016/j.annals.2017.07.013>
- Alamanos, A. (2021). Water resources planning under climate and economic changes in Skiathos Island, Aegean. *Journal of Water Supply: Research and Technology-Aqua*, 70(7), 1085–1093. <https://doi.org/10.2166/aqua.2021.061>
- Amelung, B., & Moreno, A. (2012). Costing the impact of climate change on tourism in Europe: results of the PESETA project. *Climatic Change*, 112(1), 83–100. <https://doi.org/10.1007/s10584-011-0341-0>
- Amengual, A., Homar, V., Romero, R., Ramis, C., & Alonso, S. (2014). Projections for the 21st century of the climate potential for beach-based tourism in the Mediterranean. *International Journal of Climatology*, 34(13), 3481–3498. <https://doi.org/10.1002/joc.3922>
- Andreadis, O., Chatzipavlis, A., Hasiotis, T., Monioudi, I., Manoutsoglou, E., & Velegrakis, A. (2021). Assessment of and adaptation to beach erosion in islands: An integrated approach. *Journal of Marine Science and Engineering*, 9(8), 859. <https://doi.org/10.3390/jmse9080859>
- Antequera, P. D., Pacheco, J. D., Diez, A. L., & Herrera, C. B. (2021). Tourism, transport and climate change: The carbon footprint of international air traffic on islands. *Sustainability*, 13(4): 1795. <https://doi.org/10.3390/su13041795>
- Arias, P. A., Bellouin, N., Coppola, E., Jones, R. G., Krinner, G., Marotzke, J., Naik, V., Palmer, M. D., Plattner, G.-K., Rogelj, J., Rojas, M., Sillmann, J., Storelvmo, T., Thorne, P. W., Trewin, B., Achuta Rao, K., Adhikary, B., Allan, R. P., Armour, K., ... Zickfeld, K. (2021). Technical Summary. In Masson-Delmotte, V.P., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R., Zhou, B. (Eds.), *Climate change 2021: The physical science basis. Contribution of Working Group I to the sixth assessment report of the intergovernmental panel on climate change*. Cambridge University Press.
- Auvergne-Rhône-Alpes Tourisme. (2021). L'impact du changement climatique sur les activités outdoor en montagne. <https://pro.auvergnerhonealpes-tourisme.com/wp-content/uploads/2021/03/CarnetChangementClimatique-BaT3.pdf>.
- Bafaluy, D., Amengual, A., Romero, R., & Homar, V. (2014). Present and future climate resources for various types of tourism in the Bay of Palma, Spain. *Regional Environmental Change*, 14(5), 1995–2006. <https://doi.org/10.1007/s10113-013-0450-6>
- Bagdanavičiūtė, I., Kelpšaitė-Rimkienė, L., Galinienė, J., & Soomere, T. (2019). Index based multi-criteria approach to coastal risk assessment. *Journal of Coastal Conservation*, 23(4), 785–800. <https://doi.org/10.1007/s11852-018-0638-5>
- Balbi, S., Giupponi, C., Perez, P., & Alberti, M. (2013). A spatial agent-based model for assessing strategies of adaptation to climate and tourism demand changes in an alpine tourism destination. *Environmental Modelling & Software*, 45, 29–51. <https://doi.org/10.1016/j.envsoft.2012.10.004>
- Barr, S., & Prillwitz, J. (2012). Green travellers? Exploring the spatial context of sustainable mobility styles. *Applied Geography*, 32(2), 798–809. <https://doi.org/10.1016/j.apgeog.2011.08.002>
- Barrios, S., Ibanez, J.N., 2015. Time is of the essence: Adaptation of tourism demand to climate change in Europe. *Climatic Change* 132 (4), 645–660. <https://doi.org/10.1007/s10584-015-1431-1>
- Bausch, T., Gartner, W. C., & Humpe, A. (2021). How weather conditions affect guest arrivals and duration of stay: An alpine destination case. *International Journal of Tourism Research*, 23(6), 1006–1026. <https://doi.org/10.1002/jtr.2459>
- Bausch, T., Humpe, A., & Gossling, S. (2019). Does climate change influence guest loyalty at alpine winter destinations? *Sustainability*, 11(15), 4233. <https://doi.org/10.3390/su11154233>
- Becken, S., Whittlesea, E. R., Loehr, J., & Scott, D. (2020). Tourism and climate change: Evaluating the extent of policy integration. *Journal of Sustainable Tourism*, 28(10), 1603–1624. <https://doi.org/10.1080/09669582.2020.1745217>
- Bischof, M., Schmude, J., & Bauer, M. (2017). Tourism and climate change—A demand-side analysis of perception and reaction by using the example of the Alps. *Zeitschrift Für Tourismuswissenschaft*, 9(2), 221–247. [Mismatch] <https://doi.org/10.1515/tw-2017-0014>

- Blanc, E., & Winchester, N. (2013). The impact of the EU emissions trading system on air passenger arrivals in the Caribbean. *Journal of Travel Research*, 52(3), 353–363. <https://doi.org/10.1177/0047287512465960>
- Bonzanigo, L., Giupponi, C., & Balbi, S. (2016). Sustainable tourism planning and climate change adaptation in the Alps: A case study of winter tourism in mountain communities in the Dolomites. *Journal of Sustainable Tourism*, 24(4), 637–652. <https://doi.org/10.1080/09669582.2015.1122013>
- Brudermann, T., Zaman, R., & Posch, A. (2019). Not in my hiking trail? Acceptance of wind farms in the Austrian Alps. *Clean Technologies and Environmental Policy*, 21(8), 1603–1616. <https://doi.org/10.1007/s10098-019-01734-9>
- Bujosa, A., & Rossello, J. (2013). Climate change and summer mass tourism: The case of Spanish domestic tourism. *Climatic Change*, 117(1–2), 363–375. <https://doi.org/10.1007/s10584-012-0554-x>
- Cadarso, M. Á., Gómez, N., López, L. A., & Tobarra, M. Á. (2016). Calculating tourism's carbon footprint: Measuring the impact of investments. *Journal of Cleaner Production*, 111, 529–537. <https://doi.org/10.1016/j.jclepro.2014.09.019>
- Cadarso, M.-Á., Gómez, N., López, L.-A., Tobarra, M.-Á., & Zafrilla, J.-E. (2015). Quantifying Spanish tourism's carbon footprint: The contributions of residents and visitors. A longitudinal study. *Journal of Sustainable Tourism*, 23(6), 922–946. <https://doi.org/10.1080/09669582.2015.1008497>
- Caldeira, A. M., & Kastenholz, E. (2018). It's so hot: Predicting climate change effects on urban tourists' time-space experience. *Journal of Sustainable Tourism*, 26(9), 1516–1542. <https://doi.org/10.1080/09669582.2018.1478840>
- Carlsen, H., Dreborg, K. H., & Wikman-Svahn, P. (2013). Tailor-made scenario planning for local adaptation to climate change. *Mitigation and Adaptation Strategies for Global Change*, 18(8), 1239–1255. <https://doi.org/10.1007/s11027-012-9419-x>
- Cavallaro, F., Ciari, F., Nocera, S., Prettenhaler, F., & Scuttari, A. (2017a). The impacts of climate change on tourist mobility in mountain areas. *Journal of Sustainable Tourism*, 25(8), 1063–1083. <https://doi.org/10.1080/09669582.2016.1253092>
- Cavallaro, F., Galati, O. I., & Nocera, S. (2017b). Policy strategies for the mitigation of GHG emissions caused by the mass-tourism mobility in coastal areas. *Transportation Research Procedia*, 27, 317–324. <https://doi.org/10.1016/j.trpro.2017.12.062>
- Cavallaro, F., Galati, O. I., & Nocera, S. (2021). Climate change impacts and tourism mobility: A destination-based approach for coastal areas. *International Journal of Sustainable Transportation*, 15(6), 456–473. <https://doi.org/10.1080/15568318.2020.1762951>
- Čavlek, N., Cooper, C., Krajinović, V., Srnc, L., & Zaninović, K. (2019). Destination climate adaptation. *Journal of Hospitality & Tourism Research*, 43(2), 314–322. <https://doi.org/10.1177/1096348018793507>
- CBS. (2017). Milieu-economische verkenning toerismesector. <https://www.cbs.nl/nl-nl/nieuws/2017/22/milieu-economische-verkenning-toerismesector>.
- CCSA. (2021). How COVID-19 is changing the world: A statistical perspective. Volume III. https://unstats.un.org/unsd/ccsa/documents/covid19-report-ccsa_vol3.pdf.
- Cellini, R., & Cuccia, T. (2019). Weather conditions and museum attendance: A case-study from Sicily. *Climatic Change*, 154(3–4), 511–527. <https://doi.org/10.1007/s10584-019-02453-2>
- Clarivate. (2022). Web of science. <https://www.webofscience.com/wos/woscc/basic-search>.
- Coles, T., Zschiegner, A. K., & Dinan, C. (2013). Climate change mitigation policy and the tourism sector: perspectives from the South West of England. *Journal of Policy Research in Tourism Leisure and Events*, 5(1), 1–27. <https://doi.org/10.1080/19407963.2012.734991>
- Coles, T., Zschiegner, A. K., & Dinan, C. (2014). A cluster analysis of climate change mitigation behaviours among SMTEs. *Tourism Geographies*, 16(3), 382–399. <https://doi.org/10.1080/14616688.2013.851270>
- Comodi, G., Cioccolanti, L., & Renzi, M. (2014). Modelling the Italian household sector at the municipal scale: Micro-CHP, renewables and energy efficiency. *Energy*, 68, 92–103. <https://doi.org/10.1016/j.energy.2014.02.055>
- Csete, M., & Szecsi, N. (2015). The role of tourism management in adaptation to climate change—A study of a European inland area with a diversified tourism supply. *Journal of Sustainable Tourism*, 23(3), 477–496. <https://doi.org/10.1080/09669582.2014.969735>
- Cupac, R., Trbic, G., & Zahirovic, E. (2020). Cost-benefit analysis of climate change adaptation measures in Bosnia and Herzegovina. *Euro-Mediterranean Journal for Environmental Integration*, 5(2). <https://doi.org/10.1007/s41207-020-00160-4>
- Damm, A., Köberl, J., & Prettenhaler, F. (2014). Does artificial snow production pay under future climate conditions?—A case study for a vulnerable ski area in Austria. *Tourism Management*, 43, 8–21. <https://doi.org/10.1016/j.tourman.2014.01.009>
- Dannevig, H., Gildestad, I., Steiger, R., & Scott, D. (2021). Adaptive capacity of ski resorts in Western Norway to projected changes in snow conditions. *Current Issues in Tourism*, 24(22), 3206–3221. <https://doi.org/10.1080/13683500.2020.1865286>
- Demiroglu, O. C., Akbas, A., Turp, M. T., Ozturk, T., An, N., & Kurnaz, M. L. (2018). Case study Turkey: Climate change and coastal tourism: Impacts of climate change on the Turquoise Coast. In Jones, A.L., Phillips, M.R. (Eds.), *Global climate change and coastal tourism. Recognizing problems, managing solutions and future expectations* (pp. 247–262). CABI, Wallingford, Oxfordshire.

- Demiroglu, O. C., Kucerova, J., & Ozecelebi, O. (2015). Snow reliability and climate elasticity: Case of a Slovak ski resort. *Tourism Review*, 70(1), 1–12. <https://doi.org/10.1108/TR-01-2014-0003>
- Demiroglu, O. C., Lundmark, L., Saarinen, J., & Muller, D. K. (2020a). The last resort? Ski tourism and climate change in Arctic Sweden. *Journal of Tourism Futures*, 6(1), 91–101. <https://doi.org/10.1108/JTF-05-2019-0046>
- Demiroglu, O. C., Saygili-Araci, F. S., Pacal, A., Hall, C. M., & Kurnaz, M. L. (2020b). Future Holiday Climate Index (HCI) performance of urban and beach destinations in the Mediterranean. *Atmosphere*, 11(9), 911. <https://doi.org/10.3390/atmos11090911>
- Demiroglu, O. C., & Turhan, E. (2021). Degrowing tourism: Can grassroots form the norm?. In Hall, C.M., Lundmark, L., Zhang, J.J. (Eds.), *Degrowth and tourism: New perspectives on tourism entrepreneurship, destinations and policy* (pp. 202–219). Routledge, Abingdon, Oxon.
- Demiroglu, O. C., Turp, M. T., Kurnaz, M. L., & Abegg, B. (2021). The Ski Climate Index (SCI): Fuzzification and a regional climate modeling application for Turkey. *International Journal of Biometeorology*, 65(5), 763–777. <https://doi.org/10.1007/s00484-020-01991-0>
- Demiroglu, O. C., Turp, M. T., Ozturk, T., An, N., & Kurnaz, M. L. (2016a). Technical climate change adaptation options of the major ski resorts in Bulgaria. In Koulov, B., & Zhelezov, G. (Eds.), *Sustainable mountain regions: Challenges and perspectives in Southeastern Europe* (pp. 77–88). Springer International Publishing.
- Dickinson, J. E., Robbins, D., Filimonau, V., Hares, A., & Mika, M. (2013). Awareness of tourism impacts on climate change and the implications for travel practice: A Polish perspective. *Journal of Travel Research*, 52(4), 506–519. <https://doi.org/10.1177/0047287513478691>
- Dickinson, J. E., Robbins, D., & Lumsdon, L. (2010). Holiday travel discourses and climate change. *Journal of Transport Geography*, 18(3), 482–489. <https://doi.org/10.1016/j.jtrangeo.2010.01.006>
- Dinares, M., & Sauri, D. (2015). Water consumption patterns of hotels and their response to droughts and public concerns regarding water conservation: The case of the Barcelona hotel industry during the 2007–2008 episode. *Documents D Anàlisi Geogràfica*, 61(3), 623–649. <https://doi.org/10.5565/rev/dag.255>
- Dogru, T., Bulut, U., Kocak, E., Isik, C., Suess, C., & Sirakaya-Turk, E. (2020). The nexus between tourism, economic growth, renewable energy consumption, and carbon dioxide emissions: Contemporary evidence from OECD countries. *Environmental Science and Pollution Research International*, 27(32), 40930–40948. <https://doi.org/10.1007/s11356-020-10110-w>
- Ebert, K., Ekstedt, K., & Jarsjo, J. (2016). GIS analysis of effects of future Baltic sea level rise on the island of Gotland, Sweden. *Natural Hazards and Earth System Sciences*, 16(7), 1571–1582. <https://doi.org/10.5194/nhess-16-1571-2016>
- Eijgelaar, E., Nawijn, J., Barten, C., Okuhn, L., & Dijkstra, L. (2016). Consumer attitudes and preferences on holiday carbon footprint information in the Netherlands. *Journal of Sustainable Tourism*, 24(3), 398–411. <https://doi.org/10.1080/09669582.2015.1101129>
- Endler, C., & Matzarakis, A. (2011). Climate and tourism in the Black Forest during the warm season. *International Journal of Biometeorology*, 55(2), 173–186. <https://doi.org/10.1007/s00484-010-0323-3>
- Energiezukunft.eu. (2022). Im Nachtzug durch Europa. <https://www.energiezukunft.eu/mobilitaet/im-nachtzug-durch-europa/>.
- Enriquez, A. R., & Bestard, A. B. (2020). Measuring the economic impact of climate-induced environmental changes on sun-and-beach tourism. *Climatic Change*, 160(2), 203–217. <https://doi.org/10.1007/s10584-020-02682-w>
- European Commission. (2022). Trans-European Transport Network (TEN-T). https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en.
- Eurostat. (2018). Tourism industries—Employment. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tourism_industries_-_employment.
- Eurostat. (2022). Data browser. https://ec.europa.eu/eurostat/databrowser/product/page/TOUR_OCC_NIM.
- Eyuboglu, K., & Uzar, U. (2020). The impact of tourism on CO2 emission in Turkey. *Current Issues in Tourism*, 23(13), 1631–1645. <https://doi.org/10.1080/13683500.2019.1636006>
- Falk, M. T., & Hagsten, E. (2021). Determinants of CO2 emissions generated by air travel vary across reasons for the trip. *Environmental Science and Pollution Research International*, 28(18), 22969–22980. <https://doi.org/10.1007/s11356-020-12219-4>
- Filimonau, V., & Hogstrom, M. (2017). The attitudes of UK tourists to the use of biofuels in civil aviation: An exploratory study. *Journal of Air Transport Management*, 63, 84–94. <https://doi.org/10.1016/j.jairtraman.2017.06.002>
- Filimonau, V., Matute, J., Mika, M., & Faracik, R. (2018a). National culture as a driver of pro-environmental attitudes and behavioural intentions in tourism. *Journal of Sustainable Tourism*, 26(10), 1804–1825. <https://doi.org/10.1080/09669582.2018.1511722>
- Filimonau, V., Mika, M., & Pawlusiński, R. (2018b). Public attitudes to biofuel use in aviation: Evidence from an emerging tourist market. *Journal of Cleaner Production*, 172, 3102–3110. <https://doi.org/10.1016/j.jclepro.2017.11.101>
- Foghagen, C. (2014). The blooming paradise: algae blooms, environmental change and tourism. *European Journal of Tourism Research*, 7, 79–91. <https://doi.org/10.54055/ejtr.v7i.141>

- Furunes, T., & Mykletun, R. J. (2012). Frozen adventure at risk? A 7-year follow-up study of Norwegian Glacier tourism. *Scandinavian Journal of Hospitality and Tourism*, 12(4), 324–348. <https://doi.org/10.1080/15022250.2012.748507>
- Garriga Sala, J. (2008). Documentos del Cambio Climático Estudios de base para una estrategia de prevención y adaptación al cambio climático en Cataluña Número 1: el Delta del Ebro. [http://www.gencat.cat/mediamb/publicacions/monografies/estudis_base_estrategia_DELTA_\(cas_ang\).pdf](http://www.gencat.cat/mediamb/publicacions/monografies/estudis_base_estrategia_DELTA_(cas_ang).pdf).
- Gerbaux, M., Spandre, P., Francois, H., George, E., & Morin, S. (2020). Snow reliability and water availability for snow-making in the ski resorts of the ISERE Department (French Alps) under current and future climate conditions. *Revue De Geographie Alpine-Journal of Alpine Research*, 108(1), 1–19.
- Gonçalves, C., Honrado, J. P., Cerejeira, J., Sousa, R., Fernandes, P. M., Vaz, A. S., Alves, M., Araújo, M., Carvalho-Santos, C., Fonseca, A., Fraga, H., Gonçalves, J. F., Lomba, A., Pinto, E., Vicente, J. R., & Santos, J. A. (2022). On the development of a regional climate change adaptation plan: Integrating model-assisted projections and stakeholders' perceptions. *The Science of the Total Environment*, 805, 150320. <https://doi.org/10.1016/j.scitotenv.2021.150320>
- Gonseth, C., & Vielle, M. (2019). A general equilibrium assessment of climate change impacts on Swiss winter tourism with adaptation. *Environmental Modeling & Assessment*, 24(3), 265–277. <https://doi.org/10.1007/s10666-018-9641-3>
- Gössling, S., & Hall, M. (2008). Swedish tourism and climate change mitigation: An emerging conflict? *Scandinavian Journal of Hospitality and Tourism*, 8(2), 141–158. <https://doi.org/10.1080/15022250802079882>
- Gössling, S., Hanna, P., Higham, J., Cohen, S., & Hopkins, D. (2019). Can we fly less? Evaluating the 'necessity' of air travel. *Journal of Air Transport Management*, 81, 101722. <https://doi.org/10.1016/j.jairtraman.2019.101722>
- Gössling, S., Lohmann, M., Grimm, B., & Scott, D. (2017). Leisure travel distribution patterns of Germans: Insights for climate policy. *Case Studies on Transport Policy*, 5(4), 596–603. <https://doi.org/10.1016/j.cstp.2017.10.001>
- Gössling, S., Peeters, P., Ceron, J.-P., Dubois, G., Patterson, T., & Richardson, R. B. (2005). The eco-efficiency of tourism. *Ecological Economics*, 54(4), 417–434. <https://doi.org/10.1016/j.ecolecon.2004.10.006>
- Gössling, S., Scott, D., & Hall, C. M. (2015). Inter-market variability in CO2 emission-intensities in tourism: Implications for destination marketing and carbon management. *Tourism Management*, 46, 203–212. <https://doi.org/10.1016/j.tourman.2014.06.021>
- Grdic, Z. S., Gregoric, M., & Nizic, M. K. (2019). Investigating the influence of tourism on economic growth and climate change—The case of Croatia. *Contemporary Economics*, 13(2), 111–122. <https://doi.org/10.5709/ce.1897-9254.302>
- Grdic, Z. S., & Nihe, M. K. (2016). Development of tourist demand in correlation with climate change in the republic of Croatia. *Ekonomski Pregled*, 67(1), 27–43.
- Grillakis, M.G., Koutroulis, AG, Tsanis, I.K., 2016. The 2 degrees C global warming effect on summer European tourism through different indices. *International Journal of biometeorology*, 60 (8), 1205–1215. <https://doi.org/10.1007/s00484-015-1115-6>
- Grizane, T., & Blumberga, D. (2020). Carbon emissions in recreation fishing travelling. Case of Latvia. *Environmental and Climate Technologies*, 24(3), 493–512. <https://doi.org/10.2478/rtuect-2020-0119>
- Grizane, T., Julija, G., Sannikova, A., & Jurgelane-Kaldava, I. (2019). Emissions of carbon dioxide (co2) and growth the tourism industry: Case study of Latvia [Paper presentation]. *Economic science for rural development*, 347–354. <https://doi.org/10.22616/ESRD.2019.141>
- Grizane, T., & Jurgelane-Kaldava, I. (2019). Tourist transportation generated carbon dioxide (CO2) emissions in Latvia. *Environmental and Climate Technologies*, 23(3), 274–292. <https://doi.org/10.2478/rtuect-2019-0095>
- Gutiérrez, J. M., Jones, R. G., Narisma, G. T., Alves, L. M., Amjad, M., Gorodetskaya, I. V., Grose, M., Klutse, N., Krakovska, S., Li, J., Martínez-Castro, D., Mearns, L. O., Mernild, S. H., Ngo-Duc, T., van den Hurk, B., & Yoon, J.-H. (2021). Atlas. In Masson-Delmotte, V.P., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R., Zhou, B. (Eds.), *Climate change 2021: The physical science basis. Contribution of Working Group I to the sixth assessment report of the intergovernmental panel on climate change*. Cambridge University Press.
- Gyamfi, B. A., Bein, M. A., Adedoyin, F. F., & Bekun, F. V. (2021). To what extent are pollutant emission intensified by international tourist arrivals? Starling evidence from G7 Countries. *Environment Development and Sustainability*. 7896–7917. <https://doi.org/10.1007/s10668-021-01765-7>
- Haanpaa, S., Juhola, S., & Landauer, M. (2015). Adapting to climate change: Perceptions of vulnerability of down-hill ski area operators in Southern and Middle Finland. *Current Issues in Tourism*, 18(10), 966–978. <https://doi.org/10.1080/13683500.2014.892917>
- Hall, C. M. (2014). Will climate change kill Santa Claus? Climate change and high-latitude Christmas place branding. *Scandinavian Journal of Hospitality and Tourism*, 14(1), 23–40. <https://doi.org/10.1080/15022250.2014.886101>
- Hamilton, J. M. (2007). Coastal landscape and the hedonic price of accommodation. *Ecological Economics*, 62(3–4), 594–602. <https://doi.org/10.1016/j.ecolecon.2006.08.001>

- Hanna, P., & Adams, M. (2019). Positive self-representations, sustainability and socially organised denial in UK tourists: Discursive barriers to a sustainable transport future. *Journal of Sustainable Tourism*, 27(2), 189–206. <https://doi.org/10.1080/09669582.2017.1358272>
- Hares, A., Dickinson, J., & Wilkes, K. (2010). Climate change and the air travel decisions of UK tourists. *Journal of Transport Geography*, 18(3), 466–473. <https://doi.org/10.1016/j.jtrangeo.2009.06.018>
- Haugom, E., Malasevska, I., Alnes, P. K., & Mydland, O. (2021). Willingness to pay for "green skiing". *Journal of Hospitality and Tourism Management*, 47, 252–255. <https://doi.org/10.1016/j.jhtm.2021.03.010>
- Hein, L. (2007). The impact of climate change on Tourism in Spain. Universitetet i Oslo, CICERO—Senter for klimaforskning.
- Higham, J. E., & Cohen, S. A. (2011). Canary in the coalmine: Norwegian attitudes towards climate change and extreme long-haul air travel to Aotearoa/New Zealand. *Tourism Management*, 32(1), 98–105. <https://doi.org/10.1016/j.tourman.2010.04.005>
- Ioncica, D., Ioncica, M., & Petrescu, E. C. (2016). The environment, tourist transport and the sustainable development of tourism. *Amfiteatru Economic*, 18, 898–912.
- IPCC. (2014). Climate change 2014: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva.
- IPCC. (2021). Summary for policymakers. In Masson-Delmotte, V.P., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R., Zhou, B. (Eds.), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 3–32). Cambridge University Press.
- İşik, C., Kasımatı, E., & Oğan, S. (2017). Analyzing the causalities between economic growth, financial development, international trade, tourism expenditure and/on the CO2 emissions in Greece. *Energy Sources Part B-Economics Planning and Policy*, 12(7), 665–673. <https://doi.org/10.1080/15567249.2016.1263251>
- Jacob, D., Kotova, L., Teichmann, C., Sobolowski, S. P., Vautard, R., Donnelly, C., Koutroulis, A. G., Grillakis, M. G., Tsanis, I. K., Damm, A., Sakalli, A., & van Vliet, M. T. (2018). Climate impacts in Europe under +1.5 degrees C global warming. *Earths Future*, 6(2), 264–285. <https://doi.org/10.1002/2017EF000710>
- Jarvis, N., & Ortega, A. P. (2010). The impact of climate change on small hotels in Granada, Spain. *Tourism Planning & Development*, 7(3), 283–299. <https://doi.org/10.1080/1479053X.2010.502389>
- Jenkins, K., & Nicholls, S. (2010). The impacts of climate variability and potential climate change on tourism business in Torbay, England and implications for adaptation. *Tourism Analysis*, 15(1), 17–30. <https://doi.org/10.3727/108354210X12724734223513>
- Jimenez, J. A., Valdemoro, H. I., Bosom, E., Sanchez-Arcilla, A., & Nicholls, R. J. (2017). Impacts of sea-level rise-induced erosion on the Catalan coast. *Regional Environmental Change*, 17(2), 593–603. <https://doi.org/10.1007/s10113-016-1052-x>
- Jones, C. (2013). Scenarios for greenhouse gas emissions reduction from tourism: An extended tourism satellite account approach in a regional setting. *Journal of Sustainable Tourism*, 21(3), 458–472. <https://doi.org/10.1080/09669582.2012.708039>
- Juschten, M., Brandenburg, C., Hossinger, R., Liebl, U., Offenzeller, M., Prutsch, A., Unbehau, W., Weber, F., & Jiricka-Purrer, A. (2019). Out of the city heat-way to less or more sustainable futures? *Sustainability*, 11(1), 214. <https://doi.org/10.3390/su11010214>
- Juvan, E., & Dolnicar, S. (2014). Can tourists easily choose a low carbon footprint vacation? *Journal of Sustainable Tourism*, 22(2), 175–194. <https://doi.org/10.1080/09669582.2013.826230>
- Kajan, E. (2014). Arctic tourism and sustainable adaptation: Community perspectives to vulnerability and climate change. *Scandinavian Journal of Hospitality and Tourism*, 14(1), 60–79. <https://doi.org/10.1080/15022250.2014.886097>
- Kapeller, M. L., Fullsack, M., & Jager, G. (2019). Holiday travel behaviour and correlated CO2 emissions-modelling trend and future scenarios for Austrian tourists. *Sustainability*, 11(22), 6418. <https://doi.org/10.3390/su11226418>
- Karaca, M., & Nicholls, R. J. (2008). Potential implications of accelerated sea-level rise for Turkey. *Journal of Coastal Research*, 24(2), 288–298. <https://doi.org/10.2112/07A-0003.1>
- Katavoutas, G., Founda, D., Kitsara, G., & Giannakopoulos, C. (2021). Climate change and thermal comfort in top tourist destinations—The case of Santorini (Greece). *Sustainability*, 13(16), 9107. <https://doi.org/10.3390/su13169107>
- Katircioglu, S. T., Feridun, M., & Kilinc, C. (2014). Estimating tourism-induced energy consumption and CO2 emissions: The case of Cyprus. *Renewable & Sustainable Energy Reviews*, 29, 634–640. <https://doi.org/10.1016/j.rser.2013.09.004>
- Katirtzidou, M., & Latinopoulos, P. (2018). Allocation of surface and subsurface water resources to competing uses under climate changing conditions: A case study in Halkidiki, Greece. *Water Supply*, 18(4), 1151–1161. <https://doi.org/10.2166/ws.2017.166>

- Kennedy, V., Crawford, K. R., Main, G., Gauci, R., & Schembri, J. A. (2022). Stakeholder's (natural) hazard awareness and vulnerability of small island tourism destinations: A case study of Malta. *Tourism Recreation Research*, 47(2), 160–176. <https://doi.org/10.1080/02508281.2020.1828554>
- Kietavainen, A., & Tuulentie, S. (2013). Tourism strategies and climate change: rhetoric at both strategic and grass-roots levels about growth and sustainable development in Finland. *Journal of Sustainable Tourism*, 21(6), 845–861. <https://doi.org/10.1080/09669582.2012.750326>
- Klein, J., Ekstedt, K., Walter, M. T., & Lyon, S. W. (2015). Modeling potential water resource impacts of mediterranean tourism in a changing climate. *Environmental Modeling & Assessment*, 20(2), 117–128. <https://doi.org/10.1007/s10666-014>
- Klein, R., Adams, K. M., Dzebo, A., Davis, M., & Siebert, C. K. (2017). Advancing climate adaptation practices and solutions: Emerging research priorities. Stockholm Environment Institute (SEI). <https://www.sei.org/wp-content/uploads/2017/05/klein-et-al-2017-adaptation-research-priorities.pdf>.
- Köberl, J., Pretenthaler, F., & Bird, D. N. (2016). Modelling climate, change impacts on tourism demand: A comparative study from Sardinia (Italy) and Cap Bon (Tunisia). *The Science of the Total Environment*, 543(Pt B), 1039–1053. <https://doi.org/10.1016/j.scitotenv.2015.03.099>
- Kocak, E., Ulucak, R., & Ulucak, Z. S. (2020). The impact of tourism developments on CO2 emissions: An advanced panel data estimation. *Tourism Management Perspectives*, 33, 100611. <https://doi.org/10.1016/j.tmp.2019.100611>
- Koutroulis, A. G., Grillakis, M. G., Tsanis, I. K., & Jacob, D. (2018). Mapping the vulnerability of European summer tourism under 2 degrees C global warming. *Climatic Change*, 151(2), 157–171. <https://doi.org/10.1007/s10584-018-2298-8>
- Kovacs, A., Unger, J., Gal, C., & Kantor, N. (2016). Adjustment of the thermal component of two tourism climatological assessment tools using thermal perception and preference surveys from Hungary. *Theoretical and Applied Climatology*, 125(1–2), 113–130. <https://doi.org/10.1007/s00704-015-1488-9>
- Kroesen, M. (2013). Exploring people's viewpoints on air travel and climate change: understanding inconsistencies. *Journal of Sustainable Tourism*, 21(2), 271–290. <https://doi.org/10.1080/09669582.2012.692686>
- Kundzewicz, Z. W., Giannakopoulos, C., Schwarb, M., Stjernquist, I., Schlyter, P., Szwed, M., & Palutikof, J. (2008). Impacts of climate extremes on activity sectors—stakeholders' perspective. *Theoretical and Applied Climatology*, 93(1–2), 117–132. <https://doi.org/10.1007/s00704-007-0327-z>
- Lam-Gonzalez, Y. E., Galindo, C. G., Hernandez, M. M., & Leon, C. J. (2020). Understanding the heterogeneity of tourists' choices under climate change risks: A segmentation analysis. *Atmosphere*, 12(1), 22. <https://doi.org/10.3390/atmos12010022>
- Land Tirol. (2020). Der Tiroler Weg. Perspektiven für eine verantwortungsvolle Tourismusedwicklung. https://www.lebensraum.tirol/wp-content/uploads/2021/06/210608_149_21-Tiroler-Weg_screen_FINAL.pdf.
- Landauer, M., Goodsite, M. E., & Juhola, S. (2018). Nordic national climate adaptation and tourism strategies—(How) Are they interlinked? *Scandinavian Journal of Hospitality and Tourism*, 18(sup1), S75–S86. <https://doi.org/10.1080/15022250.2017.1340540>
- Landauer, M., Haider, W., & Pröbstl-Haider, U. (2014). The influence of culture on climate change adaptation strategies: Preferences of cross-country skiers in Austria and Finland. *Journal of Travel Research*, 53(1), 96–110. <https://doi.org/10.1177/0047287513481276>
- Landauer, M., Pröbstl, U., & Haider, W. (2012). Managing cross-country skiing destinations under the conditions of climate change—Scenarios for destinations in Austria and Finland. *Tourism Management*, 33(4), 741–751. <https://doi.org/10.1016/j.tourman.2011.08.007>
- Landauer, M., Sievanen, T., & Neuvonen, M. (2009). Adaptation of Finnish cross-country skiers to climate change. *Fennia-International Journal of Geography*, 187(2), 99–113.
- Lee, J. W., & Brahmaresne, T. (2013). Investigating the influence of tourism on economic growth and carbon emissions: Evidence from panel analysis of the European Union. *Tourism Management*, 38, 69–76. <https://doi.org/10.1016/j.tourman.2013.02.016>
- Lefebvre, G., Redmond, L., Germain, C., Palazzi, E., Terzago, S., Willm, L., & Poulin, B. (2019). Predicting the vulnerability of seasonally-flooded wetlands to climate change across the Mediterranean Basin. *The Science of the Total Environment*, 692, 546–555. <https://doi.org/10.1016/j.scitotenv.2019.07.263>
- Leitão, N. C., & Lorente, D. B. (2020). The linkage between economic growth, renewable energy, tourism, CO2 emissions, and international trade: The evidence for the European Union. *Energies*, 13(18), 4838. <https://doi.org/10.3390/en13184838>
- Lemesios, G., Giannakopoulos, C., Papadaskalopoulou, C., Karali, A., Varotsos, K. V., Moustakas, K., Malamis, D., Zachariou-Dodou, M., Petrakis, M., & Loizidou, M. (2016). Future heat-related climate change impacts on tourism industry in Cyprus. *Regional Environmental Change*, 16(7), 1915–1927. <https://doi.org/10.1007/s10113-016-0997-0>
- Lenzen, M., Sun, Y.-Y., Faturay, F., Ting, Y.-P., Geschke, A., & Malik, A. (2018). The carbon footprint of global tourism. *Nature Climate Change*, 8(6), 522–528. <https://doi.org/10.1038/s41558-018-0141-x>
- Leon, C. J., Giannakis, E., Zittis, G., Serghides, D., Lam-Gonzalez, Y. E., & Garcia, C. (2021). Tourists' preferences for adaptation measures to build climate resilience at coastal destinations. *Tourism Planning & Development*, 1–27. <https://doi.org/10.1080/21568316.2021.1958914>

- León, C. J., Lam-González, Y. E., Galindo, C. G., & Hernández, M. M. G. (2020). Measuring the Impact of Infectious Diseases on Tourists' Willingness to Pay to Visit Island Destinations. *Atmosphere*, 11(10), 1117. <https://doi.org/10.3390/atmos11101117>
- Lepy, E., Heikkinen, H. I., Karjalainen, T. P., Tervo-Kankare, K., Kauppila, P., Suopajarvi, T., Ponnikas, J., Siikamaki, P., & Rautio, A. (2014). Multidisciplinary and participatory approach for assessing local vulnerability of tourism industry to climate change. *Scandinavian Journal of Hospitality and Tourism*, 14(1), 41–59. <https://doi.org/10.1080/15022250.2014.886373>
- Lepy, E., Rantala, S., Huusko, A., Nieminen, P., Hippi, M., & Rautio, A. (2016). Role of winter weather conditions and slipperiness on tourists' accidents in Finland. *International Journal of Environmental Research and Public Health*, 13(8), 822. <https://doi.org/10.3390/ijerph13080822>
- Linard, C., Poncon, N., Fontenille, D., & Lambin, E. F. (2009). Risk of Malaria reemergence in Southern France: Testing scenarios with a multiagent simulation model. *Ecohealth*, 6(1), 135–147. <https://doi.org/10.1007/s10393-009-0236-y>
- Lopes, H. S., Remoaldo, P. C., Ribeiro, V., & Martín-Vide, J. (2021). Perceptions of human thermal comfort in an urban tourism destination—A case study of Porto (Portugal). *Building and Environment*, 205, 108246. <https://doi.org/10.1016/j.buildenv.2021.108246>
- López-Dóriga, U., Jiménez, J. A., Valdemoro, H. I., & Nicholls, R. J. (2019). Impact of sea-level rise on the tourist-carrying capacity of Catalan beaches. *Ocean & Coastal Management*, 170, 40–50. <https://doi.org/10.1016/j.ocecoaman.2018.12.028>
- Luthe, T., & Wyss, R. (2016). Resilience to climate change in a cross-scale tourism governance context: A combined quantitative-qualitative network analysis. *Ecology and Society*, 21(1) <https://doi.org/10.5751/ES-08234-210127>
- Martin-Arias, J., Martínez-Santos, P., & Andreo, B. (2020). Modelling the effects of climate change and population growth in four intensively exploited Mediterranean aquifers. The Mijas range, southern Spain. *Journal of Environmental Management*, 262, 110316. <https://doi.org/10.1016/j.jenvman.2020.110316>
- Masson-Delmotte, V. P., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M. I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J., Maycock, T. K., Waterfield, T., Yelekçi, O., Yu, R., & Zhou, B. (2021). Summary for policymakers. In Masson-Delmotte, V.P., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Lonnoy, E., Matthews, J., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R., Zhou, B. (Eds.), *Climate change 2021: The physical science basis. Contribution of Working Group I to the sixth assessment report of the intergovernmental panel on climate change*. Cambridge University Press.
- Matasci, C., Kruse, S., Barawid, N., & Thalmann, P. (2014). Exploring barriers to climate change adaptation in the Swiss tourism sector. *Mitigation and Adaptation Strategies for Global Change*, 19(8), 1239–1254. <https://doi.org/10.1007/s11027-013-9471-1>
- Matzarakis, A., Endler, C., & Nastos, P. T. (2014). Quantification of climate-tourism potential for Athens, Greece—Recent and future climate simulations. *Global Nest Journal*, 16(1), 43–51.
- Matzarakis, A., Georgiadis, T., & Rossi, F. (2007). Thermal bioclimate analysis for Europe and Italy. *Nuovo Cimento C- Colloquia and Communications in Physics*, 30(6), 623–632. <https://doi.org/10.1393/ncc/i2007-10268-0>
- Matzarakis, A., Hammerle, M., Endler, C., Muthers, S., & Koch, E. (2012). Assessment of tourism and recreation destinations under climate change conditions in Austria. *Meteorologische Zeitschrift*, 21(2), 157–165. <https://doi.org/10.1127/0941-2948/2012/0342>
- Matzarakis, A., Rammelberg, J., & Junk, J. (2013). Assessment of thermal bioclimate and tourism climate potential for central Europe—the example of Luxembourg. *Theoretical and Applied Climatology*, 114(1–2), 193–202. <https://doi.org/10.1007/s00704-013-0835-y>
- Michailidou, A. V., Vlachokostas, C., & Moussiopoulos, N. (2016). Interactions between climate change and the tourism sector: Multiple-criteria decision analysis to assess mitigation and adaptation options in tourism areas. *Tourism Management*, 55, 1–12. <https://doi.org/10.1016/j.tourman.2016.01.010>
- Michopoulos, A., Ziogou, I., Kerimis, M., & Zachariadis, T. (2017). A study on hot-water production of hotels in Cyprus: Energy and environmental considerations. *Energy and Buildings*, 150, 1–12. <https://doi.org/10.1016/j.enbuild.2017.05.071>
- Moià-Pol, A., Martínez-Moll, V., Nadal, R. P., Serra, & J. M., R. (2014). Solar thermal potential for collective systems in Palma Beach (Balearic Island's). *Energy Procedia*, 48, 1118–1123. <https://doi.org/10.1016/j.egypro.2014.02.126>
- Mooser, A., Anfuso, G., Williams, A. T., Molina, R., & Aucelli, P. P. (2020). An innovative approach to determine coastal scenic beauty and sensitivity in a scenario of increasing human pressure and natural impacts due to climate change. *Water*, 13(1), 49. <https://doi.org/10.3390/w13010049>
- Moreau, M. (2010). Visual perception of changes in a high mountain landscape: The case of the retreat of the Évettes Glacier (Haute-Maurienne, northern French Alps). *Géomorphologie: Relief, Processus, Environnement*, 16(2), 165–174. <https://doi.org/10.4000/geomorphologie.7901>
- Moreno, A., & Amelung, B. (2009). Climate change and tourist comfort on Europe's beaches in Summer: A reassessment. *Coastal Management*, 37(6), 550–568. <https://doi.org/10.1080/08920750903054997>

- Mourey, J., Marcuzzi, M., Ravanel, L., & Pallandre, F. (2019). Effects of climate change on high Alpine mountain environments: Evolution of mountaineering routes in the Mont Blanc massif (Western Alps) over half a century. *Arctic, Antarctic, and Alpine Research*, 51(1), 176–189. <https://doi.org/10.1080/15230430.2019.1612216>
- Mourey, J., Perrin-Malterre, C., & Ravanel, L. (2020). Strategies used by French Alpine guides to adapt to the effects of climate change. *Journal of Outdoor Recreation and Tourism*, 29, 100278. <https://doi.org/10.1016/j.jort.2020.100278>
- Mourey, J., & Ravanel, L. (2017). Evolution of access routes to high mountain refuges of the Mer de Glace Basin (Mont Blanc Massif, France). *Revue De Géographie Alpine*, 105 (4), 1–16. <https://doi.org/10.4000/rga.3790>
- Nastos, P. T., & Matzarakis, A. (2019). Present and future climate-tourism conditions in Milos Island. *Greece Atmosphere*, 10(3), 145. <https://doi.org/10.3390/atmos10030145>
- Navratil, J., Picha, K., Buchecker, M., Martinat, S., Svec, R., Brezinova, M., & Knotek, J. (2019). Visitors' preferences of renewable energy options in "green" hotels. *Renewable Energy*, 138, 1065–1077. <https://doi.org/10.1016/j.renene.2019.02.043>
- NBTC. (2019). Perspectief 2030. Bestemming Nederland. <https://www.nbtc.nl/site/download/perspectief-bestemming-nl-2030.htm?disposition=inline>.
- Neger, C., Prettenthaler, F., Gössling, S., & Damm, A. (2021). Carbon intensity of tourism in Austria: Estimates and policy implications. *Journal of Outdoor Recreation and Tourism*, 33, 100331. <https://doi.org/10.1016/j.jort.2020.100331>
- Nilsson, J. H., & Gössling, S. (2013). Tourist responses to extreme environmental events: The case of Baltic Sea Algal Blooms. *Tourism Planning & Development*, 10(1), 32–44. <https://doi.org/10.1080/21568316.2012.723037>
- Nizic, M. K., & Grdic, Z. S. (2018). Winter tourism in Croatia: Is it possible? *Sustainability*, 10(10), 3563. <https://doi.org/10.3390/su10103563>
- Nizic, M. K., Grdic, Z. S., & Endres, R. (2017). Energy sustainability and its impacts on Croatian Tourism. *Croatian Economic Survey*, 19(2), 83–104. <https://doi.org/10.15179/ces.19.2.3>
- Nunes, P., & Loureiro, M. L. (2016). Economic valuation of climate-change-induced vineyard landscape impacts on tourism flows in Tuscany. *Agricultural Economics*, 47(4), 365–374. <https://doi.org/10.1111/agec.12236>
- OPCC. (2019). Résultats du projet OPCC2 et des autres projets associés: CLIM'PY, REPLIM, CANOPEE, FLORAPYR, PIRAGUA. <https://docplayer.fr/162520643-Resultats-du-projet-opcc2-et-des-autres-projets-associes-clim-py-replim-canopee-florapyr-piragua-octobre-2019.html>.
- Otrachshenko, V., & Nunes, L. C. (2022). Fire takes no vacation: Impact of fires on tourism. *Environment and Development Economics*, 27(1), 86–101. <https://doi.org/10.1017/S1355770X21000012>
- Pablo-Romero, M., Sánchez-Braza, A., & Sánchez-Rivas, J. (2017). Relationships between hotel and restaurant electricity consumption and tourism in 11 European Union countries. *Sustainability*, 9(11), 2109. <https://doi.org/10.3390/su9112109>
- Pace, L. A. (2016). How do tourism firms innovate for sustainable energy consumption? A capabilities perspective on the adoption of energy efficiency in tourism accommodation establishments. *Journal of Cleaner Production*, 111, 409–420. <https://doi.org/10.1016/j.jclepro.2015.01.095>
- Pala, A. (2020). The relation between climate change and economic growth: the investigation the regional differences with RCM model in EU-28 countries. *International Journal of Economic Sciences*, 19(1), 135–154. <https://doi.org/10.20472/ES.2020.9.1.008>
- Pata, U. K., & Balsalobre-Lorente, D. (2022). Exploring the impact of tourism and energy consumption on the load capacity factor in Turkey: a novel dynamic ARDL approach. *Environmental Science and Pollution Research*, 29(9), 13491–13503. <https://doi.org/10.1007/s11356-021-16675-4>
- Peeters, P., Szimba, E., & Duijnsveld, M. (2007). Major environmental impacts of European tourist transport. *Journal of Transport Geography*, 15(2), 83–93. <https://doi.org/10.1016/j.jtrangeo.2006.12.007>
- Perch-Nielsen, S., Sesartic, A., & Stucki, M. (2010a). The greenhouse gas intensity of the tourism sector: The case of Switzerland. *Environmental Science & Policy*, 13(2), 131–140. <https://doi.org/10.1016/j.envsci.2009.12.002>
- Perch-Nielsen, S. L. (2010). The vulnerability of beach tourism to climate change—An index approach. *Climatic Change*, 100(3–4), 579–606. <https://doi.org/10.1007/s10584-009-9692-1>
- Perch-Nielsen, S. L., Amelung, B., & Knutti, R. (2010b). Future climate resources for tourism in Europe based on the daily Tourism Climatic Index. *Climatic Change*, 103(3–4), 363–381. <https://doi.org/10.1007/s10584-009-9772-2>
- Perfetto, G., Lamacchia, F. P., Raimondo, L., & Roccasalva, G. (2018). A Regional Energy Efficiency Strategy: integrated sustainable design process by adopting BIM, innovative energy solutions and dynamic energy analyses for a Hotel within the Historical Village of Sant'Angelo Le Fratte (PZ), Italy. In 2018 IEEE International Conference And Workshop In Obuda On Electrical And Power Engineering. CANDO-EPE, pp. 227–236.
- Peric, J., & Grdic, Z. S. (2015). Economic impacts of sea level rise caused by climate change. *Tourism in South East Europe*, 3, 285–294.
- Pieri, S. P., Stamos, A., & Tzouvadakis, I. (2016). Reducing tourist carbon footprint through strategic mapping of the existing hotel stock—Attica. *International Journal of Sustainable Energy*, 35(8), 734–745. <https://doi.org/10.1080/14786451.2014.943757>

- Pintassilgo, P., Rossello, J., Santana-Gallego, M., & Valle, E. (2016). The economic dimension of climate change impacts on tourism: The case of Portugal. *Tourism Economics*, 22(4), 685–698. <https://doi.org/10.1177/1354816616654242>
- Pioppi, B., Pigliantile, I., Piselli, C., & Pisello, A. L. (2020). Cultural heritage microclimate change: Human-centric approach to experimentally investigate intra-urban overheating and numerically assess foreseen future scenarios impact. *The Science of the Total Environment*, 703, 134448. <https://doi.org/10.1016/j.scitotenv.2019.134448>
- Polderman, A., Haller, A., Viesi, D., Tabin, X., Sala, S., Giorgi, A., Darmayan, L., Rager, J., Vidovic, J., Daragon, Q., Verchere, Y., Zupan, U., Hoube, N., Heinrich, K., Bender, O., & Bidault, Y. (2020). How can ski resorts get smart? Transdisciplinary approaches to sustainable winter tourism in the European Alps. *Sustainability*, 12(14), 5593. <https://doi.org/10.3390/su12145593>
- Pons, M., Johnson, P. A., Rosas, M., & Jover, E. (2014). A georeferenced agent-based model to analyze the climate change impacts on ski tourism at a regional scale. *International Journal of Geographical Information Science*, 28(12), 2474–2494. <https://doi.org/10.1080/13658816.2014.933481>
- Pons, M., Larrabeiti, J. J., & Jover, E. (2013). Economic impact of the Ski Tourism in Andorra. Ski Andorra Report.
- Pons, M., Lopez-Moreno, J. I., Rosas-Casals, M., & Jover, E. (2015). The vulnerability of Pyrenean ski resorts to climate-induced changes in the snowpack. *Climatic Change*, 131(4), 591–605. <https://doi.org/10.1007/s10584-015-1400-8>
- Pouta, E., Neuvonen, M., & Sievanen, T. (2009). Participation in cross-country skiing in Finland under climate change: Application of multiple hierarchy stratification perspective. *Journal of Leisure Research*, 41(1), 92–109. <https://doi.org/10.1080/00222216.2009.11950161>
- Pretenthaler, F., Köberl, J., & Bird, D. N. (2016). 'Weather value at risk': A uniform approach to describe and compare sectoral income risks from climate change. *The Science of the Total Environment*, 543(Pt B), 1010–1018. <https://doi.org/10.1016/j.scitotenv.2015.04.035>
- Priego, F. J., Rossello, J., & Santana-Gallego, M. (2015). The impact of climate change on domestic tourism: A gravity model for Spain. *Regional Environmental Change*, 15(2), 291–300. <https://doi.org/10.1007/s10113-014-0645-5>
- Pröbstl-Haider, U., Dabrowska, K., & Haider, W. (2016). Risk perception and preferences of mountain tourists in light of glacial retreat and permafrost degradation in the Austrian Alps. *Journal of Outdoor Recreation and Tourism*, 13, 66–78. <https://doi.org/10.1016/j.jort.2016.02.002>
- Pröbstl-Haider, U., & Haider, W. (2013). Tools for measuring the intention for adapting to climate change by winter tourists: Some thoughts on consumer behavior research and an empirical example. *Tourism Review*, 68(2), 44–55. <https://doi.org/10.1108/TR-04-2013-0015>
- Pröbstl-Haider, U., Haider, W., Wirth, V., & Beardmore, B. (2015). Will climate change increase the attractiveness of summer destinations in the European Alps? A survey of German tourists. *Journal of Outdoor Recreation and Tourism-Research Planning and Management*, 11, 44–57. <https://doi.org/10.1016/j.jort.2015.07.003>
- Pröbstl-Haider, U., Hödl, C., Ginner, K., & Borgwardt, F. (2021). Climate change: Impacts on outdoor activities in the summer and shoulder seasons. *Journal of Outdoor Recreation and Tourism*, 34, 100344. <https://doi.org/10.1016/j.jort.2020.100344>
- Rech, Y., Paget, E., & Dimanche, F. (2019). Uncertain tourism: Evolution of a French winter sports resort and network dynamics. *Journal of Destination Marketing & Management*, 12, 95–104. <https://doi.org/10.1016/j.jdmm.2019.03.003>
- Rey-Valette, H., Rocle, N., Vye, D., Mineo-Kleiner, L., Longépée, E., Bazart, C., & Lautrédou-Audouy, N. (2019). Acceptabilité sociale des mesures d'adaptation au changement climatique en zones côtières: une revue de dix enquêtes menées en France métropolitaine. *Vertigo*, 19(2), 32–47. <https://doi.org/10.4000/vertigo.26537>
- Rey-Valette, H., Rulleau, B., Hellequin, A. P., Meur-Ferec, C., & Flanquart, H. (2015). Second-home owners and sea-level rise: The case of the Languedoc-Roussillon region (France). *Journal of Policy Research in Tourism Leisure and Events*, 7(1), 32–47. <https://doi.org/10.1080/19407963.2014.942734>
- Rice, H., Cohen, S., Scott, D., & Steiger, R. (2022). Climate change risk in the Swedish ski industry. *Journal of Sustainable Tourism*, 1–17, 2805–2820. <https://doi.org/10.1080/13683500.2021.1995338>
- Rico, A., Martinez-Blanco, J., Montlleo, M., Rodriguez, G., Tavares, N., Arias, A., & Oliver-Sola, J. (2019). Carbon footprint of tourism in Barcelona. *Tourism Management*, 70, 491–504. <https://doi.org/10.1016/j.tourman.2018.09.012>
- Rico-Amoros, A. M., Sauri, D., Olcina-Cantos, J., & Vera-Rebollo, J. F. (2013). Beyond megaprojects? Water alternatives for mass tourism in Coastal Mediterranean Spain. *Water Resources Management*, 27(2), 553–565. <https://doi.org/10.1007/s11269-012-0201-3>
- Ristic, D., Vukoicic, D., Nikolic, M., Milincic, M., & Kicovic, D. (2019). Capacities and energy potential of thermal-mineral springs in the area of the Kopaonik tourist region (Serbia). *Renewable & Sustainable Energy Reviews*, 102, 129–138. <https://doi.org/10.1016/j.rser.2018.12.005>
- Rizzo, A., Vandelli, V., Buhagiar, G., Micallef, A. S., & Soldati, M. (2020). Coastal vulnerability assessment along the North-Eastern Sector of Gozo Island (Malta, Mediterranean Sea). *Water*, 12(5), 1405. <https://doi.org/10.3390/w12051405>

- Robaina-Alves, M., Moutinho, V., & Costa, R. (2016). Change in energy-related CO₂ (carbon dioxide) emissions in Portuguese tourism: a decomposition analysis from 2000 to 2008. *Journal of Cleaner Production*, 111, 520–528. <https://doi.org/10.1016/j.jclepro.2015.03.023>
- Rodrigues, L. C., van den Bergh, J., Loureiro, M. L., Nunes, Paulo, A. L. D., & Rossi, S. (2016). The cost of Mediterranean sea warming and acidification: A choice experiment among Scuba Divers at Medes Islands, Spain. *Environmental and Resource Economics*, 63(2), 289–311. <https://doi.org/10.1007/s10640-015-9935-8>
- Roibas, L., Loiseau, E., & Hospido, A. (2017). Determination of the carbon footprint of all Galician production and consumption activities: Lessons learnt and guidelines for policymakers. *Journal of Environmental Management*, 198(Pt 1), 289–299. <https://doi.org/10.1016/j.jenvman.2017.04.071>
- Royo, M. L., Ranasinghe, R., & Jimenez, J. A. (2016). A rapid, low-cost approach to coastal vulnerability assessment at a national level. *Journal of Coastal Research*, 32(4), 932–945. <https://doi.org/10.2112/JCOASTRES-D-14-00217.1>
- Rulleau, B., & Rey-Valette, H. (2017). Forward planning to maintain the attractiveness of coastal areas: Choosing between seawalls and managed retreat. *Environmental Science & Policy*, 72, 12–19. <https://doi.org/10.1016/j.envsci.2017.01.009>
- Rutty, M., & Scott, D. (2010). Will the Mediterranean become "Too Hot" for tourism? A reassessment. *Tourism Planning & Development*, 7(3), 267–281. <https://doi.org/10.1080/1479053X.2010.502386>
- Saarinen, J., & Tervo, K. (2006). Perceptions and adaptation strategies of the tourism industry to climate change: the case of Finnish nature-based tourism entrepreneurs. *International Journal of Innovation and Sustainable Development*, 1(3), 214–228. <https://doi.org/10.1504/IJISD.2006.012423>
- Salim, E., Mourey, J., Ravanel, L., Picco, P., & Gauchon, C. (2019). Mountain guides facing the effects of climate change. What perceptions and adaptation strategies at the foot of Mont Blanc? *Revue De Géographie Alpine*, 107(4), 1–14. <https://doi.org/10.4000/rga.5865>
- Salim, E., & Ravanel, L. (2020). Last chance to see the ice: Visitor motivation at Montanvers-Mer-de-Glace, French Alps. *Tourism Geographies*, 1–23. <https://doi.org/10.1080/14616688.2020.1833971>
- Salim, E., Ravanel, L., Bourdeau, P., & Deline, P. (2021a). Glacier tourism and climate change: Effects, adaptations, and perspectives in the Alps. *Regional Environmental Change*, 21(4), 120. <https://doi.org/10.1007/s10113-021-01849-0>
- Salim, E., Ravanel, L., & Gauchon, C. (2021b). Aesthetic perceptions of the landscape of a shrinking glacier: Evidence from the Mont Blanc massif. *Journal of Outdoor Recreation Education and Leadership*, 35, 100411. <https://doi.org/10.1016/j.jort.2021.100411>
- Santos-Lacueva, R., Ariza, E., Romagosa, F., & Saladie, O. (2019). The vulnerability of destinations to climate change: A comparative analysis of contextual socio-political factors. *Journal of Sustainable Tourism*, 27(8), 1217–1238. <https://doi.org/10.1080/09669582.2019.1607865>
- Sanye-Mengual, E., Romanos, H., Molina, C., Oliver, M. A., Ruiz, N., Perez, M., Carreras, D., Boada, M., Garcia-Orellana, J., Duch, J., & Rieradevall, J. (2014). Environmental and self-sufficiency assessment of the energy metabolism of tourist hubs on Mediterranean Islands: The case of Menorca (Spain). *Energy Policy*, 65, 377–387. <https://doi.org/10.1016/j.enpol.2013.10.011>
- Saseanu, A. S., Ghita, S. I., Albastroiu, I., & Stoian, C.-A. (2020). Aspects of digitalization and related impact on green tourism in European Countries. *Information*, 11(11), 507. <https://doi.org/10.3390/info11110507>
- Sauri, D., Olcina, J., Vera, J. F., Martín-Vide, J., March, H., Serra-Llobet, A., & Padilla, E. (2013). Tourism, climate change and water resources: Coastal Mediterranean Spain as an example. *European Climate Vulnerabilities and Adaptation* (pp. 231–252). John Wiley & Sons, Ltd.
- Schmidt, P., Steiger, R., & Matzarakis, A. (2012). Artificial snowmaking possibilities and climate change based on regional climate modeling in the Southern Black Forest. *Meteorologische Zeitschrift*, 21(2), 167–172. <https://doi.org/10.1127/0941-2948/2012/0281>
- Schwirplies, C., & Ziegler, A. (2017). Adaptation of future travel habits to climate change: A microeconomic analysis of tourists from Germany. *Tourism Economics*, 23(6), 1275–1295. <https://doi.org/10.1177/1354816616683053>
- Scott, D. (2021). Sustainable tourism and the grand challenge of climate change. *Sustainability*, 13(4), 1966. <https://doi.org/10.3390/su13041966>
- Scott, D., & Gössling, S. (2022). A review of research into tourism and climate change—Launching the annals of tourism research curated collection on tourism and climate change. *Annals of Tourism Research*, 95, 103409. <https://doi.org/10.1016/j.annals.2022.103409>
- Scott, D., Hall, C. M., & Gössling, S. (2019). Global tourism vulnerability to climate change. *Annals of Tourism Research*, 77, 49–61. <https://doi.org/10.1016/j.annals.2019.05.007>
- Scott, D., Knowles, N., & Steiger, R. (2022). Is snowmaking climate change maladaptation? *Journal of Sustainable Tourism*, 1–22. <https://doi.org/10.1080/09669582.2022.2137729>
- Scott, D., Rutty, M., Amelung, B., & Tang, M. T. (2016). An inter-comparison of the Holiday Climate Index (HCI) and the Tourism Climate Index (TCI) in Europe. *Atmosphere*, 7(6), 80. <https://doi.org/10.3390/atmos7060080>
- Scott, D., Steiger, R., Dannevig, H., & Aall, C. (2020). Climate change and the future of the Norwegian alpine ski industry. *Current Issues in Tourism*, 23(19), 2396–2409. <https://doi.org/10.1080/13683500.2019.1608919>

- Semeoshenkova, V., & Newton, A. (2015). Overview of erosion and beach quality issues in three Southern European countries: Portugal, Spain and Italy. *Ocean & Coastal Management*, 118, 12–21. <https://doi.org/10.1016/j.oceco-man.2015.08.013>
- Serquet, G., & Rebetez, M. (2013). Changements Climatiques. Quel avenir pour les destinations touristiques des Alpes et du Jura vaudois? https://www.vd.ch/fileadmin/user_upload/themes/economie_emploi/developpement_economique/fichiers_pdf/alpe-vaud-rapp-chang-clim-wsl-2013.pdf.
- Simo-Kengne, B. D. (2022). Tourism growth and environmental sustainability: Trade-off or convergence? *Environment, Development and Sustainability*, 24(6), 8115–8144. <https://doi.org/10.1007/s10668-021-01775-5>
- Simonsen, M., Gössling, S., & Walnum, H. J. (2019). Cruise ship emissions in Norwegian waters: A geographical analysis. *Journal of Transport Geography*, 78, 87–97. <https://doi.org/10.1016/j.jtrangeo.2019.05.014>
- Skrimizea, E., & Parra, C. (2019). Social-ecological dynamics and water stress in tourist islands: The case of Rhodes, Greece. *Journal of Sustainable Tourism*, 27(9), 1438–1456. <https://doi.org/10.1080/09669582.2019.1630420>
- Soboll, A., & Dingeldey, A. (2012). The future impact of climate change on Alpine winter tourism: a high-resolution simulation system in the German and Austrian Alps. *Journal of Sustainable Tourism*, 20(1), 101–120. <https://doi.org/10.1080/09669582.2011.610895>
- Soboll, A., & Schmude, J. (2011). Simulating tourism water consumption under climate change conditions using agent-based modeling: The example of Ski Areas. *Annals of the Association of American Geographers*, 101(5), 1049–1066. <https://doi.org/10.1080/00045608.2011.561126>
- Sottini, V. A., Barbierato, E., Bernetti, I., & Capecchi, I. (2021). Impact of climate change on wine tourism: An approach through social media data. *Sustainability*, 13(13), 7489–7410. <https://doi.org/10.3390/su13137489>
- Sousa, L. B., de, Loureiro, C., & Ferreira, O. (2018). Morphological and economic impacts of rising sea levels on cliff-backed platform beaches in southern Portugal. *Applied Geography*, 99, 31–43. <https://doi.org/10.1016/j.apgeog.2018.07.023>
- Spandre, P., Francois, H., Verfaillie, D., Pons, M., Vernay, M., Lafaysse, M., George, E., & Morin, S. (2019a). Winter tourism under climate change in the Pyrenees and the French Alps: Relevance of snowmaking as a technical adaptation. *Cryosphere*, 13(4), 1325–1347. <https://doi.org/10.5194/tc-13-1325-2019>
- Spandre, P., François, H., Verfaillie, D., Lafaysse, M., Déqué, M., Eckert, N., George, E., & Morin, S. (2019b). Climate controls on snow reliability in French Alps ski resorts. *Scientific Reports*, 9(1), 8043. <https://doi.org/10.1038/s41598-019-44068-8>
- Steiger, R. (2012). Scenarios for skiing tourism in Austria: Integrating demographics with an analysis of climate change. *Journal of Sustainable Tourism*, 20(6), 867–882. <https://doi.org/10.1080/09669582.2012.680464>
- Steiger, R., & Abegg, B. (2013). The sensitivity of Austrian Ski Areas to climate change. *Tourism Planning & Development*, 10(4), 480–493. <https://doi.org/10.1080/21568316.2013.804431>
- Steiger, R., & Abegg, B. (2018). Ski areas' competitiveness in the light of climate change: Comparative analysis in the Eastern Alps. In Müller, D., Więckowski, M. (Eds.), *Tourism in Transition, Recovering from Decline and Managing Change* (pp. 187–199). Springer International Publishing.
- Steiger, R., Damm, A., Pretenthaler, F., & Pröbstl-Haider, U. (2021). Climate change and winter outdoor activities in Austria. *Journal of Outdoor Recreation and Tourism-Research Planning and Management*, 34, 100330. <https://doi.org/10.1016/j.jort.2020.100330>
- Steiger, R., & Mayer, M. (2008). Snowmaking and climate change future options for snow production in Tyrolean Ski Resorts. *Mountain Research and Development*, 28(3/4), 292–298. <https://doi.org/10.1659/mrd.0978>
- Steiger, R., Posch, E., Tappeiner, G., & Walde, J. (2020). The impact of climate change on demand of ski tourism—A simulation study based on stated preferences. *Ecological Economics*, 170, 106589. <https://doi.org/10.1016/j.ecolecon.2019.106589>
- Steiger, R., & Scott, D. (2020). Ski tourism in a warmer world: Increased adaptation and regional economic impacts in Austria. *Tourism Management*, 77, 104032. <https://doi.org/10.1016/j.tourman.2019>
- Steiger, R., & Stötter, J. (2013). Climate change impact assessment of Ski tourism in Tyrol. *Tourism Geographies*, 15(4), 577–600. <https://doi.org/10.1080/14616688.2012.762539>
- Surugiu, C., Ana-Irina, D., & Marius-Razvan, S. (2012). An empirical analysis of the CO₂ emissions impact: Evidence from Romanian tourism sector. *Actual Problems of Economics*, 2(1), 42–71.
- Surugiu, C., Frent, C., & Breda, Z. (2011). Effects of climate change on Romanian mountain tourism: Are they positive or mostly negative? *European Journal of Tourism Hospitality and Recreation*, 2(1), 42–71.
- Suto, A., & Fejes, L. (2019). Territorial differences in existing and potential climate vulnerability of the tourism sector in Hungary. *Ter Es Tarsadalom*, 33(3), 108–126. <https://doi.org/10.17649/TET.33.3.3178>
- Tervo, K. (2008). The operational and regional vulnerability of winter tourism to climate variability and change: The case of the Finnish nature-based tourism entrepreneurs. *Scandinavian Journal of Hospitality and Tourism*, 8(4), 317–332. <https://doi.org/10.1080/15022250802553696>
- Tervo-Kankare, K. (2019). Entrepreneurship in nature-based tourism under a changing climate. *Current Issues in Tourism*, 22(11), 1380–1392. <https://doi.org/10.1080/13683500.2018.1439457>
- Tervo-Kankare, K., Hall, C. M., & Saarinen, J. (2013). Christmas tourists' perceptions to climate change in Rovaniemi, Finland. *Tourism Geographies*, 15(2), 292–317. <https://doi.org/10.1080/14616688.2012.726265>

- Tervo-Kankare, K., Kajan, E., & Saarinen, J. (2018). Costs and benefits of environmental change: Tourism industry's responses in Arctic Finland. *Tourism Geographies*, 20(2), 202–223. <https://doi.org/10.1080/14616688.2017.1375973>
- Tonisson, H., Kont, A., Orviku, K., Suursaar, U., Rivas, R., & Palginomm, V. (2019). Application of system approach framework for coastal zone management in Parnu, SW Estonia. *Journal of Coastal Conservation*, 23(5), 931–942. <https://doi.org/10.1007/s11852-018-0637-6>
- Torres-Bagur, M., Palom, A. R., & Vila-Subiros, J. (2019). Perceptions of climate change and water availability in the Mediterranean tourist sector—A case study of the Muga River basin (Girona, Spain). *International Journal of Climate Change Strategies and Management*, 11(4), 552–569. <https://doi.org/10.1108/IJCCSM-10-2018-0070>
- Torres-Bagur, M., Ribas, A., & Vila-Subiros, J. (2020). Understanding the key factors that influence efficient water-saving practices among tourists: A Mediterranean case study. *Water*, 12(8), 2083. <https://doi.org/10.3390/w12082083>
- Tourmis. (2022). Europäische Länder—Aktuelle Entwicklung. <https://www.tourmis.info/cgi-bin/tmintro.pl>
- Townhill, B. L., Radford, Z., Pecl, G., Putten, I., Pinnegar, J. K., & Hyder, K. (2019). Marine recreational fishing and the implications of climate change. *Fish and Fisheries*, 20(5), 977–992. <https://doi.org/10.1111/faf.12392>
- Trawöger, L. (2014). Convinced, ambivalent or annoyed: Tyrolean ski tourism stakeholders and their perceptions of climate change. *Tourism Management*, 40, 338–351. <https://doi.org/10.1016/j.tourman.2013.07.010>
- Tsagarakis, K. P., Bounialetou, F., Gillas, K., Profylienou, M., Pollaki, A., & Zografakis, N. (2011). Tourists' attitudes for selecting accommodation with investments in renewable energy and energy saving systems. *Renewable & Sustainable Energy Reviews*, 15(2), 1335–1342. <https://doi.org/10.1016/j.rser.2010.10.009>
- TSG. (2012). European charter for sustainable and responsible tourism. European Commission. <http://ec.europa.eu/DocsRoom/documents/520/attachments/1/translations/en/renditions/native>.
- Tzoraki, O., Monioudi, i., Velegrakis, a., Moutafis, N., Pavlogeorgatos, G., & Kitsiou, D. (2018). Resilience of touristic island beaches under sea level rise: A methodological framework. *Coastal Management*, 46(2), 78–102. <https://doi.org/10.1080/08920753.2018.1426376>
- UNEP. (2022). Emissions gap report 2022. <https://www.unep.org/resources/emissions-gap-report-2022>.
- UNFCCC. (2021). NDC registry. <https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx>.
- UNFCCC. (2022). NDC registry. <https://unfccc.int/NDCREG>.
- Unger, R., Abegg, B., Mailer, M., & Stampfl, P. (2016). Energy consumption and greenhouse gas emissions resulting from tourism travel in an alpine setting. *Mountain Research and Development*, 36(4), 475–483. <https://doi.org/10.1659/MRD-JOURNAL-D-16-00058.1>
- United Nations. (2015). United Nations Treaty Collection Chapter XXVII environment. Paris Agreement. <https://treaties.un.org/doc/Publication/CN/2016/CN.92.2016-Eng>.
- UNWTO. (2021). Mountain tourism—Towards a more sustainable path.
- UNWTO and ITF. (2019). Transport-related CO2 emissions of the tourism sector—Modelling results.
- UNWTO/UNEP/WMO. (2008). Climate change and tourism—Responding to global challenges. WMO, Madrid.
- Vandarakis, D., Panagiotopoulos, I. P., Loukaidi, V., Hatiris, G. A., Drakopoulou, P., Kikaki, A., Gad, F. K., Petrakis, S., Malliouri, D., Chatzinaki, M., Morfis, I., Kanellopoulos, T. D., & Kapsimalis, V. (2021). Assessment of the coastal vulnerability to the ongoing sea level rise for the exquisite Rhodes Island (SE Aegean Sea, Greece). *Water*, 13(16), 2169. <https://doi.org/10.3390/w13162169>
- Vanham, D., Fleischacker, E., & Rauch, W. (2009). Impact of snowmaking on alpine water resources management under present and climate change conditions. *Water Science and Technology: A Journal of the International Association on Water Pollution Research*, 59(9), 1793–1801. <https://doi.org/10.2166/wst.2009.211>
- Varela, V., Vlachogiannis, D., Sfetos, A., Politi, N., & Karozis, S. (2020). Methodology for the study of near-future changes of fire weather patterns with emphasis on archaeological and protected touristic areas in Greece. *Forests*, 11(11), 1168. <https://doi.org/10.3390/f11111168>
- Vaske, J. J., Jacobs, M. H., & Espinosa, T. K. (2015). Carbon footprint mitigation on vacation: A norm activation model. *Journal of Outdoor Recreation and Tourism-Research Planning and Management*, 11, 80–86. <https://doi.org/10.1016/j.jort.2015.05.002>
- vLex (1990). Ley de declaración de Monumentos Naturales de los glaciares pirenaicos. <https://vlex.es/vid/ley-declaracion-monumentos-naturales-637123217>.
- Vohringer, F., Vielle, M., Thalmann, P., Frehner, A., Knoke, W., Stocker, D., & Thurm, B. (2019). Costs and benefits of climate change in Switzerland. *Climate Change Economics*, 10(02), 1950005. <https://doi.org/10.1142/S2010007819500052>
- Vonk, E., Cirkel, D. G., & Blokker, M. (2019). Estimating peak daily water demand under different climate change and vacation scenarios. *Water*, 11(9), 1874. <https://doi.org/10.3390/w11091874>
- Welling, J., & Abegg, B. (2021). Following the ice: Adaptation processes of glacier tour operators in Southeast Iceland. *International Journal of Biometeorology*, 65(5), 703–715. <https://doi.org/10.1007/s00484-019-01779-x>
- Welling, J., Arnason, T., & Olafsdottir, R. (2020). Implications of climate change on nature-based tourism demand: A segmentation analysis of glacier site visitors in Southeast Iceland. *Sustainability*, 12(13), 5338. <https://doi.org/10.3390/su12135338>

- Welling, J., Ólafsdóttir, R., Árnason, Þ., & Guðmundsson, S. (2019). Participatory planning under scenarios of glacier retreat and tourism growth in Southeast Iceland. *Mountain Research and Development*, 39(2), D1–D13. <https://doi.org/10.1659/MRD-JOURNAL-D-18-00090.1>
- Weston, R., Guia, J., Mihalic, T., Prats, L., Blasco, D., Ferrer-Roca, N., Lawler, M., & Jarrat, D. (2019). Research for TRAN Committee—European tourism: Recent developments and future challenges.
- Whittlesea, E. R., & Owen, A. (2012). Towards a low carbon future—The development and application of REAP tourism, a destination footprint and scenario tool. *Journal of Sustainable Tourism*, 20(6), 845–865. <https://doi.org/10.1080/09669582.2012.680699>
- Wicker, P. (2019). The carbon footprint of active sport participants. *Sport Management Review*, 22(4), 513–526. <https://doi.org/10.1016/j.smr.2018.07.001>
- Willibald, F., Kotlarski, S., Gret-Regamey, A., & Ludwig, R. (2020). Anthropogenic climate change versus internal climate variability: Impacts on snow cover in the Swiss Alps. *Cryosphere*, 14(9), 2909–2924. <https://doi.org/10.5194/tc-14-2909-2020>
- Witting, M., Bischof, M., & Schmude, J. (2021). Behavioural change or "business as usual"? Characterising the reaction behaviour of winter (sport) tourists to climate change in two German destinations. *International Journal of Tourism Research*, 23(1), 110–122. <https://doi.org/10.1002/jtr.2399>
- Witting, M., & Schmude, J. (2019). Impacts of climate and demographic change on future skier demand and its economic consequences—Evidence from a ski resort in the German Alps. *Journal of Outdoor Recreation and Tourism-Research Planning and Management*, 26, 50–60. <https://doi.org/10.1016/j.jort.2019.03.002>
- Wolfsegger, C., Gössling, S., & Scott, D. (2008). Climate change risk appraisal in the Austrian Ski industry. *Tourism Review International*, 12(1), 13–23. <https://doi.org/10.3727/154427208785899948>
- World Bank. (2022). World bank open data. <https://data.worldbank.org/indicator/ST.INT.ARVL>
- WTTC. (2021). Economic impact reports. <https://wttc.org/Research/Economic-Impact>
- Wyss, R. (2013). Cooperation for climate adaptation in tourism. An agenda for the Alps based on structuration theory. *Revue De Géographie Alpine-Journal of Alpine Research*, 101(1), 568–577.
- Wyss, R., Abegg, B., & Luthe, T. (2014). Perceptions of climate change in a tourism governance context. *Tourism Management Perspectives*, 11, 69–76. <https://doi.org/10.1016/j.tmp.2014.04.004>
- Zachariadis, T. (2010). Residential water scarcity in Cyprus: Impact of climate change and policy options. *Water*, 2(4), 788–814. <https://doi.org/10.3390/w2040788>
- Zaman, K., Shahbaz, M., Loganathan, N., & Raza, S. A. (2016). Tourism development, energy consumption and environmental Kuznets curve: Trivariate analysis in the panel of developed and developing countries. *Tourism Management*, 54, 275–283. <https://doi.org/10.1016/j.tourman.2015.12.001>
- Zekollari, H., Huss, M., & Farinotti, D. (2019). Modelling the future evolution of glaciers in the European Alps under the EURO-CORDEX RCM ensemble. *Cryosphere*, 13(4), 1125–1146. <https://doi.org/10.5194/tc-13-1125-2019>

Appendix

Table A1. Contribution of tourism to GDP and number of reviewed papers.

Country	Tourism in % GDP (2019)*	Papers reviewed	
		Climate risk	Carbon risk
Albania	20.5	11	2
Andorra	n.a.	15	1
Armenia	12.9	3	2
Austria	11	51	16
Azerbaijan	7.7	3	2
Belarus	6.1	7	4
Belgium	5.6	17	12
Bosnia and Herzegovina	9.8	11	2
Bulgaria	10.7	18	10
Croatia	24.3	21	9
Cyprus	13.4	18	13
Czechia	6.2	13	12
Denmark	6.4	12	12
Estonia	11.8	16	11
Finland	7.8	31	14
France	8.5	60	23
Georgia	26.8	6	2
Germany	9.8	47	16
Greece	20.3	38	17
Hungary	7.9	21	11
Iceland	21.8	9	3
Ireland	4.2	16	10
Italy	13.1	48	21
Kazakhstan	5.2	3	2
Kosovo	n.a.	8	1
Latvia	7.7	14	14
Liechtenstein	n.a.	8	1
Lithuania	6	14	11
Luxembourg	8.9	11	11
Malta	15.9	17	11
Moldova	6.6	7	2
Monaco	n.a.	7	1
Montenegro	30.9	9	2
Netherlands	10.8	16	17
North Macedonia	6.6	9	2
Northern Cyprus	n.a.	5	0
Norway	7.9	24	13
Poland	4.7	17	14
Portugal	17.1	27	15
Republic of Serbia	5.9	14	3
Romania	6.1	20	12
Russia	4.9	8	4
San Marino	n.a.	7	1
Slovakia	6.4	15	11
Slovenia	10.6	21	12
Spain	14.1	68	28
Sweden	7.3	23	17
Switzerland	7.4	41	11
Turkey	11	19	11
Ukraine	6.3	9	0
United Kingdom	10.1	22	32
Vatican	n.a.	7	1

*WTTC, 2021.