Tourism Management 94 (2023) 104630

Contents lists available at ScienceDirect

Tourism Management

journal homepage: www.elsevier.com/locate/tourman

The role of holiday styles in shaping the carbon footprint of leisure travel within the European Union

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A R T I C L E I N F O

Keywords:
Leisure travel
Tourism
Preferences
Ecosystem services demand
European union
Carbon footprint
Transport
Distance

A B S T R A C T

Leisure travel within the European Union (EU) contributes significantly to the carbon footprint of global tourism. Distance travelled is a main factor in this impact, but some of its determinants remain unexplored. We examined the role of tourists' holiday preferences in shaping the carbon footprint of leisure travel within the EU by calculating demand and impact indicators associated with eight holiday styles. We find a substantial and equivalent carbon footprint for visiting relatives, nature tourism and sea, sun and sand tourism, but a higher carbon intensity of travel per trip for the latter. This is due to widespread demand for sea, sun, and sand tourism despite the concentration of destinations in Southern Europe. Furthermore, international travel within the EU is on average three times more carbon intensive than domestic travel. Our insights suggest that tourists' holiday preferences can be leveraged for the sustainable development of leisure travel within the EU.

1. Introduction

The European Union (EU) is the main destination for Europeans' leisure travel, with 95% of tourism trips by EU residents being domestic or to another EU country (Eurostat, 2020). Europeans are also the main market for the EU tourism sector, as nearly three-quarters of leisure-related trips to EU destinations are coming from EU countries (Eurostat, 2020). Vacations in foreign destinations have been gaining momentum among Europeans in recent years (Eurostat, 2020), who travel especially to neighbouring countries (McKercher & Mak, 2019). More than half of the EU population who participated in tourism in 2018, went on holiday abroad at least once during that year (UNWTO, 2018). Yet, domestic travel is by far the most popular and accounts for the vast majority of leisure trips in most EU countries, with the exception of small countries like Luxembourg, Belgium, Malta and Slovenia (Eurostat, 2020).

Participation rates in tourism are higher in northern and western EU countries than in southern and eastern EU countries. Similar trends are observed in travel frequency, which revolves around the EU average of four trips per tourist per year (UNWTO, 2018). Participation in tourism is influenced by living conditions, particularly income, which determines the capacity to afford leisure travel (UNWTO, 2018). Legal entitlement to paid vacations and numerous public holidays in most countries explain the relatively high demand for leisure travel in the EU (Gössling & Peeters, 2015).

Spatial patterns of leisure travel flows are shaped by the interplay between tourists' preferences for specific holiday experiences and the leisure activities offered in destinations (e.g., wine tourism, Brown & Getz, 2005). Preferences tend to be shared within socio-economic groups (Lamondia, Snell, & Bhat, 2010), as they are influenced by social context (e.g., family) and media (press, television, travel guides), and transmitted through peer communication. The competitiveness of alternative destinations is determined by a combination of factors enhancing accessibility, accommodation capabilities, safety and security, and the value of natural and cultural assets (Rodríguez-Antón & Rubio-Andrada, 2016).

The choice of a destination is often determined by prior assessment of a broad and diverse set of factors (Scholte, van Teeffelen, & Verburg, 2015), such as travel costs and possible activities (e.g., skiing, sightseeing, visiting relatives). Additionally, the distinctive characteristics between origin and destination might play a role. For example, areas with a higher likelihood of sunny weather are attractive for people living in relatively colder and wetter climate (Eugenio-Martin & Campos-Soria, 2010). Therefore, the variety of climatic conditions,

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https://doi.org/10.1016/j.tourman.2022.104630
Received 7 January 2022; Received in revised form 12 July 2022; Accepted 15 July 2022
Available online 27 August 2022

landscapes and cultures (including language and gastronomy) in the EU could explain the large number of trips between European countries (UNWTO & ITF, 2019).

Global tourism accounts for about 8% of total greenhouse gas emissions (Lenzen et al., 2018), and transport between origin and destination explains three quarters of this impact (Gössling & Peeters, 2015). Despite various research efforts to quantify and decompose the carbon footprint of global tourism (e.g., Graver, Zhang, & Rutherford, 2019; UNWTO & ITF, 2019), the contribution of leisure travel within the EU remains unclear. While there are studies looking into the impact of leisure travel for a specific origin country (e.g., Eijgelaar, Peeters, Neelis, de Bruijn, & Dirven, 2021) or destination (e.g., Neger, Prettenthaler, Gössling, & Damm, 2021; Unger, Abegg, Mailer, & Stampfl, 2016), existing figures at the EU level do not distinguish between leisure and business travel (e.g., Peeters, Szimba, & Duijnisveld, 2007), nor between international travel within the EU and to other regions of the world (UNWTO & ITF, 2019). In addition, uncertainties remain regarding estimates of the carbon footprint of domestic travel, as there are currently no statistics on the distance travelled for this type of tourism.

Recently, scholars have suggested that the carbon footprint of tourism could be reduced through strategic market development, targeting a reduction of the distances travelled for holiday, especially by air and car (Gössling, Scott, & Hall, 2015). To attract closer markets, destinations need to tailor tourism experiences to the preferences of tourists (Sun, Lin, & Higham, 2020). In addition, marketing actions can shift tourists' preferences towards tourism experiences offered in nearer locations (Gössling et al., 2015). To date, stated preferences for holiday experiences have been used to understand the difference between current and desired tourism flows (Eugenio-Martin & Cazorla-Artiles, 2020), but focusing on an exclusively international sample of trips. Additionally, distinct interests in leisure travel have been characterized into a number of specific holiday styles (Peeters, Egmond, & Visser, 2004), but their variable contributions to carbon emissions have not been assessed. Consequently, the preferences underlying leisure travel within the EU are not clearly outlined, concealing potential leverage points for reducing the carbon footprint of tourism.

The objective of this study is to examine tourists' holiday preferences as a determinant of the carbon footprint of leisure travel within the EU. We hypothesize that the spatial patterns of demand for different holiday styles shape the distance travelled for these holiday styles, and that consequently holiday styles contribute differently to the carbon footprint of leisure travel within the EU. This understanding could be critical to designing marketing strategies to steer the development of leisure travel within the EU in a sustainable direction.

2. Methods

To test our hypotheses, we mapped demand for eight different holiday styles, and calculated the carbon footprint of these holiday styles. Demand for leisure travel as a cultural ecosystem service may refer to the direct use of tourism assets, or to a preference for locations or activities (Wolff, Schulp, & Verburg, 2015) outside usual environment. In this study, the term *demand* refers to direct use, and is quantified per origin region based on actual flows of tourists and their motivation. Available records of bilateral leisure travel flows at the EU level only indicate the number of trips taken, without specifying the holiday style associated to the trips nor the modes of transport used. Moreover, they do not go beyond the national level, allowing only rough estimates of the distance between origin and destination. Therefore, prior to calculating indicators of demand and carbon footprint associated to different holiday styles (section 2.3), we estimated and mapped flows for different holiday styles at the sub-national level, specifying the modes of transport used (section 2.2). To do this, we collected data from various sources and compiled them into datasets of different resolutions that could be integrated with available records of bilateral leisure travel flows (section 2.1). We excluded Guadeloupe, Martinique, Guyana, Reunion and the Azores as destinations because of their long distance from the European continent, and relatively low number of arrivals at the airports.

2.1. Data collection and processing

This section presents our data sources on tourists' holiday preferences, tourism assets, distances between EU regions, and modal split, and how we processed and compiled these data to create datasets that could be integrated with available records of bilateral leisure travel flows. Bilateral flow records contain the number of trips taken within and between EU countries for personal purposes (Eurostat, 2020), which includes leisure activities and visits to friends and relatives, but excludes business trips. Due to reporting inconsistencies between years, we based this study on the average number of trips per year over the period 2010–2018.

2.1.1. Preferences for different holiday styles and associated flows

The first step when characterizing the demand and impact of different holiday styles is to understand the motivations of tourists travelling to different destinations. We obtained information on European tourists' preferences from the microdata of three editions of the Flash Eurobarometer surveys *Preferences of Europeans towards Tourism*, which were conducted in 2013, 2014, and 2015 (European Commission, 2014, 2015; 2016a). Each survey is based on a new and independent sample, stratified at the national level proportional to population size and density (GESIS., n.d.). Across the three editions, a total of 61,493 respondents took at least one leisure-related trip with a minimum of one overnight stay (see Table S1). For each respondent, the microdata indicated the NUTS region of residence (NUTS 0, 1, 2 or 3, see Figure S1), the countries visited over the last year, and reasons for going on holiday, classified as *Sun/beach, Wellness/Spa/health treatment, City*

Table 1
List of datasets and attributes defined or calculated in this study.

Attributes	Description	Size
Oc	Origin country	28
Or	Origin region	286
Dc	Destination country	28
Dr	Destination region	267
x	Holiday style	8
y	Transport option	3
Input datasets		
$T_{Oc,\ Dc}$	Number of trips from origin country to destination country	28 × 28
Processed datasets		
$R_{x,Or,\ Dc}$	Number of respondents, for each combination of holiday style, origin region and destination country	8 × 286 x 28
$PF_{x,Or,\ Dc}$	Preference (0–1), for each combination of holiday style, origin region and destination country	8 × 286 x 28
$PO_{x,\ Dr}$	Potential (0–1), for each combination of holiday style and destination region	8 × 267
$M_{y,Or,\ Dr}$	Modal share (0–1), for each combination of transport option, origin region and destination region	3 × 286 x 267
$D_{y,Or,\ Dr}$	Distance (kilometres) for each combination of transport option, origin region and destination region	3 × 286 x 267
$A_{x,Or,\ Dr}$	Attractiveness (0–1), for each combination of holiday style, origin region and destination region	8 × 286 x 267
Integrated datasets		
$T_{x,y,Or,\ Dr}$	Number of trips, for each combination of holiday style, transport option, origin region and destination region	8 × 3 x 286 × 267
$W_{x,y,Or,\ Dr}$	Total distance travelled (kilometres), for each combination of holiday style, transport option, origin region and destination region	8 × 3 x 286 × 267

trips, Sport-related activities, Nature, Culture, Visiting family/-friends/relatives, Specific events, and Others (Table S2). We interpreted declared reasons for going on holiday as stated preferences for eight different holiday styles that we named: sea, sun and sand tourism, wellness tourism, city tourism, active outdoors tourism, nature tourism, culture tourism, visiting relatives, and event tourism.

From the Eurobarometer microdata, we extracted $R_{x,Or,Dc}$ (Table 1) which indicates the number of respondents from origin region *Or*, who travelled to destination country *Dc* and stated a preference for holiday style *x*, and used it to calculate a dataset of preference for different holiday styles according to the tourist's origin region and the country of destination (Eq. (1)) (Table 1).

$$PF_{x,Or,Dc} = \frac{R_{x,Or,Dc}}{\sum_{x=1}^{n} R_{x,Or,Dc}} \quad (1)$$

where $PF_{x,Or,Dc}$ is the preference for holiday style *x* associated to tourists from origin region *Or* who travelled to destination country *Dc*, and $R_{x,Or,Dc}$ is the number of respondents from *Or* who travelled to *Dc* and stated a preference for. *x*

2.1.2. Potential of NUTS2 regions for the different holiday styles

While the Eurobarometer microdata provides information about the origin region of tourists (EU NUTS 0, 1, 2, or 3), information on the destination is only given at country level. To allow for better estimates of the distance travelled, we mapped the potential of NUTS2 regions to support different holiday styles so as to enable downscaling trip destinations from country to NUTS2 region. We collected spatial data indicating the presence, and if available, attractiveness, of assets that are relevant for the different holiday styles (Fig. 2). For the four holiday styles city tourism, culture tourism, event tourism, and wellness tourism, we collected lists of addresses of relevant assets, and, when available, additional variables indicating the attractiveness of these assets. For the three holiday styles nature tourism[1], active outdoors tourism, and sea, sun and sand tourism, we used maps (Komossa, van der Zanden, Schulp, & Verburg, 2018; Van Berkel & Verburg, 2011) indicating the suitability of the EU territory for different types of outdoor recreation (e.g., winter sports, beach tourism) at a 1 km resolution. For the holiday style visiting relatives, we used the population per NUTS2 regions, assuming that people are more likely to have friends or family living in more populated regions.

From these spatial data, we calculated $PO_{x,\,Dr}$ (Table 1), which indicates the potential of destination region *Dr* to support holiday style *x*. This indicator was obtained from either one asset variable or the normalized sum of two asset variables following the weights identified in Fig. 2. Asset variables were calculated as the normalized sum of assets, multiplied by their attractiveness when available, or suitability per square kilometre, yet excluding areas with low or very low suitability (i.e. scored below 3 on a discrete scale from 0 to 5) (Fig. 2). All normalizations were done based on min and max values per country so that the potential of one region is relative to that of other regions in the same country, while acknowledging differences in overall potential between countries. Maps showing the potential of NUTS2 regions for the eight holiday styles are provided in Figure S2.

2.1.3. Distances

To be able to identify the distance travelled for each trip, we inventoried distances between the centroids of EU NUTS 0, 1, 2, or 3 regions, by three multimodal transport options: road, public transport and air. Distance by road and public transport are based on road networks and ferry lines (European Commission, 2010b; 2016b). For trips within a region, we calculated and used the maximum distance between the centroid and a border of the region. The road and public transport options are available for all routes, except those from or to Cyprus, Canarias Islands, Ionian Islands and Southern Aegean Islands. Distances by air were calculated based on a network of 96 airports (see Figure S3) that each contribute at least 4% of the national passenger flow (Eurostat, 2020), or that are located on islands (Corsica, Sardinia and Lesvos) or in autonomous cities (Melilla, Ceuta). We used the itinerary with the fewest transfers to calculate air trip distances, based on the connections listed in European Commission (2010a), while distances between the centroid of the origin/destination region and the nearest airport in the origin/destination country were calculated as the crow flies. The air option is available for all routes where origin and destination airports are different.

We compiled these data in $D_{y,Or,Dr}$ (Table 1) which indicates the physical distance between the centroids of origin region *Or* (NUTS 0, 1, 2, or 3, see Figure S1) and destination region *Dr* (NUTS2) for multimodal transport option *y*.

2.1.4. Modal split

Data on modal split allowed us to account for modal choices when estimating the distance travelled and the carbon footprint of the trips. We distinguish road trips (by car, motorcycle, and boat), public transport trips (by train, high-speed train, and bus/coach), and air trips (by airplane). We used various data sources to compile $M_{y,Or,Dr}$ (Table 1) indicating the modal share of transport option *y* for trips between origin region *Or* and destination region *Dr*. For trips between 300 and 1000 km, and of more than 1000 km, we used modal split data derived from a survey on modes of transport conducted in the EU in 2014 (Fiorello & Zani, 2015). For trips of less than 300 km, we applied modal split reported for domestic tourism for personal purposes (average 2013–2015) (Eurostat, 2020). We considered that journeys of more than 2000 km always use the air option, under the assumption that the travel time associated with other options does not fit holiday schedules (e.g., Christensen, 2016). For air trips, the portions between centroid and nearest airport are travelled by car or train. The share by train corresponds to the proportion of respondents who declared that they always or most of the time use the train to get to the airport, by origin country (Fiorello & Zani, 2015).

2.2. Integration

The data collection and processing steps (Section 2.1) resulted in datasets containing information about tourists' holiday preferences, tourism potential in EU regions, distances between EU regions, and modal split among three multimodal transport options (Table 1). This section presents the steps we took to integrate these datasets with available records of bilateral leisure travel flows, to estimate and map the flows associated with different holiday styles at the sub-national level, specifying the modes of transport used. We performed three consecutive integration steps to determine the number of trips from each origin region (2.2.1) to each destination region for each holiday style (2.2.2), subdivided by the transport option (2.2.3). In a final step, we converted leisure travel flows from number of trips to total distance travelled (Fig. 1), to enable carbon footprint calculations (2.3.2). Note that all operations between datasets were element-wise.

2.2.1. Trips per origin region

To determine how many trips are initiated in each origin region, we extrapolated results from the microdata of the Flash Eurobarometer surveys *Preferences of Europeans towards Tourism* (2.1.1) to bilateral leisure travel flows from each country (Eurostat, 2020) (Eq. (2)). This step resulted in a dataset indicating the number of trips between each origin region and each destination country.

[1] The most recent suitability maps for nature tourism (Komossa et al., 2018) did not cover Croatia, Malta, Cyprus, Melilla, Ceuta and the Canary Islands. Therefore, only for these regions, we used a different suitability map (Van Berkel & Verburg, 2011) based on similar but slightly older data.

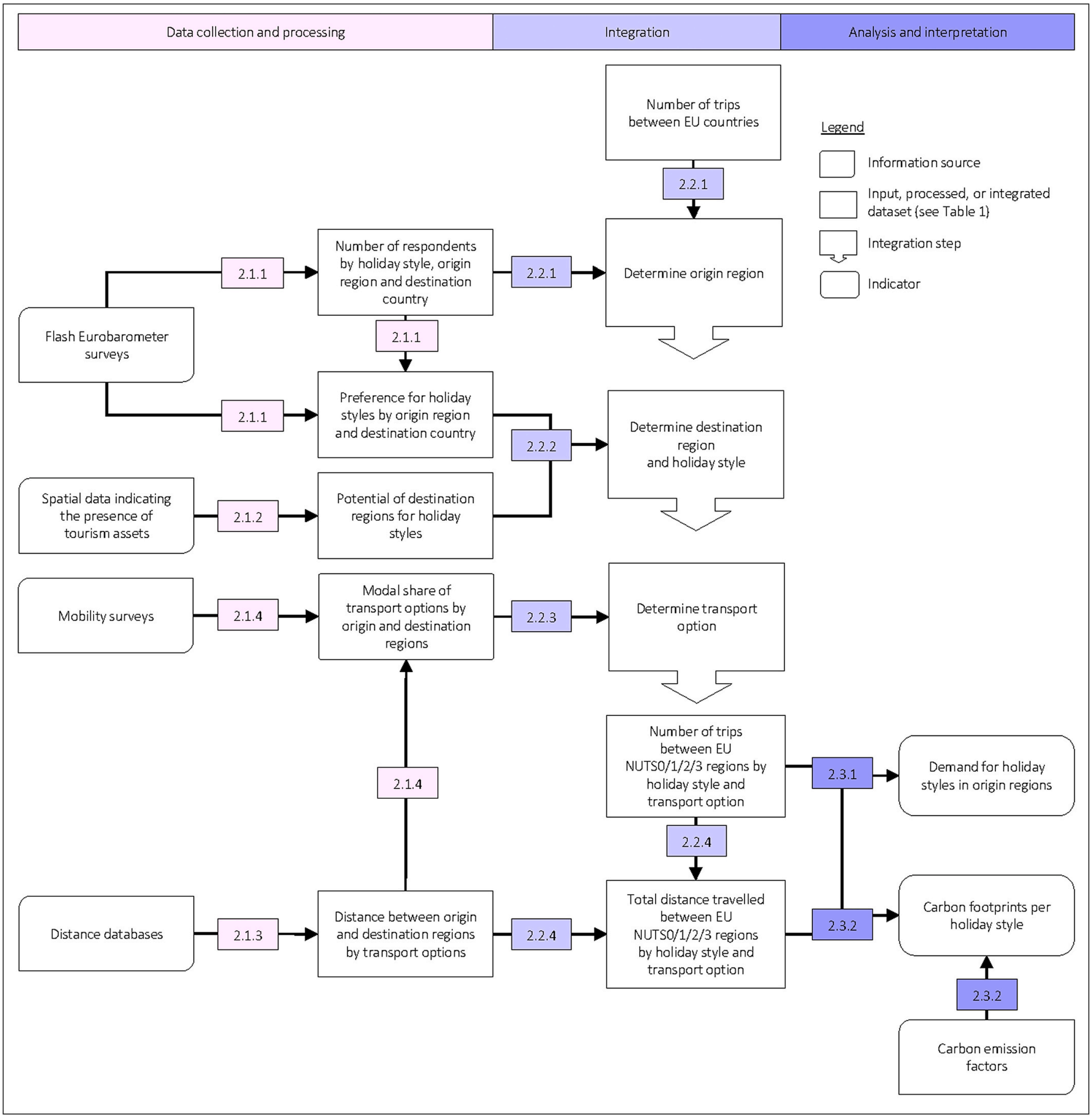

Fig. 1. Flowchart of the methodological approach. Numbers refer to the sections where calculation steps are described.

$$T_{Or,Dc} = T_{Oc,Dc} \cdot \frac{R_{Or,Dc}}{\sum_{Or=1}^{n_{Oc}} R_{Or,Dc}} \quad (2)$$

where $T_{Or,Dc}$ is the number trips from origin region Or to destination country Dc, $T_{Oc,Dc}$ is the number of trips from origin country Oc to Dc, $R_{Or,Dc}$ is the number of respondents (sum over all holiday styles) per pair Or, Dc.

2.2.2. Destination region and holiday style

Next, to downscale trip destinations from country to NUTS2 region and determine the holiday style of the trips, we estimated the attractiveness of destination regions for the different holiday styles (Table 1) based on data on tourists' holiday preferences (2.1.1) and tourism potential in NUTS2 regions (2.1.2) (Eq. (3)). The attractiveness of a region for a specific holiday style in a given destination country depends on the potential of that region relative to the other regions in the country, and on the preferences of the tourists visiting the country. For instance, a region with warm climate and ample beaches along its coast will be attractive for tourists with a preference for sea, sun and sand tourism, and will be allocated many trips if this preference is high. Conversely, absence of coastline in a destination region (e.g., in Austria) implies null potential for sea, sun and sand tourism, which translates into null attractiveness, regardless of tourists' preferences for this holiday style. We then used the attractiveness indicator to simultaneously determine the NUTS2 region of destination and the holiday style of the trips (Eq. (4)). This step resulted in a dataset indicating the number of

Holiday style (x)	Icon	Asset or suitability variable	Spatial data	Method to aggregate spatial data to NUTS2 level	Weight
City tourism		Cities with tourist accommodations	Presence of major cities with a significant number of tourist accommodations (679 cities), as inventoried by Eurostat (2020). The total number of beds in tourist accommodations in these cities, averaged over the period 2010-2019 (Eurostat 2020), was used as a proxy of cities' attractiveness. We used the number of beds reported for a specific year for Manchester (2012), Coventry (2004) and Lincoln (2003) because some of the values reported between 2010 and 2019 were abnormally high, i.e. higher than values reported for major European capitals (i.e., Stockholm, Paris).	$\sum assets * attractiveness$	50%
		World-class cities	Presence of cities with exceptional historical, artistic, gastronomic and/or aesthetic attributes that were identified world-class cities (123 cities) or world's greatest cities (5 cities: London, Paris, Venice, Florence and Rome) for tourism in 2019 (Eupedia, 2020). World-class cities are assigned an attractiveness of 1, world's greatest cities 2.	$\sum assets * attractiveness$	50%
Nature tourism		Attractive landscape for convenience recreationist	Suitability of landscapes for outdoor recreation fitting interests of convenience recreationists at 1km resolution (Komossa et al., 2018), in relation to the proximity of water bodies, easily accessible mountain areas, varied vegetation, and low levels of air pollution. Values were classified categorically from 0 to 5.	$\sum suitability \geq 3$	50%
		Attractive landscape for nature trekker	Suitability of landscapes for outdoor recreation fitting interests of nature trekkers at 1km resolution (Komossa et al., 2018), in relation to the naturalness of the landscape, presence of terrestrial protected areas classified by IUCN and UNEP-WCMC (2016), and low population density. Values were classified categorically from 0 to 5.	$\sum suitability \geq 3$	50%
Culture tourism		Museums	Presence of museums in a 10km radius, at 1km resolution. Density map produced based on the spatial distribution of 20504 museums (OpenStreetMap 2020), excluding points without a name, and duplicates, and using a quadratic kernel with decay 0.	$\sum suitability$	50%
		UNESCO sites	Presence of UNESCO cultural and mixed sites (325 sites) (UNESCO 2020) in 2019.	$\sum assets$	50%
Event tourism		Music festivals	Presence of renowned metal, rock, dance, hip-hop and world music festivals (Festival Searcher, 2020) (162 festivals)) and renowned classical music festivals (9 festivals) (Wonders, 2017). The number of visitors at previous editions were collected from festivals' website and posts on social media, and used as a proxy of festivals' attractiveness.	$\sum assets * attractiveness$	100%
Active outdoors tourism		Suitable conditions for outdoor sports	Suitability of landscapes for water, mountain and trail sports at 1km resolution (Komossa et al., 2018), in relation to the presence of water bodies, marked trails for walking and cycling, and variations in altitude. Values were classified categorically from 0 to 5.	$\sum suitability \geq 3$	50%
		Suitable conditions for winter sports	Suitability of landscapes for winter tourism at 1km resolution (Van Berkel & Verburg, 2011), in relation to cold temperatures, snowfall, slopes favouring downhill skiing, open landscapes and a good connection to urban centres. Values were scaled continuously from 0 to 1.	$\sum suitability$	50%
Sea, sun and sand tourism		Suitable conditions for beach tourism	Suitability of landscapes for beach tourism in the EU at 1km resolution (Van Berkel & Verburg, 2011), in relation to high temperatures and the presence of coastal areas, sandy beaches and campsites. Values were scaled continuously from 0 to 1.The coastal zone is defined as the territory located at a maximum distance of 10 km from the coast.	$\sum suitability$	100%
Visiting relatives		Friends and family	Total population in NUTS2 regions averaged over the period 2013-2015 (Eurostat, 2020).	$Population$	100%
Wellness tourism		Thermal springs & Wellness retreats	Presence of thermal springs (132 sites) in the EU (OpenStreetMap, 2020b) and wellness retreats (168 retreats) as promoted in blogposts on The Culture Trip (2020), where titles contain the name of an EU country and one of the following keywords: "retreat", "wellness", "yoga", "sauna", "hammam", and "spa" (Table S3).	$\sum assets$	100%

Fig. 2. Inventory of assets considered relevant for the different holiday styles, spatial data revealing the distribution of assets in the EU, and methods used to estimate the potential of NUTS2 regions for different holiday styles. Sources spatial data: (Eupedia, 2020; OpenStreetMap, 2020a,b; The Culture trip, 2020; Wonders, 2017; GESIS. n.d.; Searcher, 2020; UNESCO, 2020).

trips between each origin region and each destination region, for each holiday style.

$$A_{x,Or,Dr} = PF_{x,Or,Dc}.PO_{x,Dr} \tag{3}$$

$$T_{x,Or,Dr} = T_{Or,Dc} \cdot \frac{A_{x,Or,Dr}}{\sum_{x=1}^{n}\sum_{Dr=1}^{m_{Dc}} A_{x,Or,Dr}} \tag{4}$$

where $A_{x,Or,Dr}$, is the attractiveness of destination region *Dr* for tourists from origin region *Or* for holiday style *x*, $PF_{x,Or,Dc}$ is the preference for *x* associated to tourists from *Or* who travelled to *Dc*, $PO_{x,Dr}$ is the potential for *x* in *Dr*, $T_{x,Or,Dr}$ is the number of trips between *Or* and *Dr* for *x*, and $T_{Or,Dc}$ is the number trips from *Or* to *Dc*.

2.2.3. Transport option

To account for the influence of modal choice on distance travelled and carbon emissions, we linked the modal split of trips between each pair of origin and destination region (2.1.3) to the number of trips between these regions (Eq. (5)). This step resulted in a dataset indicating the number of trips between each origin region and each destination region, for each holiday style, and by each transport option (Table 1).

$$T_{x,y,Or,Dr} = T_{x,Or,Dr} {}^{*} M_{y,Or,Dr} \tag{5}$$

where $T_{x,y,Or,Dr}$ is the number of trips between origin region *Or* and destination region *Dr* for holiday style *x* and by transport option *y*, $T_{x,Or,Dr}$ is the number of trips between *Or* and *Dr* for *x*, and $M_{y,Or,Dr}$ is the modal share of *y* between *Or* and *Dr*.

2.2.4. Total distance travelled

Because the distance travelled strongly determines carbon emissions from tourism (Lenzen et al., 2018), we finally converted leisure travel flows from number of trips to distance travelled (Eq. (6)). We took into account modal choices (2.1.4) and assumed that all trips are return trips. This step resulted in a dataset indicating the total distance travelled between each origin region and each destination region, per holiday style and transport option (Table 1).

$$W_{x,y,Or,Dr} = T_{x,y,Or,Dr} {}^{*}2^{*} D_{y,Or,Dr} \tag{6}$$

where $W_{x,y,Or,Dr}$ is the total distance travelled between origin region *Or* and destination region *Dr* for holiday style *x* and by transport option *y*, $T_{x,y,Or,Dr}$ is the number of trips between *Or* and *Dr* for *x* by *y*, and $D_{y,Or,Dr}$ is the distance between *Or* and *Dr* by *y*.

2.3. Analysis and interpretation

To explore the spatial patterns of demand for different holiday styles and role in shaping the impact of leisure travel within the EU, we calculated a number of indicators to characterize the demand and carbon footprint associated with the different holiday styles, using the integrated datasets (Table 1) obtained from sections 2.1 and 2.2.

2.3.1. Demand for holiday styles in origin region

We assessed three indicators of demand for different holiday styles in origin regions. First, we calculated the relative demand for each holiday style based on the share of each holiday style in the total number of trips. Second, we determined the physical distance required to meet the demand for each holiday style using the average distance per trip. Third, we quantified the demand for international travel for different holiday styles using the share of international trips in the total number of trips per holiday style.

2.3.2. Carbon footprints

We calculated the total carbon footprint, as well as the average carbon intensity of travel per trip and per kilometre, to characterize the impact of the different holiday styles. Carbon footprints are commonly estimated by multiplying distances travelled by emission factors. Emission factors expressed in CO_2e were preferred over CO_2 to better reflect the impact of air transport on the atmosphere, as about half of aviation's global warming effect is attributable to nitrous oxide (NO_x) emissions (Peeters et al., 2007). We multiplied the total distance per route, holiday style and mode of transport from section 2.2.2 by emissions factors that are specific to the EU and mode of transport (Table 2) (van Goeverden, van Arem, & van Nes, 2016 based on Otten, 'tHoen, & den Boer, 2015, p. 88 (page 14)). For air trips with stopovers, we calculated emissions for each individual flight because the emission factor is sensitive to the distance travelled. The emission factor for ferry travel (GOV 2020) is higher for a passenger boarding with a car than for a passenger boarding alone, given the weight and space taken up by the vehicle. We assumed that people travelling by road board the ferry by car, so we applied the value for a passenger with a car. Conversely, we assumed that people travelling by public transport do not have a car to board, so we applied the value for a passenger alone.

3. Results

3.1. Spatial patterns of travel flows per holiday style

Visiting relatives and nature tourism are the holiday styles that contribute the most to leisure travel flows within the EU, each accounting for more than one fifth of total trips. The contributions of culture tourism, sea, sun and sand tourism, and city tourism to total number of leisure-related trips range between 10% and 17%, while that of active outdoors tourism, wellness tourism, and event tourism are below 10% (Table 3). Air travel is more prevalent for sea, sun and sand tourism than for other holiday styles (Table 3). The large majority of leisure-related trips are domestic, yet international travel between EU countries is substantial for all holiday styles, especially for active outdoors tourism, city tourism, culture tourism, and sea, sun and sand tourism (Table 3).

Three quarters of all leisure-related trips in the EU are less than 750 km (one-way), with one quarter less than 250 km, one quarter between 250 and 500 km, and one quarter between 500 and 750 km. One quarter of trips is over 750 km, but only 2.5% of trips exceed 2500 km, mostly trips from Scandinavia to the Canary Islands. The distribution of trips across one-way distance varies among holiday styles, shaping the distribution of total distance travelled across one-way distance (Fig. 3), and yielding differences in the average one-way distance per trip (Table 3). For instance, half of the trips for sea, sand and sun tourism are over 650 km and up to 6% are over 2500 km, while nearly three quarters of nature tourism trips are less than 650 km and only 1% are over 2500 km. As a result, the average distance per trip for sea, sun and sand tourism is the highest of all holiday styles, and is 1.6 times greater than for nature tourism and up to 1.7 times greater than for event tourism (Table 3). The singular distribution observed for sea, sun and sand tourism (Fig. 3) relates to the prevalence of destinations in southern Europe for this holiday style, while origins are more spread across the continent (Fig. 4).

The spatial patterns of travel flows within the EU vary by holiday style. Overall, domestic routes account for larger numbers of trips, but

Table 2
Emission factors.

Mode of transport	Characteristics	Kg CO_2e[a] per km
Airplane	<1000 km	0.297
Airplane	1000–3000 km	0.200
Airplane	>3000 km	0.147
Train or Coach		0.031
Car		0.110
Ferry	Passenger boarding alone	0.019
Ferry	Passenger boarding by car	0.130

[a] CO_2 equivalents, combining emissions of CO_2 (1 kg CO_2 = 1 kg CO_2e) and NO_x (1 kg NO_x = 298 kg CO_2e) (Eurostat, 2017).

Table 3
Proportion of trips per holiday style of total leisure-related trips within the EU (953 million trips), share of air and international travel, and average distance per trip. Highest numbers are in bold.

Holiday style	Proportion of total leisure-related trips	Share of trips by air	Share of international trips	Average one-way distance per trip (km)		
				All trips	Domestic trips	International trips
Sea, sun, sand	14%	**22%**	25%	**873**	**621**	**1645**
Visiting relatives	**24%**	9%	16%	537	417	1166
Nature	22%	9%	19%	551	421	1103
Culture	17%	13%	26%	635	431	1230
City	10%	12%	28%	636	435	1165
Active outdoors	7%	13%	**29%**	647	437	1168
Wellness	5%	10%	18%	582	449	1186
Event	2%	9%	20%	519	379	1079
All	100%	12%	22%	621	450	1239

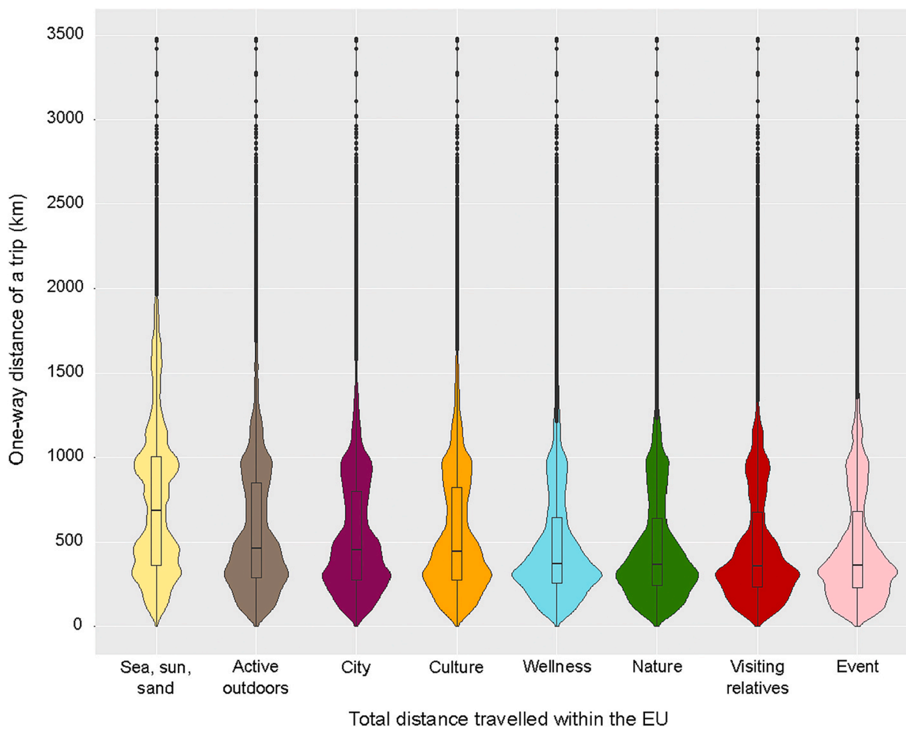

Fig. 3. Distribution of the total distance travelled within the EU for the different holiday styles, according to the one-way distance of trips.

some international routes represent a substantial share of total trips for certain holiday styles (Fig. 4). Flows for active outdoors tourism are primarily North-to-South in France, Germany, and the Netherlands, East-to-West in Hungary, Austria, Slovenia, and Croatia, South-to-North in Poland, the United Kingdom, Sweden, and Finland, and outskirts-to-centre in Denmark. In Spain, active outdoors tourism flows mainly go from the centre towards the outskirts in multiple directions. In contrast, flows for visiting relatives are commonly two-way, e.g. in Germany, Spain, the United Kingdom, Sweden and Finland. France is an exception, with most flows for visiting relatives going from the region of Paris to the provinces. Flows for culture tourism, city tourism, and nature tourism are less concentrated on specific routes. International flows are mainly one-way coming from Germany and the United Kingdom, but the range of destinations varies with origin region and holiday style (Figure S4). Sea, sun and sand tourists from northwest Germany primarily go to the Dutch or Spanish coasts, those from south Germany to the Italian, Spanish or Croatian coasts, and those from the United Kingdom and Ireland to the Spanish coast and Cyprus. There are also substantial flows from south Germany to several regions in Austria, Italy and Croatia for active outdoors tourism, city tourism and culture tourism, and from Finland to Estonia for all holiday styles except wellness tourism and event tourism.

3.2. Spatial patterns of demand for the different holiday styles

3.2.1. Relative demand for each holiday style by origin region

Distinct regional patterns of demand can be observed for some holiday styles, while for others, demand is more equally spread across the EU. For instance, the relative demand for sea, sun and sand tourism is higher in Southern Europe, representing around 30% of the trips (Fig. 5). Conversely, in several regions of Central Europe, more than 40% of trips are for nature tourism, and between 10% and 20% are for active outdoors tourism. The relative demand for other holiday styles is more even across EU regions. Visiting relatives represents commonly over 20% of trips, culture tourism and city tourism between 10% and 20%, and wellness tourism and event tourism less than 10%.

3.2.2. Average distance per trip by origin region

The average one-way distance per trip from origin regions varies by holiday style (Fig. 6). The one-way distance is between 250 and 500 km in two thirds of origin regions for culture tourism and city tourism, and in around half of origin regions for visiting relatives, nature tourism, sea,

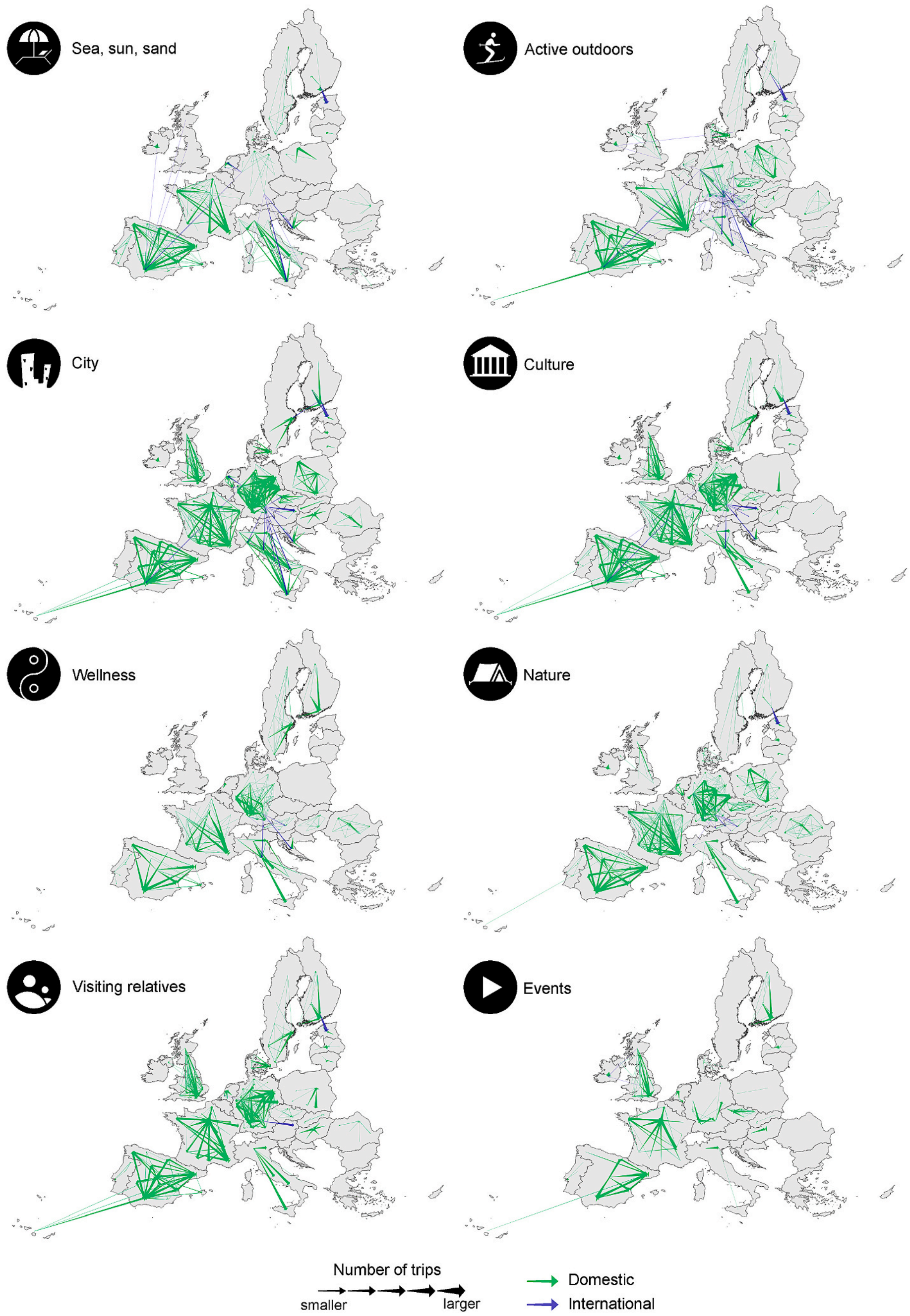

Fig. 4. Spatial patterns of leisure travel per holiday style. For clarity, each map only shows the routes with the largest number of trips, representing a total of 50% of total trips per holiday style. Directional arrows indicate routes from origin to destination regions and are sized by contribution to total number of trips per holiday style and coloured to differentiate domestic and international routes. See Figure S4 for more details on international flows.

sun and sand tourism, and active outdoors tourism. In the remaining origin regions, the average distance per trip for these holiday styles is generally below 250 km, except for sea, sun and sand tourism. In fact, the average distance per sea, sun and sand tourism trip is over 500 km in 30% of origin regions, mainly located in the United Kingdom, Belgium, Central and Northern Europe (Fig. 6). Moreover, the average distance per trip is over 500 km for wellness tourism in many regions of Poland, the Baltics and Ireland, and for event tourism in many regions of Romania and Bulgaria.

3.2.3. *Demand for international travel by origin region*

Origin regions where the average distance per trip for sea, sun and sand tourism, wellness tourism or event tourism is relatively long are also those with the highest share of international trips for these holiday styles (Figure S5). This correspondence is not observed for other holiday styles. As an example, in most origin regions of Germany and Belgium, more than 50% of active outdoors tourism trips are international, but the average distance per active outdoors tourism trip is not higher than in other origin regions (Figure S6).

3.3. *Carbon footprints per holiday style*

We estimated the total carbon footprint of leisure travel within the EU at 139 million tons of CO_2e per year on average over the period 2010–2018, split almost equally between domestic (70 million tons) and international travel (69 million tons). Sea, sand and sun tourism, visiting

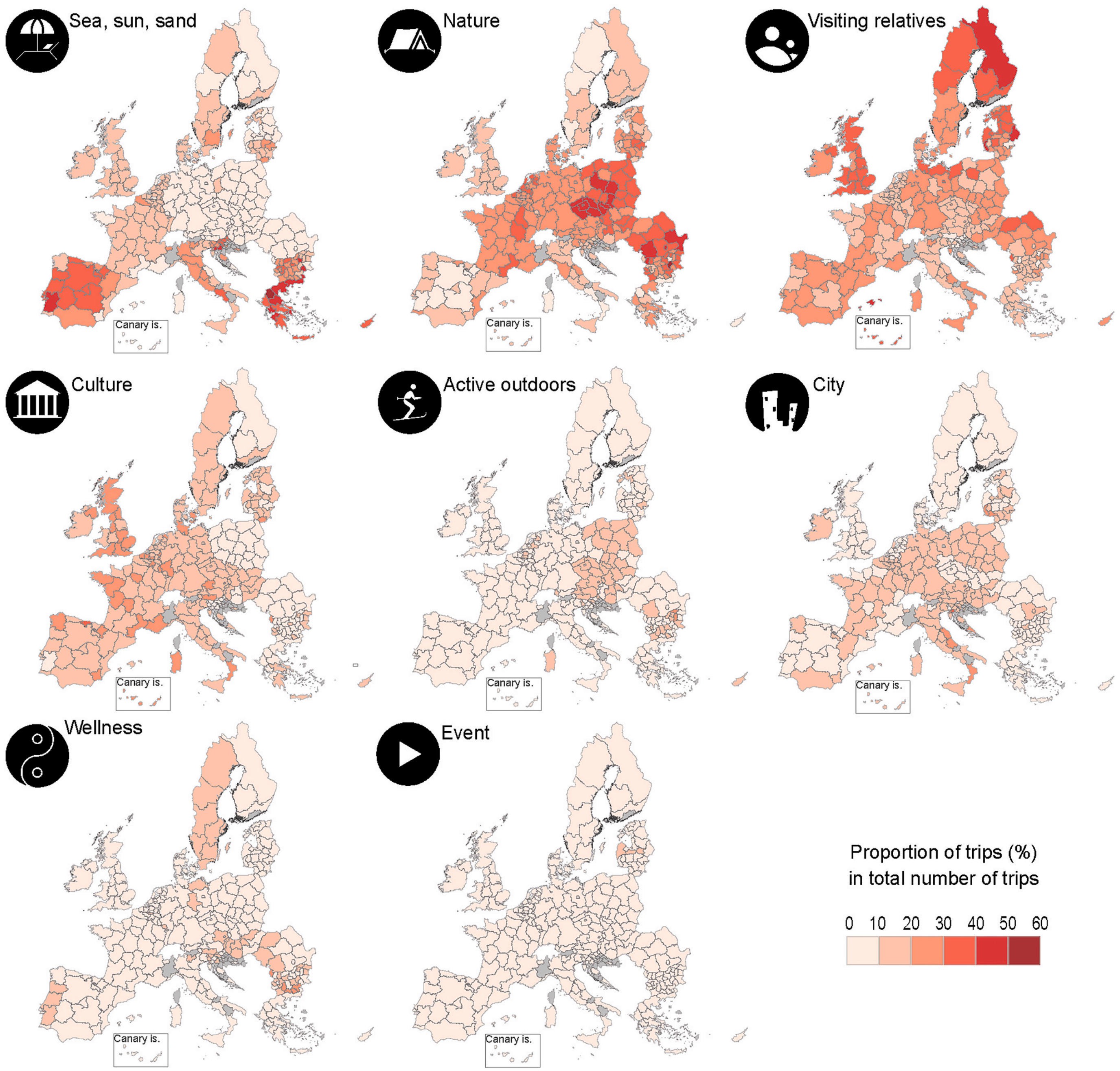

Fig. 5. Relative demand for the different holiday styles, by origin region. Origin regions from which no trip was allocated are shown in grey.

relatives, and nature tourism are the holiday styles with the largest aggregate carbon footprint, each accounting for a fifth of total carbon emissions (Table 4). The carbon intensity of travel per trip and per kilometre for sea, sand and sun tourism is also the highest, but those for visiting relatives and nature tourism are comparatively low. Carbon intensity of travel for active outdoors tourism, culture tourism and city tourism is close to that estimated for all holiday styles combined (145 kg per trip and 0.117 kg per kilometre). Moreover, international travel is on average three times more carbon-intensive than domestic travel, for all holiday styles (Table 4). For active outdoors tourism, culture tourism, city tourism, and sea, sun and sand tourism, more than half of carbon emissions originates from international travel. The proportion of emissions from air travel is the highest for sea, sun and sand tourism and the lowest for nature tourism (Table 4).

Carbon emissions are unequally distributed among the trips (see Gini coefficient in Table S3). The 25% most carbon-intensive trips explain more than 50% of total carbon emissions from Europeans' leisure travel within the EU, while the 25% least carbon-intensive trips explain only 5%. Small nuances are observed between holiday styles (Fig. 7). The most unequal distribution is observed for active outdoors tourism, and the least unequal for wellness tourism (Table S3). When domestic and international travel are considered independently, inequalities in the distribution of carbon emissions among trips decreases (Figure S6; Table S3), supporting the significant difference between the carbon intensity per trip of domestic and international travel.

4. Discussion

4.1. Interpretation of the results

This study provides an estimate of the carbon footprint of leisure travel within the EU28, covering domestic trips and trips between EU28

Fig. 6. Maps of the average one-way distance per trip for each holiday style, by origin region. Origin regions from which no trip was allocated are shown in grey.

countries. Our estimate of 139 million tons of CO_2e per year, as an average for the period 2010–2018, corresponds to 12% of the carbon footprint of global tourism, including both leisure and business travel, estimated in CO_2 for 2010 (Gössling & Peeters, 2015), and to 3% of the EU28's total carbon footprint estimated in CO_2e for 2014 (EEA, 2021). If differences in scope and methods are acknowledged, our figures are in line with that from Peeters et al. (2007), who also studied the carbon footprint of Europeans' tourism travel. Peeters et al. (2007) estimated that tourism travel within the EU emitted 210 million tons of CO_2e in 2000, which is higher than our estimate of 139 million tons of CO_2e, yet their quantification is for the EU25 and includes business trips. They also documented a concentration of carbon emissions in carbon-intensive trips, with between 60% and 80% of carbon emissions being explained by the 25% most carbon-intensive trips. We estimated this share at only 50%, likely because, unlike Peeters et al., (2007) we omit intercontinental trips, which are expected to be of longer distance than trips within the EU.

This study goes beyond quantifying the carbon footprint of leisure travel by distinguishing the holiday style associated to the trips. This allows us to compare the carbon emissions associated with eight holiday styles (Table 4) and observe their differences in impact. The carbon intensity of travel per trip for sea, sun and sand tourism is the highest, approaching the global average impact per tourism trip (including transport and accommodation) of 250 kg of CO_2 (Gössling et al., 2015), because the distance travelled per trip is relatively long and air travel is more common. In contrast, the carbon intensity of travel per trip for

Table 4
Carbon emissions (in CO_2e) associated with different holiday styles. Highest numbers are indicated in bold.

Holiday style	Proportion CO_2e in total CO_2e from leisure travel	Share CO_2e from air travel	Share CO_2e from international travel	Average CO_2e of travel per trip (kg)			Average CO_2e per km (kg)
				All trips	Domestic trips	International trips	
Sea, sun, sand	**20%**	**60%**	52%	**220**	**141**	**460**	**0.126**
Visiting relatives	**20%**	37%	40%	122	87	307	0.114
Nature	19%	34%	44%	124	86	284	0.113
Culture	17%	43%	56%	150	89	326	0.118
City	10%	42%	56%	149	90	304	0.117
Active outdoors	7%	45%	**58%**	153	90	308	0.118
Wellness	5%	35%	43%	131	91	311	0.113
Event	2%	36%	47%	118	78	278	0.114
All	100% 139 million tons	43%	49%	145	95	329	0.117

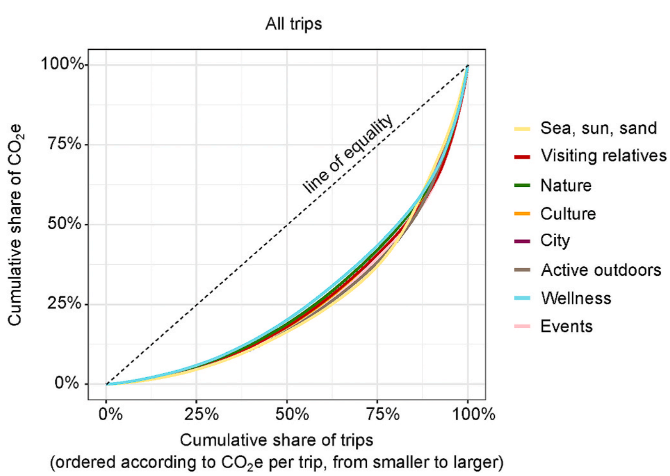

Fig. 7. Lorenz curves showing the distribution of CO_2e among all trips per holiday style. See Figure S6 for domestic vs international trips.

visiting relatives and nature tourism is relatively low, but the largest number of trips are made for these holiday styles (Tables 3 and 4). Consequently, the aggregate carbon footprint of visiting relatives, nature tourism and sea, sun and sand tourism is akin (Table 4). While the carbon intensity of travel per trip for active outdoors tourism, culture tourism and city tourism is within the same range, substantial differences in the number of trips result in very different aggregate carbon footprints (Tables 3 and 4).

Furthermore, our results suggest that the spatial distribution of demand for different holiday styles is a determinant of the carbon footprint of leisure travel within the EU because it influences the total distance travelled. We observe that preferences and potential for different holiday styles tend to spatially match, meaning that demand for a specific holiday style tends to be stronger in the regions where potential for this holiday style is high. This match leads to shorter-distance but more frequent travel, and is reflected by the prevalence of certain holiday styles in the demand from specific regions (Fig. 5). For example, the relative demand for active outdoors tourism is highest in Central Europe (Fig. 5), where mountains offer opportunities for various outdoor sports (Komossa et al., 2018), while the relative demand for sea, sun and sand tourism is highest in Southern Europe, where the attractiveness of beaches is enhanced by high temperatures (Van Berkel & Verburg, 2011) (Fig. 5, S2). Since a large variety of landscapes is suitable for nature tourism, demand for this holiday style is relatively high in a larger part of the EU (Figure S2).

Finally, our results suggest that the motivations underlying long-distance travel vary among the holiday styles. A first motivation to long-distance travel is people's appreciation of specific climatic and environmental conditions (Scott, Gössling, & Hall, 2012). The concentration of flows for active outdoors tourism and sea, sun and sand tourism on certain routes, converging towards specific locations (e.g., the Mediterranean coast, the Alps) (Fig. 4), suggests that this motivation particularly applies to these holiday styles. Conversely, flows for city tourism and culture tourism are relatively scattered across the routes (Fig. 4, S5) and often go two-ways, indicating that people travel to other regions and abroad even when potential is found nearby. Long-distance travel for city tourism and culture tourism is likely to be driven by travellers' sense of discovery, referring to the desire to change scenery and experience other cultures (Almeida-Santana & Moreno-Gil, 2018), but could also be related to the presence of unique cultural assets in specific cities. Besides internal motivations, external factors such as the presence or absence of airports and train stations, deals on flights or holiday packages in certain destinations also contribute to shaping the spatial patterns of travel for different holiday styles.

4.2. Limitations and further research

This paper used a novel approach to track bilateral leisure travel flows at the subnational level, using spatial data on tourism preferences and potential. This allows for a refined estimation of the distances travelled for leisure within the EU, which contributes to a better assessment of the associated carbon footprint. Moreover, by attributing trips to eight holiday styles, we provide valuable insights into the behaviour of European tourists and the influence of preferences on the distance travelled for leisure within the EU. However, this study does not cover intercontinental travel, as information on preferences was only available at the world regions level (see Table S5) and spatial data supporting the potential indicators were difficult to collect for those regions. While accounting for only 5% of Europeans' leisure travel trips, intercontinental travel is responsible for substantial carbon emissions that were not factored into this study, which therefore does not capture the complete carbon footprint of Europeans' leisure travel.

Despite these advances, our approach has uncertainties and potential biases. Most importantly, we do not account for the link between preferences and modal choice when calculating carbon emissions by holiday style. Besides distance between origin and destination, multiple factors influence modal choice for leisure travel (Peeters et al., 2004), but little is known about their association with specific holiday experiences. For example, a family with children is more likely to plan a camping trip in the nature than a wellness retreat, and to travel by car for convenience (Lamondia et al., 2010). Nature lovers might avoid air travel for environmental considerations, but air travel might be preferred for city trips, which tend to be of shorter duration. To unravel this link, future research could quantify leisure travel flows in terms of overnight stays (e.g., Eijgelaar et al., 2021) and look into the socioeconomic characteristics of tourists travelling on different routes. Such improvement would help refine the aggregate carbon footprint estimate and its allocation among holiday styles.

Our analysis focuses on carbon emissions from transport between origin and destination, which is the largest segment of the carbon footprint of global tourism (Gössling & Peeters, 2015). However, in the case of leisure travel within the EU, the contribution of other segments (e.g., accommodation, leisure activities) could be substantial (e.g., Eijgelaar et al., 2021), given that the average distance of a trip is relatively short compared to an intercontinental trip (UNWTO & ITF, 2019). For example, a significant part of the impact of a road trip is likely to be related to on-site transportation. Expressing leisure travel flows in terms of the durations in overnight stays should help quantify emissions from other segments as well. A more holistic perspective on carbon emissions from leisure travel could also help link its impact to the revenues or expenditures it generates and further differentiate holiday styles in terms of sustainability (Gössling et al., 2005).

Finally, the accuracy of the preference and potential indicators is affected by our input data. For example, in the Flash Eurobarometer questionnaire, the countries visited and reasons for going on holiday are not jointly surveyed. In future editions, specifically asking about reasons for going on holiday by country visited would help improve the accuracy of the preference indicator, but such rephrasing could then challenge the comparability of results over time (Gúčik, Rapacz, & Jaremen, 2018). Potential for certain holiday styles may be overlooked in some regions due to missing data for the spatial indicators, with implications for the distribution of trips to destination regions within a country and to holiday styles. Data for wellness tourism was for instance particularly scarce in Eastern Europe. Moreover, a few major events took place in the EU between 2013 and 2015 (e.g., 2015 Milan World Expo, European Capitals of Culture events in Marseille, Kosice, Umea, Riga, Mons, and Plzen), which we did not include because attendance was not reported. Major sporting events such as the Olympic Games and the FIFA World Cup were not taken into account as none took place in the EU within the survey period. As a result, the number of trips for event tourism and wellness tourism may be underestimated.

5. Implications for tourism management

Carbon emissions from transport between origin and destination for leisure travel are a critical segment of tourism's impact (Gössling & Peeters, 2015; Neger et al., 2021). Our results can inform several avenues for strategic market development to reduce the distance travelled, as suggested by Gössling et al. (2015).

A first avenue is to promote domestic travel. Domestic tourism is associated with shorter distance per trip than international travel (Table 3) and is proven to have economic benefits and to enhance cohesion among a country's regions (Llorca-Rodríguez, Chica-Olmo, & Casas-Jurado, 2020). Moreover, domestic tourism has been more resilient to the downturn imposed by the COVID-19 pandemic (European Commission, 2022), arguably due to a shift in tourism strategies since the beginning of the pandemic (UNWTO, 2020). In this regard, the EU could enhance the attractiveness of regional territories for locals by funding the development of tourist attractions in areas where tourist activity is not yet developed (European Commission, 2017). Such investment should be particularly targeted at assets related to wellness tourism (e.g. health-tourism package within national parks), nature tourism (e.g. agri-tourism activities on farms), and active outdoors tourism (e.g. hiking and biking trails); preferences for these forms of leisure travel may have increased during the pandemic as they could be enjoyed outdoors and away from congested areas. Promoting regional cultures through territorial branding (e.g., Atout France, 2021) could revive Europeans' sense of discovery and have the adverse long-term effect of increasing demand for international travel once all travel restrictions have been lifted and travellers' confidence in the sanitary conditions of other countries has been restored. In contrast, stressing the value of time spent with loved ones may foster domestic travel, given that family and friendship networks are primarily domestic.

In order to reduce long-distance travel, tourism marketing strategies could focus on advertising opportunities to find similar assets in closer destinations. To this end, communication campaigns could capitalize on the effects of climate change to enhance the competitiveness of climatic conditions in temperate regions, especially during the summer season (Scott et al., 2012). Furthermore, encouraging a shift from destination-based to experience-based search (e.g., Airbnb, 2021), echoing internal motivations to travel (e.g., escape, rest, prestige), can guide tourists towards closer destinations, and help satisfy their sense of discovery within a smaller radius. The dichotomy between domestic and international tourism is not entirely appropriate for sustainability strategies in the tourism sector, given the different sizes of EU countries and the low influence of borders on origin-destination travel cost and time. Furthermore, discouraging international tourism is likely to be a difficult objective to incorporate into sustainability policies that are primarily mindful of their economic impact. Indeed, the tourism industry in the EU has a high economic return but its carbon intensity per unit of revenue is low compared to other economic sectors (Wan Lee & Brahmasrene, 2013). In this regard, further research into the eco-efficiency of different holiday styles may reveal additional leverage points for the sustainable development of leisure travel.

In addition to reducing the distance travelled, the impact of leisure travel can be mitigated by modal shifts to public transport (Gössling & Higham, 2020). The analysis of spatial patterns associated with different holiday styles presented in this study can guide the design and promotion of public transport services tailored to tourist uses. The Alpen Express (2021) which connects the Netherlands and Germany to ski resorts in Austria overnight, and the Interrail/Eurail (2021) pass which allows travellers to explore European cities by train, are living examples of such services. However, opportunities might be limited if preferences are inherently mode-bound or if the capacity of alternative transport modes is limited. For example, by creating opportunities for weekend getaways to European capitals, low-cost airlines may have spawned a preference for city tourism in the EU (Peeters et al., 2018). Ending the preferential tax regime applied to the aviation sector, which creates distortions in relative prices compared to other modes of transport, might therefore affect tourists' holiday preferences and create a more level playing field between modes of transport (Krenek & Schratzenstaller, 2017). This could be further encouraged by adding a proxy for the environmental costs to ticket prices. Another approach is to encourage an increase in length of stay (Gössling & Higham, 2020) through promotions on accommodations beyond a certain duration for instance, which could trigger slower modes of transportation to reach a given destination and reduce the yearly number of trips.

6. Conclusion

Our study is the first to examine tourists' holiday preferences as a determinant of the carbon footprint of leisure travel. We developed a novel approach to integrate a broad and varied set of data on different aspects of Europeans' recreation, tourism, and transport practices to estimate and map leisure travel flows between EU NUTS regions for eight holiday styles, specifying the modes of transport used. This level of detail allowed us to generate insights into the distance travelled for domestic tourism and tourism between EU countries, as well as the preferences underlying leisure travel within the EU and its environmental impact. As such it is an important step towards identifying exact causes of differences between impacts of different holiday styles, and a call to take into account tourists' holiday preferences in public and private strategies for the sustainable development of leisure travel within the EU.

7. Impact statement

This paper contributes to a better understanding of the determinants of the environmental impact of leisure travel within the European Union, by characterizing the demand and carbon footprints associated with different holiday styles. Businesses in the tourism sector (e.g. hospitality, booking platforms, travel agencies) and public institutions can capitalize on this information when developing marketing or funding strategies to meet sustainability goals. This research is all the more relevant as the European Green Deal asserts the tourism sector's responsibility to respond to the climate emergency. Results from this study provide insight into the spatial distribution of demand for eight holiday styles across subnational regions of the European Union, and how this influences carbon emissions from leisure travel. Taking tourists' holiday preferences into account in tourism development and marketing strategies can contribute to sustainability gains. Such insights can be used to substantiate some of the avenues already identified for developing sustainable tourism, or to support the tourism sector in the face of the covid-19 pandemic.

Author contribution

Perrine Laroche: Conceptualization, Methodology, Data curation, Formal analysis, Visualization, Writing – original draft, Catharina Schulp: Conceptualization, Writing – review & editing, Funding acquisition, Thomas Kastner: Methodology, Writing – review & editing, Peter Verburg: Conceptualization, Writing – review & editing, Funding acquisition

Data availability

The datasets supporting the results presented in this paper are available from http://dataverse.nl under “Leisure travel flows within the European Union" https://doi.org/10.34894/XLM0PC

Declaration of competing interest

none.

Acknowledgements

This research was funded by the Marie Skłodowska-Curie actions (MSCA) grant agreement No 765408 from the European Commission: COUPLED ‘Operationalising Telecouplings for Solving Sustainability Challenges for Land Use’, and the Deutsche Forschungsgemeinschaft (DFG, German Reuter Foundation) project No. KA 4815/1-1. Authors are grateful to Franziska Komossa for providing methodological insights, to Anne-Elise Stratton for proofreading the manuscript, and to three anonymous reviewers for their valuable suggestions.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.tourman.2022.104630.

References

Airbnb. (2021). *Airbnb experiences*. Retrieved from airbnb.com.

Almeida-Santana, A., & Moreno-Gil, S. (2018). Understanding tourism loyalty: Horizontal vs. destination loyalty. *Tourism Management, 65*, 245–255. https://doi.org/10.1016/j.tourman.2017.10.011

Alpen Express. (2021). *Alpen express*. Retrieved. from https://alpen.express/. (Accessed 12 July 2021).

Brown, G., & Getz, D. (2005). Linking wine preferences to the choice of wine tourism destinations. *Journal of Travel Research, 43*(3), 266–276. https://doi.org/10.1177/0047287504272027

Christensen, L. (2016). Environmental impact of long distance travel. *Transportation Research Procedia, 14*, 850–859. https://doi.org/10.1016/j.trpro.2016.05.033

EEA. (2021). *Total GHG emissions in the EU28*. Retrieved from https://www.eea.europa.eu/data-and-maps/daviz/total-ghg-emissions#tab-chart_1.

Eijgelaar, E., Peeters, P., Neelis, I., de Bruijn, K., & Dirven, R. (2021). *Travelling large in 2019: The carbon footprint of Dutch holidaymakers in 2019 and the development since 2002* (pp. 1–45). Breda University of Applied Sciences.

Eugenio-Martin, J. L., & Campos-Soria, J. A. (2010). Climate in the region of origin and destination choice in outbound tourism demand. *Tourism Management, 31*(6), 744–753. https://doi.org/10.1016/j.tourman.2009.07.015

Eugenio-Martin, J. L., & Cazorla-Artiles, J. M. (2020). The shares method for revealing latent tourism demand. *Annals of Tourism Research, 84*(May), Article 102969. https://doi.org/10.1016/j.annals.2020.102969

Eupedia. (2020). *Map of the top travel destinations in Europe*. .. Retrieved from https://www.eupedia.com/europe/highlights_of_europe_map.shtml. (Accessed 5 August 2020).

European Commission. (2010a). *Airports distance matrix*. Retrieved from https://gisco-services.ec.europa.eu/tercet/flat-files.

European Commission. (2010b). *TERCET NUTS Distance matrices*. Retrieved from https://gisco-services.ec.europa.eu/tercet/flat-files.

European Commission. (2014). *Flash eurobarometer 392 (2013) preferences of Europeans towards tourism*. ZA5905. Data file Version 1.0.0. Cologne: GESIS Data Archive. https://doi.org/10.4232/1.13652.

European Commission. (2015). *Flash eurobarometer 414 (2014) preferences of Europeans towards tourism*. GESIS Data Archive. https://doi.org/10.4232/1.13652. Cologne. ZA5685. Data file Version 1.0.0.

European Commission. (2016a). *Flash eurobarometer 432 (2015) preferences of Europeans towards tourism*. GESIS Data Archive. https://doi.org/10.4232/1.13652. Cologne. ZA6654. Data file Version 1.0.0.

European Commission. (2016b). *TERCET NUTS Distance matrices*. Retrieved from https://gisco-services.ec.europa.eu/tercet/flat-files.

European Commission. (2017). Guide on EU funding for the tourism sector (2014-2020). *Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs*. Publications Office. https://data.europa.eu/doi/10.2873/251606.

European Commission. (2022). *Transition pathway for tourism*. Retrieved from https://ec.europa.eu/docsroom/documents/48697.

Eurostat. (2017). *Glossary: Carbon dioxide equivalent*. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Carbon_dioxide_equivalent.

Eurostat. (2020). *Eurostat statistical database*. Retrieved from https://ec.europa.eu/eurostat/data/database.

Fiorello, D., & Zani, L. (2015). *EU Survey on issues related to transport and mobility*. https://doi.org/10.2791/48322

France, A. (2021). *#CetÉtéJeVisiteLaFrance*. Retrieved from https://www.france.fr/fr/campagne/cetetejevisitelafrance.

GESIS. (n.d.) Eurobarometer data service - sampling and fieldwork. Retrieved from https://www.gesis.org/en/eurobarometer-data-service/survey-series/standard-special-eb/sampling-and-fieldwork. (Accessed April 2021).

van Goeverden, K., van Arem, B., & van Nes, R. (2016). Volume and GHG emissions of long-distance travelling by Western Europeans. *Transportation Research Part D: Transport and Environment, 45*, 28–47. https://doi.org/10.1016/j.trd.2015.08.009

Gössling, S., & Higham, J. (2020). The low-carbon imperative: Destination management under urgent climate change. *Journal of Travel Research, 60*(6), 1167–1179. https://doi.org/10.1177/0047287520933679

Gössling, S., & Peeters, P. (2015). Assessing tourism's global environmental impact 1900–2050. *Journal of Sustainable Tourism, 23*(5), 639–659. https://doi.org/10.1080/09669582.2015.1008500

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

Gov, U. K. (2020). *Greenhouse gas reporting: Conversion factors 2020*. Retrieved from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2020.

Graver, B., Zhang, K., & Rutherford, D. (2019). *CO 2 emiss. commer. aviat.*, (No. 16), 2018.

Gúčik, M., Rapacz, A., & Jaremen, D. E. (2018). The usefulness of Flash eurobarometer to study changes in tourists' preferences. *Ekonomiczne Problemy Turystyki, 43*(3), 7–20. Retrieved from https://www.ceeol.com/search/article-detail?id=787614.

Interrail/Eurail. (2021). *Interrail/Eurail pass*. Retrieved from https://www.interrail.eu/en.

Komossa, F., van der Zanden, E. H., Schulp, C. J. E., & Verburg, P. H. (2018). Mapping landscape potential for outdoor recreation using different archetypical recreation user groups in the European Union. *Ecological Indicators, 85*, 105–116. https://doi.org/10.1016/j.ecolind.2017.10.015. May 2017.

Krenek, A., & Schratzenstaller, M. (2017). Sustainability-oriented tax-based own resources for the European union: A European carbon-based flight ticket tax. *Empirica, 44*(4), 665–686. https://doi.org/10.1007/s10663-017-9381-7

Lamondia, J., Snell, T., & Bhat, C. R. (2010). Traveler behavior and values analysis in the context of vacation destination and travel mode choices: European Union case study. *Transportation Research Record*, (2156), 140–149. https://doi.org/10.3141/2156-16

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

Llorca-Rodríguez, C. M., Chica-Olmo, J., & Casas-Jurado, A. C. (2020). The effects of tourism on EU regional cohesion: A comparative spatial cross-regressive assessment of economic growth and convergence by level of development. *Journal of Sustainable Tourism, 29*(8), 1319–1343. https://doi.org/10.1080/09669582.2020.1835930

McKercher, B., & Mak, B. (2019). The impact of distance on international tourism demand. *Tourism Management Perspectives, 31*(March), 340–347. https://doi.org/10.1016/j.tmp.2019.07.004

Neger, C., Prettenthaler, F., Gössling, S., & Damm, A. (2021). Carbon intensity of tourism in Austria: Estimates and policy implications. *J. Outdoor Recreat. Tour., 33*. https://doi.org/10.1016/j.jort.2020.100331. August 2020.

OpenStreetMap. (2020a). *Museums*. Retrieved from https://www.openstreetmap.org/. (Accessed 19 August 2020).

OpenStreetMap. (2020b). *Thermal springs*. Retrieved from https://www.openstreetmap.org/. (Accessed 19 August 2020).

Otten, M., 't Hoen, M., & den Boer, E. (2015). *STREAM goederenvervoer 2014* (p. 88). Retrieved from www.ce.nl.

Peeters, P., Egmond, T. Van, & Visser, N. (2004). European tourism, transport and environment. In *Report for the DG-ENTR project 03-27 MuSST*.

Peeters, P., Gossling, S., Klijs, J., Milano, C., Novelli, M., Dijkmans, C., et al. (2018). *Research for TRAN committee - overtourism : Impact and possible policy responses*. Brussels: European Parliament, Policy Department for Structural and Cohesion Policies.

Peeters, P., Szimba, E., & Duijnisveld, 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

Rodríguez-Antón, J. M., & Rubio-Andrada, L. (2016). Tourism competitiveness in the European union: A quantitave objective model study. *ESIC Mark. Econ. Bus. J., 47*(2), 185–208. https://doi.org/10.7200/esicm.154.0472.1

Scholte, S. S. K., van Teeffelen, A. J. A., & Verburg, P. H. (2015). Integrating socio-cultural perspectives into ecosystem service valuation: A review of concepts and methods. *Ecological Economics, 114*, 67–78. https://doi.org/10.1016/j.ecolecon.2015.03.007

Scott, D., Gössling, S., & Hall, C. M. (2012). International tourism and climate change. *Wiley Interdiscip. Rev.: Climate Change, 3*(3), 213–232. https://doi.org/10.1002/wcc.165

Searcher, F. (2020). *The simple music festival search site*. Retrieved from http://www.festivalsearcher.com/default.aspx.

Sun, Y. Y., Lin, P. C., & Higham, J. (2020). Managing tourism emissions through optimizing the tourism demand mix: Concept and analysis. *Tourism Management, 81* (February), Article 104161. https://doi.org/10.1016/j.tourman.2020.104161

The Culture trip. (2020). *Unique trips, with care for the world*. .. Retrieved from https://theculturetrip.com/. (Accessed 21 July 2020).

UNESCO. (2020). *World heritage list*. Retrieved from https://whc.unesco.org/en/list/. (Accessed 30 July 2020).

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

UNWTO. (2018). *European union tourism trends*. Madrid: European Union Tourism Trends, Article doi:10.18111/9789284419470.

UNWTO. (2020). *Understanding Domestic Tourism and Seizing its Opportunities*. *Briefing Note – Tourism and COVID-19, 3*, 1–39. https://doi.org/10.18111/9789284422111. Retrieved from https://www.e-unwto.org/doi/epdf/10.18111/9789284422111.

UNWTO, & ITF. (2019). Transport-related CO_2emissions of the Tourism Sector. *Modelling Results*. Madrid: UNWTO. https://doi.org/10.18111/9789284416660.

Van Berkel, D. B., & Verburg, P. H. (2011). Sensitising rural policy: Assessing spatial variation in rural development options for Europe. *Land Use Policy, 28*(3), 447–459. https://doi.org/10.1016/j.landusepol.2010.09.002

Wan Lee, J., & Brahmasrene, 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

Wolff, S., Schulp, C. J. E., & Verburg, P. H. (2015). Mapping ecosystem services demand: A review of current research and future perspectives. *Ecological Indicators, 55*, 159–171. https://doi.org/10.1016/j.ecolind.2015.03.016

Wonders. (2017). *Hillman's top 10 lists for travellers*. .. Retrieved from http://hillmanwonders.com/top_10_classical_music_festival/top_10_classical_music_fest.htm. (Accessed 30 July 2020).

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