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The carbon impact of short-haul tourism: a case study of UK travel to Southern France using life cycle analysis

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ABSTRACT

Tourism holds a significant share in the global carbon footprint. Transportation to the destination is recognized as the primary contributor, although its contribution can be less dominant in the context of short-haul travel. Previous studies do not provide a critical comparative analysis of how changes in travel behaviour, notably modal shift, affect the total carbon impacts from short-haul holidays; nor do they explore the relative contribution of the specific elements of the holiday product or account for global variations when measuring those contributions. This paper presents a carbon impact assessment case study of short-haul tourism to Southern France by British tourists. It applies an advanced, Life Cycle Assessment-based, method of evaluation, the hybrid DEFRA-LCA (Ecoinvent) approach, which is capable of appraising both the direct and the embodied 'indirect' greenhouse gas emissions. The principal finding supports the traditional view that transportation generates the largest carbon footprint and that the most significant carbon savings can be achieved by switching from air and car-based travel to train and coach. However, the study also indicates that if tourists stay at the destination longer, and travel to the destination by train or coach, the destination-based elements of the holiday can make a large carbon contribution and even outweigh the share of the transit element. The Life Cycle Assessment also shows that the 'indirect' greenhouse gas emissions from tourism in Southern France are significant, thus emphasizing the importance of their incorporation into future carbon impact appraisals.

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1. Introduction

Accommodation, activities at the destination and transportation are the key elements of tourism (Becken and Simmons, 2002) which generate most of its greenhouse gas (GHG) emissions (Byrnes and Warnken, 2006; Dolnicar et al., 2010). The tourism industry is responsible for about 5% of the global carbon footprint (United Nations World Tourism Organisation – UNWTO, 2007) and the share of tourism transport is estimated between 50 and 97.5% (Gössling, 2000, 2002; Hunter and Shaw, 2007; Patterson et al., 2007; Peeters et al., 2006). The transit element is recognized as the largest carbon contributor to the GHG emissions from, for example, holiday tours (Gössling and Peeters, 2007) and pilgrimage travel (Hanandeh, 2013) but its share is very variable depending on the distance travelled, mode of transport used and length of time spent at the destination. The destination-based elements of holidays are attributed significantly smaller values of carbon intensity (Gössling, 2002; Gössling et al., 2002). This has, however, been challenged, especially in the context of short-haul tourism. Becken (2002) and Becken et al. (2003) argue that if tourists travel to/from a short-haul destination by overland modes of transportation or direct flights, but stay in luxurious hotels and undertake energy-intense activities at the destination, these non-transport elements of tourism may have a much more profound contribution to the total carbon footprint than conventionally accepted. Similar conclusions are drawn by Peeters et al. (2006), Chenoweth (2009) and Hunter (2002).

Research on the relative carbon significance of different elements of holiday travel is limited (Chenoweth, 2009). The number of studies is small and their geographical scope is narrow which hampers better understanding of the carbon footprint attributed to different holidaying choices in popular tourist destinations. This is because the research outcomes of existing studies cannot be directly projected onto other geographies as the carbon intensity of fuels and energy production varies considerably from region to region. For example, electricity generation in New Zealand, where the studies by Becken (2002) and Becken et al. (2003) were

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conducted, benefits from a large share of renewables (Becken and Patterson, 2006). This suggests a lower carbon intensity of both electricity-driven transport and energy use in hotels in New Zealand if compared to those European countries where the role of renewables in national energy balances is less pronounced. Some studies, such as the study by Chenoweth (2009), used the *global average* GHG emission coefficients for converting the energy consumption in hotels and fuel combustion in vehicle engines into carbon impacts. The applicability of the global average coefficients is limited because of the clear geographical variations in carbon intensity. Furthermore, other studies also rely upon outdated energy use data from the early and mid-1990s (see, for instance, Becken and Patterson, 2006) which fail to account for technological developments.

Previous research has produced some detailed estimates of the GHG emissions from specific holiday journeys, but never investigated in depth the carbon implications of a modal shift in the transit journey to/from the destination. For instance, Becken (2002) and Becken et al. (2003) examined tourism patterns in New Zealand which is a remote destination accessible only by air. The study by Chenoweth (2009) looked at a number of holiday destinations which can be reached by various modes of transport but did not perform a comparative analysis of existing travel alternatives.

Duration of stay at the destination is an important variable to examine (Filimonau et al., 2011b). The literature traditionally encourages longer stay which is considered beneficial in terms of the overall eco-efficiency (Gössling et al., 2005; Peeters et al., 2006; Peeters and Schouten, 2006) because the tourists' carbon impacts at the destination are believed to be low (Gössling et al., 2002). The studies by Becken (2002), Becken et al. (2003) and Chenoweth (2009) have challenged this standpoint in relation to short-haul holiday travel but provided no critical comparative analysis of realistic holidaying scenarios based on different durations of stay. A carbon impact assessment of different travel scenarios to a single tourist destination can contribute to a better understanding of the most and least carbon-efficient travel practices and identify the most feasible carbon mitigation strategies.

Lastly, existing studies have limitations in the accuracy and comprehensiveness of analysis. This is because they account only for the direct, operational GHG emissions, while ignoring the life cycle-related 'indirect', or embodied, carbon footprint arising from the non-operational phases of a product or service life cycle. These stem from industrial processes required to extract raw materials, manufacture tourism products and services and deliver them to the consumer; maintenance and final disposal also contribute to the 'indirect' carbon impacts (Filimonau et al., 2013). The 'indirect' carbon footprint is also embedded in the capital goods and infrastructure used to support industrial processes at different stages of a product or service life cycle and can further be magnified by the breadth and diversity of the tourism supply chain (Frischknecht et al. 2007; Sigala, 2008). For example, driving a car generates the direct GHG emissions. However, the carbon footprint is also produced when a car is manufactured, maintained and disposed of; the GHG emissions are also attributed to the production, maintenance and disposal of road infrastructure and production of petrol. This carbon footprint represents the 'indirect' GHG emissions. There is evidence that the 'indirect' carbon requirements of tourism can be significant (Berners-Lee et al., 2011; Gössling, 2009; Patterson and McDonald, 2004; Rosenblum et al., 2000). Potentially, they can alter the carbon intensities attributable to different holiday travel practices and to the component elements of the holiday (Filimonau et al., 2013; Patterson and McDonald, 2004), thus calling for more accurate and holistic appraisals.

Due to the controversy in the literature, there is a need to clarify the carbon intensity of different elements of short-haul holidays and examine the determinant variables causing variations in the absolute and relative magnitudes of GHG emissions. The focus on short-haul holidays is particularly relevant given that short-distance travel remains the mainstay of tourist demand (UNWTO, 2007), especially in Europe where continued growth in short-haul and domestic trips is projected (McKercher et al., 2010). The paper aims to demonstrate the effect of mode shift and length of stay on the total carbon footprint from short-haul holidays. To this end, it undertakes a critical analysis of realistic travel scenarios for British tourists holidaymaking in Southern France. This destination is purposefully selected as it is popular with Britons and because it can be easily reached from the UK by different means of transportation, most notably by direct rail and coach links, thus enabling a more detailed assessment of the impact of modal switch. While the article looks specifically at the carbon footprint of British holiday-makers in Southern France, it is argued that the analysis can be generalized and used to better understand the carbon intensity of short-haul tourism in other West and North European countries (for example, Germany, the Netherlands, Denmark, Sweden). This is primarily because the travel patterns of Britons are similar to other nations in Western and Northern Europe who also tend to fly or drive to the destination (see, for example, Susilo and Stead, 2009). The study develops a holistic estimate of the carbon footprint as it applies a new appraisal method which incorporates the advantages of existing carbon impact assessment techniques in tourism and accounts for both direct and 'indirect', life cycle-related GHG emissions. The paper identifies whether the inclusion of 'indirect' carbon footprint impacts on the absolute and relative magnitudes of GHG emissions from a short-haul holiday tour and its specific elements.

The outcome of this study will be of value to those developing guidelines for tourists and tourism organizations to enable more informed decisions about the carbon implications of holidays. Decision-makers can employ results of this study to develop policies directed to encourage more carbon-friendly holiday alternatives among British tourists. The study complements the bulk of the tourism literature previously published in Journal of Cleaner Production by discoursing upon environmental sustainability of travel to a popular European holiday destination. It highlights the most and least carbon-intense travel scenarios and reveals the share of the 'indirect' GHG emissions attributed to the non-operational stages of tourism products' life cycle. The 'indirect' carbon impacts are traditionally excluded from carbon footprint assessments of tourism; hence, the contribution of this study.

2. Research object and carbon footprint assessment methodology

The research object was short-haul tourism. There is no clear categorization of 'short-haul' travel distance in the literature. The definitions vary depending on transport mode and geography. The traditional approach is to consider short-haul distance from the standpoint of air travel (Peeters and Schouten, 2006). To this end, the UK Department for Environment, Food and Rural Affairs (DEFRA, 2009) refers to short-haul flights as those which are typically up to 3700 km in length. This is in broad agreement with the definition proposed by Jardine (2005) who classifies short-haul flights as those less than 3500 km. In contrast, the definition of short-haul air travel adopted in North America suggests a travel distance of around 500 km. For example, the World Resources Institute (WRI) classifies short-haul flights as those of less than 452 km in length (Clean Air Conservancy, 2010). These figures correspond to the definition of regional or domestic flights when applied in the European context (DEFRA, 2010). Other definitions include The Clear Sky Climate Solutions (2008) who categorize the

short-haul flying distance as equal to 900 km. The distance of 1108 km is often used as an estimate for short-haul flights by the UK's Civil Aviation Authority (DEFRA, 2010). The European Environment Agency (EEA) (EEA, 2007) and Peeters and Schouten (2006) argue that short-haul flights have the maximum distance of 1850–2000 km. Therefore definitions in the literature range between 452 and 3700 km. So-called 'extremely short-haul' flights, i.e. less than 800 km in length, represent a small share of the total air travel market (Matheys et al., 2008) but make a profound carbon impact per 'passenger km' due to the substantial energy requirements and GHG emissions associated with take-off and landing and the use of relatively small aircraft (Egli, 1996 cited Gössling, 2000; Jardine, 2005) but are little used for inclusive tours due to high unit costs of using small planes. Hence, short-haul holiday tours based on destinations located 800–2000 km from the UK are deemed to be the most valid objects for analysis.

2.1. Selection of a suitable short-haul destination for the case study

To identify a suitable destination for analysis, two circles of 800 km and 2000 km in radius were drawn on Google Maps around London using a dedicated free online utility (GPS Visualizer, 2011). Analysis of geographical information provided by the produced map shows that Portugal, Spain, Southern France, Italy, some countries of Central and Eastern Europe and North Africa fall within this definition of a short-haul travel destination. However, of all these international destinations France attracts both the largest number and the share of visitors who arrive by alternative modes of transport to air (Eurostat, 2012). Northern Africa can only be reached from the UK by air and travelling by overland means of transport to Eastern and Central Europe, Italy, Spain and Portugal is not popular with British holidaymakers due to travel time and often inconvenient rail schedules. In contrast, Southern France is the most easily accessible of these destinations from the UK by overland means of transportation, especially by frequent high-speed trains (Eurostat, 2012). In addition, France in general, and Southern France (Provence) in particular, is one of the most popular holiday destinations with British tourists in Europe (Table 1); hence, it is the most appropriate destination for a comparative analysis of the impact of changes in the mode of transport on the GHG emissions associated with a short haul holiday.

2.1.1. Travel scenarios under review

The travel scenarios considered in this study are presented in Fig. 1. These are limited to the most feasible travel alternatives for British tourists holidaying in Southern France. Greater London is the departure/arrival point in the UK for overland transport and London Gatwick Airport is for air travel. London Gatwick Airport is selected because it is the largest airport in the UK for leisure travel (Pels et al., 2009). It is assumed that all surface modes of transportation cross the English Channel by Eurotunnel. Holiday scenarios are based on a family of three (two parents and one child).

Table 1
Top-10 European destinations for visits by Britons in 2010.

№	Country	Number of visits, million	% of visits (of the total to the Top-10 destinations)
1	Spain	10,534	30
2	*France*	*9041*	*26*
3	Ireland	2904	8
4	Italy	2251	6
5	Germany	2080	6
6	Portugal	1905	5
7	Turkey	1802	5
8	The Netherlands	1751	5
9	Greece	1676	5
10	Belgium	1373	4

Source: Office for National Statistics (2010a)

The system boundary for the reviewed holiday tours contains all holiday travel elements starting with the departure of tourists from home to their return, i.e. following the 'door-to-door' approach (De Camillis et al., 2010) (Fig. 2). The preparatory and 'after trip' elements are not considered as their contribution to the total GHG emissions from holidays is deemed to be negligible.

Holidaymakers are assumed to stay in a hotel in Marseille where a large number of holiday resorts are located (Association of British Travel Organisers to France – ABTOF, 2011). Marseille is also selected due to a good availability of travel alternatives, such as air and train. The duration of stay equal to 7 nights was taken as a basic modelling scenario. This number represents the average duration of holidays undertaken by British tourists in France in 2009 (Office for National Statistics, 2010b). To test how a longer stay at the destination alters the total carbon footprint from holiday travel and the relative carbon intensity of its specific elements, a duration of stay equal to 14 nights was also considered. This longer duration of stay is representative of the holidays undertaken by Britons in Mediterranean destinations (Office for National Statistics, 2010b).

Scenario 1: Travel by car.

A number of studies looked into the use of car as a means of transportation for the purpose of tourism in Europe (Dolnicar et al., 2010). There is evidence that car represents a preferred mode of travel to short-haul international destinations for many German, Dutch and Swiss tourists (Bieger and Laesser, 2005; Bohler et al., 2006). While no research into the transport mode preferences of Britons travelling on holiday abroad was identified, the literature suggests that British, German and Dutch holidaymakers often demonstrate similar travel patterns and preferences (Hamilton et al., 2005). Hence, it is argued that travelling to Southern France by car represents a realistic holidaying option for Britons.

The major benefit of travelling to Southern France from the UK by car is the flexibility in choosing the itinerary and places visited en-route. The scenario considered in this review is based on the shortest driving distance from London to Marseille and assumes tourists reach their ultimate destination in the shortest possible time. The shortcoming of this approach is that tourists might use the flexibility of car travel to stop and explore attractions en-route which would result in longer distances driven. Google Maps (2011) calculate the one-way travel distance from London to Marseille as 1236 km; the overall trip duration is estimated as 12.5 h. Since it is unlikely to cover this distance by car in one go, the scenario suggests one en-route overnight stop in the Paris region. It is also assumed that tourists stay overnight in Paris on the way back to the UK. This intermediate stop then divides the journey into two parts: London–Paris (460 km, approximately 5.5 h of driving) and Paris–Marseille (776 km, 7 h). It is acknowledged that this scenario is subjective and that the real-life situation can be different, depending on travel preferences of holidaymakers. This notwithstanding, for a better comparative analysis, similar scenario settings will be applied to the analysis of coach journey.

Scenario 2: Travel by rail.

Travelling to Southern France from the UK by train is less flexible than travelling by car as holidaymakers are bound to train schedules. This notwithstanding, it is fairly easy to get from London to Marseille by rail due to the frequently operated Eurostar services and high-speed trains in France (for detailed schedules, see Rail Europe, 2011). The shortest one-way distance equates to 1134 km (Distance Calculator, 2011; Google Maps, 2011); the journey lasts approximately 7–8 h and can therefore be made within a single day.

Scenario 3: Travel by coach.

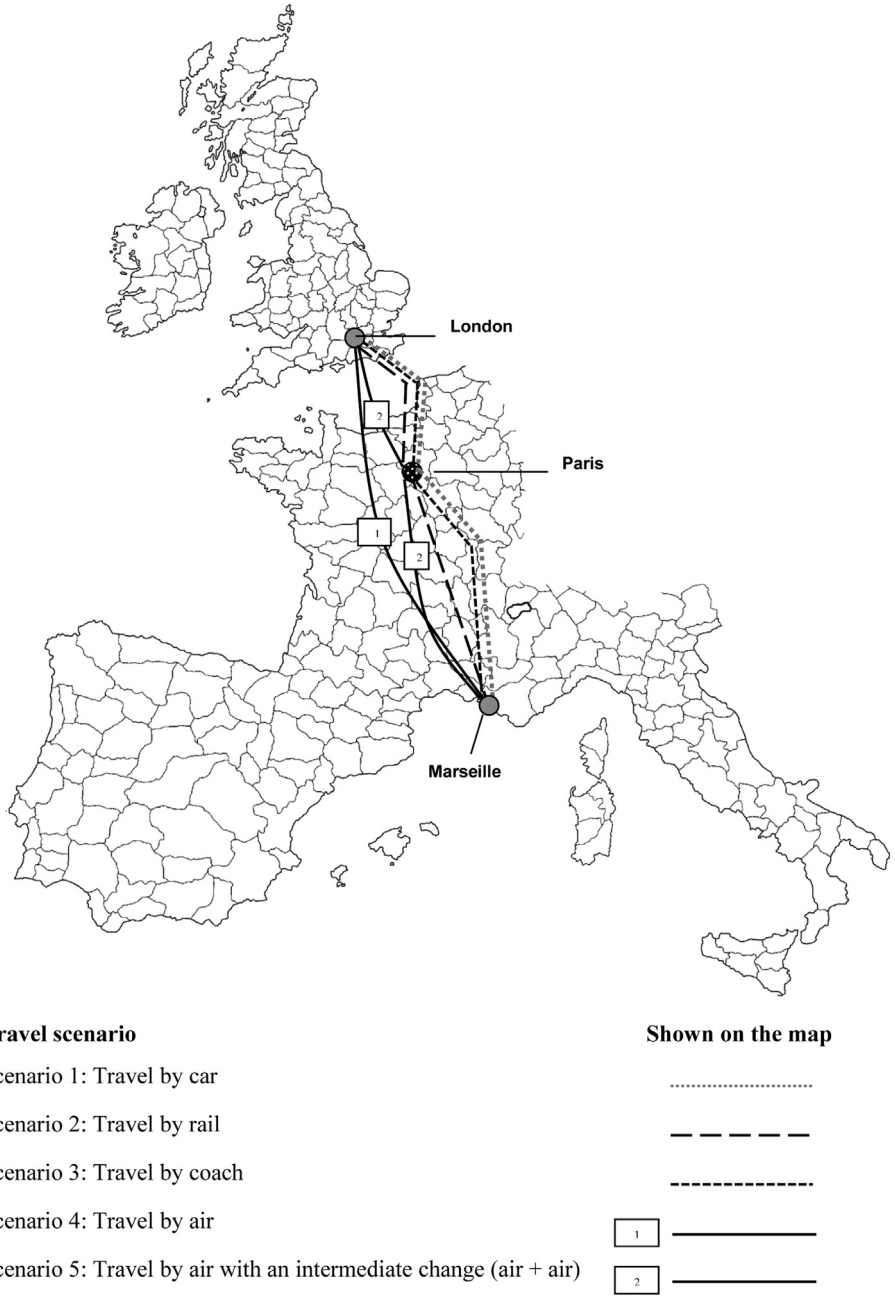


Fig. 1. Travel scenarios for holidaymaking by Britons in Southern France (schematic and not to scale).

Travelling to Southern France from the UK by coach is most feasible in organized groups and by a pre-booked coach; see, for example, Travel 55 (2010) for some existing holidaymaking options in Provence. As for independent travel, although the Eurolines coach group provides regular scheduled coach services from London to Paris (for detailed schedules, see Eurolines, 2011), there are limited opportunities for coach travel from Paris to Marseille. Hence, this scenario assumes that the journey is made by an organised coach with two overnight stays in the Paris region. The one-way driving distance from London to Marseille is identical to the car scenario and equates to 1236 km (Google Maps, 2011).

Scenario 4: Travel by air.

There are a number of direct daily scheduled flights from London Gatwick airport to Marseille Provence airport operated by Ryanair, EasyJet and British Airways. The one-way flying distance is 960 km (Air Routing International, 2011). The carbon footprint from destination travel to and from the airport in Southern France is not estimated due to data availability and because its contribution to the total GHG emissions from holidays is deemed to be small. As tourists are assumed to live in Greater London, the same argument is applied to airport transportation in the UK. Importantly, the estimates of GHG emissions from air travel produced in this study do not include the radiative forcing (RF) effect (see, for example, Grassl and Brockhagen, 2007 for more details). The science behind the RF effect is uncertain (Berners-Lee et al., 2011), and as yet no agreement exists in the literature on the magnitude of RF multiplying coefficient (Forster et al., 2006) with estimates ranging from 1.9 to 4.7 (Grassl and Brockhagen, 2007). It is therefore argued that the RF effect should only be used for a sensitivity analysis, rather than be included in carbon footprint assessments of tourism by default.

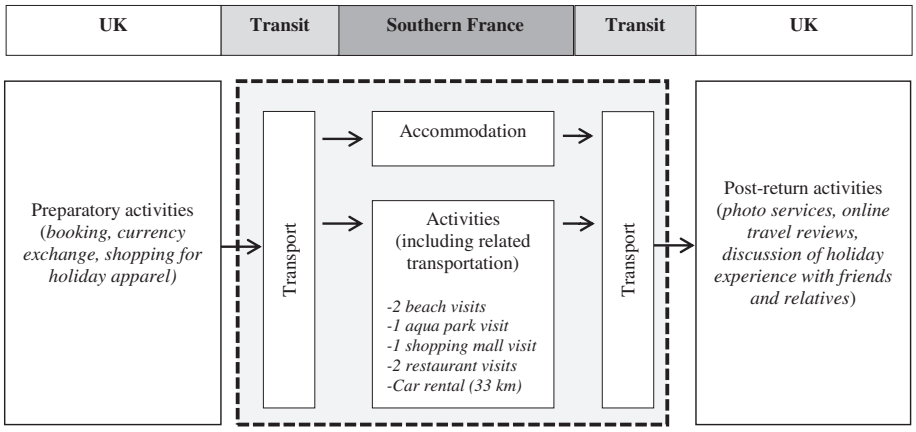


Fig. 2. System boundary for carbon footprint assessment of holidaying in Southern France.

Scenario 5: Travel by air with an intermediate change (air + air).

This scenario considers travelling to Southern France by air with an intermediate change in Paris. The one-way flying distance is 960 km (Air Routing International, 2011) where the itinerary London–Paris is 307 km and Paris–Marseille – 653 km. While it is arguably not the most popular holidaymaking scenario, it is included in analysis to demonstrate the carbon intensity of air travel interchange. It can be relevant, for example, for holiday journeys from Scotland to continental Europe where no direct flights to the destination exist. Large amounts of GHG emissions are envisaged from this scenario as it involves two flights with consequent significant carbon footprint associated with two take-off and two landing cycles. Moreover, the itinerary London–Paris falls into the category of 'regional' flights which are traditionally more carbon intense than any other flights (Jardine, 2005; Koroneos et al., 2005). Another reason for considering this scenario is to better understand the role of airline hubs in the total carbon footprint from flying. This is because flying to the destination may often involve transferring tourists in a hub which implies additional GHG emissions due to take-off and landing.

There are various 'combined' scenarios which could have also been used for analysis in this study. For example, train from London to Paris and then coach to Marseille, coach from London to Paris and then train to Marseille, train or coach from London to Paris and then plane to Marseille, or plane from London to Paris and then train to Marseille. However, these are excluded from analysis as it is argued that such travel scenarios, though theoretically possible, are less popular in reality due to potential cost, time and personal comfort concerns.

2.2. Carbon footprint assessment method

Although the necessity to produce reliable estimates of the contribution made by different tourism products and services to the global GHG emissions has been repeatedly emphasized (Cole and Sinclair, 2002; Gössling et al., 2005; Patterson and McDonald, 2004), the literature acknowledges the immaturity of existing techniques for carbon impact assessment of holiday travel (Berners-Lee et al., 2011; Bode et al., 2003). The available methods are small in number and have significant shortcomings which affect the accuracy of appraisals (Filimonau et al., 2011b; Schianetz et al., 2007). The need to advance existing and to develop new, more rigorous approaches to carbon footprint appraisal in tourism is well recognized (Berners-Lee et al., 2011; Collins et al., 2009; Schianetz et al., 2007). The primary drawback of existing methods for carbon impact assessment in tourism is their inability to produce comprehensive estimates of GHG emissions, accounting for both the direct, or operational, and the 'indirect', or embodied, life cycle-related carbon footprints. Empirical studies have shown that the magnitude of the hidden 'indirect' GHG emissions from tourism can be significant (Filimonau et al., 2013; Patterson and McDonald, 2004; Rosenblum et al., 2000). This emphasizes the necessity to integrate the 'indirect' carbon impacts into existing assessments, thus making them more accurate and truly holistic.

Efforts have begun to address the need for more rigorous carbon footprint appraisal in tourism. The GHG conversion factors produced by DEFRA, which can be employed to estimate the carbon intensity of tourism products and services, are now capable of assessing the 'indirect' GHG emissions embodied in the fuel chain (DEFRA, 2010). Despite this significant methodological improvement, the method by DEFRA is currently unable to address another important dimension of the 'indirect' carbon footprint, the GHG emissions embodied in the non-fuel chain-related capital goods and infrastructure. In the case of coach travel, for instance, these arise from the industrial processes required to extract, transport and refine the raw materials, manufacture a coach, deliver it to a final user and dispose of it (Filimonau et al., 2013; Frischknecht et al., 2007). This 'indirect' carbon footprint also stems from the renovation, refurbishment and maintenance processes and can be significantly magnified by the tourism supply chain industries (Frischknecht et al., 2007; Patterson and McDonald, 2004; Rosenblum et al., 2000). The contribution of the capital goods and infrastructure to the total carbon impact from tourism products and services can be large (Frischknecht et al., 2007; Potter, 2003 cited Chapman, 2007; Spielmann et al., 2008). The estimates of the 'indirect' carbon footprint produced by DEFRA are therefore incomplete.

The 'indirect' GHG emissions from the capital goods and infrastructure can be appraised by the Life Cycle Assessment (LCA) method, a well-recognized technique for evaluating the environmental impacts from individual products or services throughout their life cycle (Patterson and McDonald, 2004). LCA is acknowledged as the most holistic approach to impact assessment in different industries (Arena and De Rosa, 2003; Frischknecht and Rebitzer, 2005; Junnila, 2004; Ness et al., 2007). Its appraisal methodology has been approved by the International Organisation for Standardization (ISO) and is now reflected in ISO 14040 series of standards (ISO, 2006). Recently, the scope of LCA application has been extended to tourism (Berners-Lee et al., 2011; De Camillis et al., 2010; Filimonau et al., 2011a; Patterson and McDonald, 2004) although the studies are still limited in number and geography (Schianetz et al., 2007).

Despite the comprehensiveness of analysis, the LCA technique has a number of functional limitations and methodological

inconsistencies which hamper the accuracy of its estimates. LCA makes assessments of GHG emissions on the basis of extensive life cycle inventories (Koroneos et al., 2005), such as the Ecoinvent database (Frischknecht and Rebitzer, 2005), produced by specialized research groups for a broad range of products and services. The content of the Ecoinvent database enables inclusion or exclusion of the 'indirect', capital goods and infrastructure-related, carbon impacts from analysis (Frischknecht et al., 2007). Although the Ecoinvent database can provide a valuable insight into the life cycle GHG emissions from products and services, it suffers from irregular updates. Furthermore, the background information on how the appraisals are made is often missing. This hampers a critical independent review of the calculation assumptions employed in the LCA estimates (Filimonau et al., 2013). Lastly, the LCA method employs the definition of short-haul flights which follows the North American classification (see Section 2). This entails overestimation of the actual carbon impacts when the LCA technique is applied to short-haul intra-European flights appraised on a 'per passenger km' basis. In contrast, the method deployed by DEFRA follows the European categorization of short-haul flights, is annually updated to account for the latest advancements in energy and fuel technologies and provides free public access to the background data and assumptions employed.

Given that the GHG conversion factors from DEFRA have a number of critical advantages over the method by LCA, Filimonau et al. (2013) argue that they are more suitable for carbon impact assessment in tourism in terms of the overall accuracy of estimates of the direct carbon footprint and cost-effectiveness. However, in order to obtain the most *holistic* appraisals of carbon impacts, they need to be supplemented with the estimates of the 'indirect' GHG emissions embodied in the tourism capital goods and infrastructure. These can be extracted from the Ecoinvent database. The resultant hybrid values of carbon intensity represent the most accurate and holistic estimates of the carbon footprint currently available. Filimonau et al. (2013) and Norwegian household carbon calculator (2010) refer to this method of carbon impact assessment as a hybrid, DEFRA-LCA (Ecoinvent) approach. The hybrid method is applied for analysis in this study in order to achieve the highest accuracy of estimates and to demonstrate the share of the 'indirect' carbon footprint in the total GHG emissions from different holiday travel scenarios to Southern France.

2.2.1. The carbon intensity of different elements of holiday travel to Southern France

To assess the magnitude of the carbon footprint attributed to different holiday travel scenarios to Southern France, the carbon intensity coefficients were derived. In the case of transport these comprised of both direct and 'indirect' GHG emissions obtained from the database of GHG conversion factors developed by DEFRA (operational carbon footprint + fuel production-related GHG emissions) and further supplemented with the data from the LCA database Ecoinvent (Table 2). Ecoinvent provided estimates of the 'indirect' GHG emissions attributed to the 1) non-operational stages of vehicle lifecycle and 2) manufacture, transportation, installation, maintenance and disposal of transport infrastructure.

To appraise the carbon intensity of the hotel stay at the destination and en-route, the GHG emission coefficients for tourist accommodation were derived from the literature as direct measurements of energy consumption in hotels in Southern France and Paris region were not feasible. The value of 9.7 kg of CO_2-eq. per guest night (where 2.4 kg of CO_2-eq. are the 'indirect' GHG emissions) was estimated by Filimonau et al. (2013) for the hotel stay in a modern seaside resort in Portugal. As Southern France is a similar Mediterranean sun-and-sand destination, it is argued that the carbon intensity of tourist accommodation is similar to Portugal. This figure is lower than the estimates of carbon intensity of the hotel stay found in other studies (see, for example, Carbon Neutral Company, 2008 cited Chenoweth, 2009; Chan and Lam, 2002; Gössling, 2002), where the values ranging from 14 to 33 kg of CO_2-eq. per guest night were reported (Filimonau et al., 2011a). However, many of these studies focused on the hotels located in the UK and Hong Kong; hence, their estimates need to be taken with caution when applied to other geographies. The carbon intensity of the hotel stay in France is lower than in the UK and Hong Kong due to the larger share of nuclear power in the national energy balance. It is therefore argued that the lower value of 9.7 kg of CO_2-eq. per guest night as estimated by Filimonau et al. (2013) is more suitable for this study. It is also acknowledged that the estimate of the GHG emissions from the hotel stay utilized in this research represents the lower range of the possible carbon footprint range attributable to tourist accommodation.

The literature acknowledges that carbon impact assessment of tourist activities is difficult (Becken and Simmons, 2002), mainly due to their diversity and issues with data collection, systematization and further generalization (Acott et al., 1998). Concurrently, the share of tourist activities in the total carbon footprint from tourism is estimated as minor, 3–5% (UNWTO, 2007). As direct measurements of the GHG emissions from tourist activities in Southern France were not feasible, the study employed the figures retrieved from the literature. This approach is justified given the small carbon contribution of tourist activities in comparison to other elements of holiday travel.

Filimonau et al. (2013) suggest that the average carbon intensity of tourist activities undertaken by holidaymakers during the 7-

Table 2
The carbon intensity factors for transport employed for assessment of different holiday travel scenarios to Southern France, hybrid DEFRA-LCA approach, kg CO_2-eq.

Mode of transport	Unit of measurement	Direct and fuel chain-related 'indirect' GHG emissions estimated by DEFRA	Capital goods and infrastructure-related 'indirect' GHG emissions estimated by LCA (Ecoinvent)	Total GHG emissions, hybrid DEFRA-LCA approach
Transport to/from the destination				
Passenger car (petrol)[a]	Passenger km	0.083	0.019	0.102
Train[b]		0.017[c]	0.0065[d]	0.0235
Coach[e]		0.0276	0.0036	0.0312
Air travel within Europe[f]		0.12	0.03	0.15

[a] Assuming occupancy of 75% and the maximum load factor of 4.
[b] Assuming the 'average occupancy typical of train journeys by Eurostar' (DEFRA, 2010); more precise value is not available.
[c] 'International passenger rail' category.
[d] 'Long distance train' category.
[e] Assuming occupancy of 75% and the maximum load factor of 49.
[f] Assuming occupancy of 80% and the maximum load factor of 176.

night stay in a seaside resort in Portugal equates to 16.9 kg of CO_2-eq. This value represents the average amount of GHG emissions attributed to the tourist activities undertaken by 43 holidaymakers who were interviewed during their stay. The interviews were conducted in the end of August 2010 among the group of British tourists. To ensure that the 'actual', rather than the 'envisaged' consumption of tourist activities would be reported, tourists leaving the resort and waiting for airport transfers in the resort lobby on the day of departure were approached. Only one travel party member was invited to partake to enhance the representativeness of the interview sample. Tourists provided information on the number and type of tourist activities they undertook which were further converted into GHG emissions by using carbon intensity coefficients, extracted from the literature and attributed to each tourist activity type. On average each tourist undertook: 2 beach visits, 1 holiday park visit, 1 shopping trip and 2 restaurant visits. Although this qualitative sample is small in size, it does offer a comprehensive review of tourist activities over the whole stay and provides a general illustration of the typical activities undertaken by tourists. The estimate also accounted for the carbon footprint produced as a result of travel related to tourist activities, namely 33 km driven by hired car, 35 km by coach, 21 km by bus and 14 km by taxi. Concurrently, Gössling et al. (2005) argue that 40 kg of CO_2 can be served as a well-approximated measure of the carbon intensity of tourist activities. However, this latter estimate has a number of limitations. First, it is unclear how the number was obtained and what duration of stay it was based upon. Second, it represents a geographical region with less similar climatic conditions to Southern France. Hence, the figure from Filimonau et al. (2013) is more suitable for this research.

Importantly, the carbon footprint appraisal of tourist activities conducted in this study cannot be considered holistic. First, the holiday trip to Southern France includes two overnight en-route stays in some travel scenarios. Tourist activities undertaken en-route may enhance the carbon intensity of tourist activities reviewed in this study. Second, unlike tourist transport and accommodation, the estimates of the carbon intensity attributed to tourist activities did not take into account the 'indirect' GHG emissions stemming from the fuel chain and capital goods and infrastructure. As the relative contribution of tourist activities to the total carbon footprint from holiday travel is low, the exclusion of their 'indirect' carbon footprint should not make a noticeable effect on the assessment results.

3. Results and discussion

A comparative analysis demonstrates that, under the specified travel settings, going on holiday to Southern France by train or coach are the most carbon-efficient travel options (Fig. 3). They produce less than half of the GHG emissions from car and air travel. This is in line with findings from Becken (2001), Brand and Boardman (2008) and Zachariadis and Kouvaritakis (2003) who all identified trains and coaches as having from low to medium energy and carbon intensities compared to other transportation modes. Among these, rail is the least carbon intense scenario in the case study under review. Given that travelling from London to Marseille by train is fairly comfortable, quick and can attract some tourists by the visit to Paris, it is argued that train is the most viable sustainable alternative to other means of transport for holidaymaking by Britons in Southern France. Travel by coach is another carbon-efficient option which can be a feasible alternative if made in organised groups or for environment-aware tourists with limited budgets.

Fig. 3 shows that the air travel-based holidays in Southern France generate the largest carbon impacts, especially when

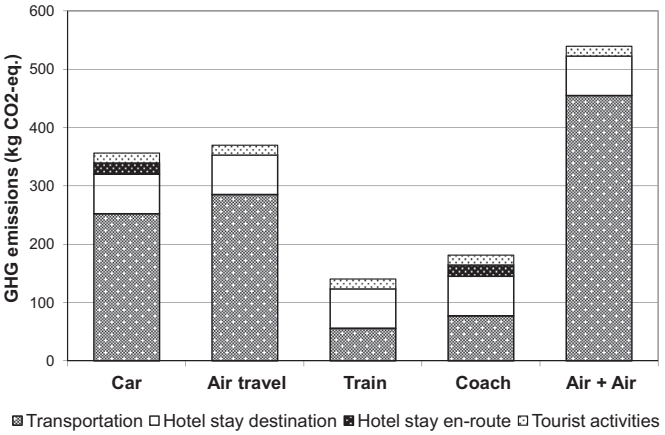


Fig. 3. The carbon footprint from different holiday travel scenarios to Southern France, per tourist (7 nights).

air + air scenario is considered. This finding is in line with existing knowledge that flying is the most carbon intense means of travel (Becken, 2001; Hanandeh, 2013; Peeters et al., 2006). Importantly, the GHG emissions from the air-based scenario (with no intermediate change) are only circa 15 kg of CO_2-eq. (about 4%) higher than the carbon footprint from the car scenario. The high carbon intensity of the car-based tours is an interesting finding, especially given that such a significant amount of GHG emissions is produced by car journeys with a high ($n = 3$) occupancy. Long distances driven by car are deemed to be the primary reason.

When the relative carbon footprint from holiday travel elements is analysed, the estimates suggest that transport holds the dominant share only in the car and air travel-based scenarios, i.e. 71% and 77% (84% in the case of the air + air scenario), respectively. In the coach scenario its contribution drops to 43%, while the role of the transport element in the rail scenario is only 40%. This is in agreement with Peeters et al. (2006) and Chenoweth (2009) who reported similar patterns. This finding suggests that, tourists willing to cut the GHG emissions from short-haul holidays will achieve the most significant carbon savings with a modal shift from air and car travel. The positive effect of this solution will be high, even if no carbon mitigation measures are applied at the destination, but it is subject to the feasibility of the surface transport alternatives.

The role played by airline hubs in the carbon footprint from holiday travel is significant. Transferring tourists in a hub almost doubles the GHG emissions from transportation to/from the destination if compared to a single, direct flight. This suggests that tour operators should avoid travel interchanges in airline hubs when designing holiday tours with low carbon footprint.

Fig. 4 shows how the relative share of the transport element in the total GHG emissions from holidaying in Southern France falls when 'a longer duration of stay at the destination' scenario is applied. If tourists stay at the destination for 14 nights, transportation contributes 65% (75%), 59%, 31% and 27% to the air travel (air + air scenario), car, coach and rail-based scenarios, respectively. The values will further reduce, should more activities be undertaken by tourists at the destination and/or intermediate hotel stays be organised en-route. First, Fig. 4 does not assume that tourists staying at the destination longer may take part in activities more often or undertake a range of activities with greater carbon footprints. Becken (2008) argues that tourists staying at the destination longer have a tendency not only to partake in tourist activities more often, but also to undertake tourist activities with larger carbon intensities. Likewise, Filimonau et al. (2013) finds that tourists

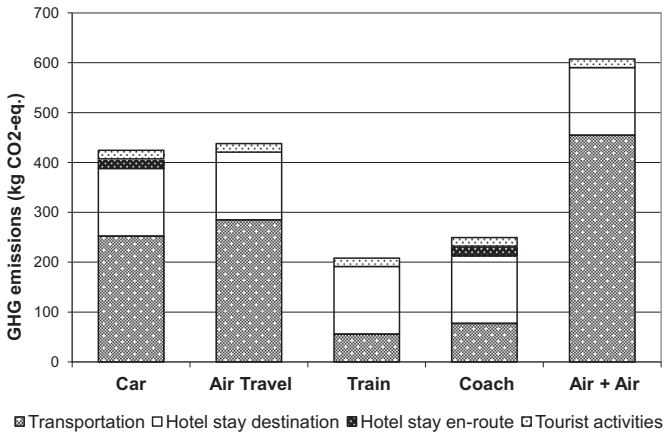


Fig. 4. The carbon footprint from different holiday travel scenarios to Southern France, per tourist (14 nights).

begin to engage in more energy-intense activities with a longer duration of stay. This argument is particularly valid when considering a 'travel by car' scenario for tourists staying at the destination for 14 nights. Given the flexibility of this travel option and long duration of stay, holidaymakers might use a car to explore the surroundings in Southern France. This would enhance the carbon intensity of the destination-based elements of holiday travel. Second, existing holiday tours to Southern France often incorporate additional overnight stays and excursions in the Champagne region; see Travel 55 (2010) for more details.

The findings demonstrate that, under certain travel scenarios and holidaymaking settings, the traditional standpoint which considers transport to/from the destination as a primary contributor to the total GHG emissions from holidays can be questioned. The non-transit elements of holiday travel can have a significant share in the total carbon footprint from short-haul holidays, especially when tourists travel to the destination by overland public transport. They should not therefore be ignored in the GHG emission assessments of holiday travel and need to be considered when developing and evaluating the carbon impact mitigation measures for holiday packages. Tour operators may impose additional carbon-related requirements on hotels, thus encouraging hoteliers to adapt carbon mitigation measures and build holiday tours around eco-certified accommodation facilities and/or demand external carbon performance appraisals from their contractors.

When the estimates of GHG emissions are made on a 'daily' basis, the analysis suggests that a longer stay in Southern France reduces the daily carbon intensity of the holiday (Table 3). The magnitude of reduction varies depending on the method of transportation to/from the destination. The daily carbon intensity of the longer stay is circa 70–80% less than of the shorter stay for such transport modes as air travel and car. For surface public means of transportation the discrepancy is less significant, 40–45%. This finding is in broad agreement with the literature which considers a longer stay at the destination more beneficial in the eco-efficiency terms if the estimates are made on a daily basis (Gössling et al., 2005; Peeters et al., 2006).

Lastly, Fig. 5 demonstrates that the 'indirect' GHG emissions make a profound contribution to the total carbon footprint from holiday travel to Southern France. The air travel and car scenarios are characterized by the largest 'indirect' carbon shares of circa 27–30%, while the other scenarios demonstrate lower, but yet significant, values of 22–25%. Most of the 'indirect' GHG emissions are attributed to the transportation element. The largest contribution of the 'indirect' GHG emissions *within the transportation element* of holiday travel was established for rail (about 40%), while the lowest – for coach travel (approximately 25%). This is in broad agreement with Spielmann et al. (2008) who found that the largest share of the 'indirect' GHG emissions is typically attributed to train (with the magnitude of up to 60% of the total carbon footprint) while the lowest (up to 20%) – to coach and bus travel. This finding has important implications for transport and environmental policy-makers. While rail is commonly considered as the most carbon-efficient transportation option, the holistic analysis of its carbon impacts shows that its advantage is reduced marginally when the 'indirect' carbon requirements are taken into account. All this emphasizes the necessity to include the estimates of the 'indirect' GHG emissions into carbon footprint assessments of tourism in general and holiday packages in particular. This finding complements existing literature which argues for broader application of the LCA method, capable of providing a valuable insight into the 'indirect' carbon requirements, to specific tourism companies, travel itineraries and tourism products (Kuo and Chen, 2009).

The findings have important implications for the emerging concept of slow travel. Within Europe, slow travel is largely conceptualized as a form of tourist travel that encourages holidaymakers to travel to destinations more slowly overland, stay longer and generally travel less (Dickinson et al., 2010). It implies a greater engagement with the transport element of tourism and with the places visited en-route. Slow travel avoids air and car journeys and embraces travel by train, coach, bus, bicycle and on foot (Dickinson and Lumsdon, 2010). A slow travel strategy therefore offers a lower carbon tourism option since carbon footprint mitigation strategies should focus primary on reducing air and car travel. On the other hand, this research indirectly demonstrated

Table 3
Estimates of the 'daily' carbon intensity for different scenarios of holidaying in Southern France, kg CO_2-eq. per tourist.

Scenario	Duration of stay at the destination	
	7 nights	14 nights
Car	50.9	30.3
Air	52.8	31.3
Air + air	77.1	43.4
Train	20.1	14.9
Coach	25.9	17.8

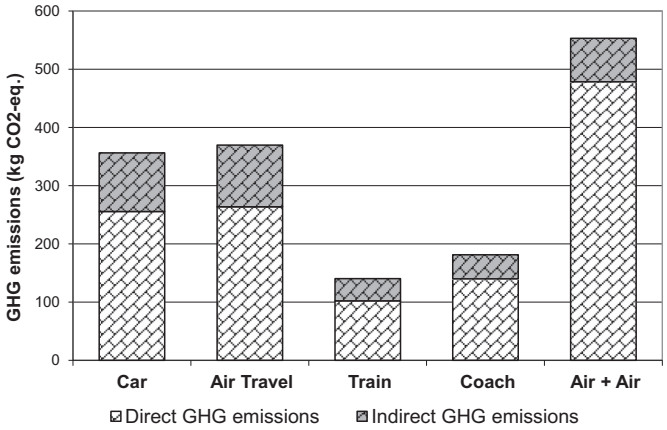


Fig. 5. Direct and 'indirect' carbon footprints from different holiday travel scenarios to Southern France, per tourist (length of stay = 7 nights). The estimates of the 'indirect' GHG emissions for 14 nights of stay in Southern France are not presented. This is because the only difference would be the additional 'indirect' carbon footprint from a longer hotel stay at the destination which equates to about 17 kg of CO_2-eq. for additional 7 nights.

that such variables as the number of overnight hotel stays/travel interchanges, staying in energy-inefficient tourist accommodation and partaking in energy-intense activities en-route may significantly increase the carbon footprint of travel to/from the destination. Therefore, in a slow travel context (i.e. train and coach scenarios), mitigation strategies should focus on accommodation and activity elements as these represent the key carbon challenges. This finding also suggests that a comprehensive analysis of the carbon intensity of different travel scenarios is crucial for designing holiday tours with the smallest carbon impact.

4. Conclusions

The critical analysis of the literature on carbon footprint assessment of tourism indicates that the transport (transit) element of holiday travel is traditionally considered as the primary contributor to its total GHG emissions, while the share of the non-transit, destination-based elements is conventionally accepted as low. A few studies have challenged this standpoint in relation to short-haul holiday travel but provided no consistent, detailed analysis of different travel scenarios to a popular holiday destination. Moreover, the outcome of these studies suffers from the limited comprehensiveness of evaluation failing to account for both the direct, or operational, and the 'indirect', or embodied, carbon footprint. Existing studies from outside of tourism argue this 'indirect' carbon contribution is significant.

This research aimed to rectify these knowledge gaps by applying a critical scenario analysis to different travel alternatives for UK tourists holidaying in Southern France. It demonstrated how the choice of transportation to/from the short-haul holiday destination affects the total carbon footprint from holidays. The results indicate that flying and driving a car are the most carbon-intense means of travel to Southern France, while travelling to the destination by train and coach produce significantly lower amounts of GHG emissions. This suggests that a modal shift in transportation should be the primary measure for carbon footprint reduction in tourism to this destination. The research contributed to better understanding of the role played by airline hubs which suggests that tour operators should avoid travel interchanges in airline hubs when designing holiday tours with low carbon footprint.

The study showed that the non-transit elements of holiday travel can make a noticeable, and even dominant, contribution to the total carbon footprint from short-haul holidays when travelling to/from the destination by public overland transport and staying longer. This finding clashes with the conventional perception of the relative carbon intensity of different elements of holiday travel which can overstate the dominant share of transportation and policy-makers and tour operators should not ignore the non-transit elements of holidays when developing carbon footprint mitigation measures for short-haul holiday tours. Nevertheless, the primary target of carbon footprint mitigation should be reducing air and car travel.

The research showed that the longer stay at the destination will increase the *absolute* amount of GHG emissions from short-haul holiday travel. However, when the carbon footprint from holidays in Southern France is assessed on a daily basis, the estimates demonstrate that the longer stay is more beneficial, thus identifying another carbon impact mitigation opportunity. The shortcoming of this study is however that it did not evaluate the economic impacts imposed by tourists with different durations of stay at the destination which outlines an avenue for further research.

It is argued that the implications of traveller's age, class, family structure and personal interests may play an important role in the carbon intensity of holiday travel as any personal decisions on selection of specific travel modes, types of accommodation and tourist activities during a holiday tour are difficult to predict. This role requires better understanding and this topic represents a promising research avenue to pursue. To produce reliable estimates of GHG emissions from holiday travel in general and tourist activities in particular, accurate and more detailed records of actual tourists' behaviour are necessary. Tour operators can help address this task by working with researchers to compile appropriate data. It is argued that travel diaries and surveys may add the necessary precision and context to the data required for holistic carbon footprint assessments of holiday tours.

The study underlines the role of academia in informing the tourism industry, policy-makers and tourists about the carbon implications of different travel choices. Given that tour operators have the capacity to educate tourists on the carbon impacts of travel, it is important to establish and maintain a constant knowledge transfer between researchers and the tourism industry. Tour operators can promote less carbon-intense travel options among tourists by providing detailed information on the GHG emissions associated with each specific travel scenario; they can also offer discounts to those tourists who opt to take less carbon-intense holidays. Policy-makers should develop a number of clear incentives for tourism businesses who actively engage with their customers in the discourse upon tourism and climate change. In turn, this may encourage tourists to align to more environmentally-responsible behaviour, both when travelling and in daily life activities.

Lastly, this study provided more empirical evidence of the applicability of a new, more advanced method for carbon footprint assessment in tourism. This hybrid, DEFRA-LCA approach incorporates the advantages of existing techniques for carbon impact appraisal and generates more accurate and holistic estimates by accounting for the 'indirect' GHG emissions. The analysis indicated that the 'indirect' carbon requirements play an important role in the total carbon footprint from holidaying in Southern France. These hidden carbon emissions would have been excluded from analysis, should the estimates have been based on conventional methods for carbon impact assessment in tourism which suggests that many of the existing estimates of GHG emissions from holiday travel are likely to underestimate its actual carbon footprint. It also underlines the necessity to account for the 'indirect' carbon requirements of tourism when conducting environmental assessments of its impacts and when developing and appraising prospective carbon footprint mitigation strategies.

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