

## *Original Paper*

# The Tourism Industry in the Island of Crete, Greece: Is It Carbon-Intensive?

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Received: November 21, 2019 Accepted: December 10, 2019 Online Published: December 12, 2019

doi:10.22158/se.v5n1p23

URL: <http://dx.doi.org/10.22158/se.v5n1p23>

### **Abstract**

*Impacts of the tourism industry on climate change are not negligible as indicated in various studies implemented so far. The eco-effectiveness of this industry can be assessed taking into account its carbon emissions combined with the tourism-generated income. The carbon intensity of the tourism industry in the island of Crete, Greece has been compared with the tourism-related carbon intensity in other tourist territories and countries as well as with the corresponding value of the Greek economy. Existing data in published literature have been used for comparison. Various measures resulting in the decrease of the carbon intensity of the tourism industry in Crete have also been examined. It has been found that the tourism-related carbon intensity in Crete is in the same range of values reported in other tourist territories. However, it is higher than the corresponding value of the whole Greek economy. If however the emissions due to international flights of tourists to Crete are excluded from the estimations, the resulting carbon intensity of this industry is significantly lower compared with its initial estimations. It is also lower than the value of the whole Greek economy as well as the required carbon intensity for achieving global sustainability.*

### **Keywords**

*carbon efficiency, carbon intensity, climate change, Crete, Greece, low carbon economy, sustainability, tourism*

### **1. Introduction**

Tourism, like other human activities, utilizes fossil fuels and emits Green House Gases (GHG) into the atmosphere. Global tourism is increasing steadily, following the increase in the global income, while many travelers choose long distance destinations for their vacations, willing to visit new and exotic places. Tourism is considered in developing countries as a low carbon economic activity, which results

in rapid local growth, while in areas without many alternative local resources, tourism development is the most desirable option for local growth, creation of new jobs and increase in the local income. However, the eco-effectiveness of the tourism industry is currently disputed while various studies have indicated that various types of international tourism have undesirable environmental impacts, higher than other economic activities. Aviation is by far the most important sector in the tourism industry regarding GHG emissions. The carbon intensity of the tourism industry can be estimated as the ratio of CO<sub>2</sub> emissions due to tourism to the income generated by this industry. Comparison of the carbon intensity in tourism with the carbon intensity in other economic sectors or the corresponding intensity of the whole economy in a country would indicate the ecological performance and eco-efficiency of tourism.

## 2. Literature Survey

### 2.1 *Tourism and Climate Change*

A report on bunker fuels and the Kyoto protocol has been published (European Federation of Transport and Environment, 2009). The report mentioned that carbon emissions from aviation and marine “bunker” fuels consist of almost 10% of the global emissions, while the Kyoto protocol has assigned responsibility for the reduction of GHG emissions due to bunker fuels to developed countries through the International Civil Aviation Organization and International Maritime Organization. It also stated that the progress made so far for the reduction of bunker fuel’s GHG emissions is not satisfactory. The relation between climate change and sustainable international tourism has been examined (Hall et al., 2013). The authors mentioned that although the positive economic impacts of international tourism are undoubted, its contribution to climate change is significant. They proposed that a reassessment regarding the potential benefits of tourism on sustainable development is needed. A report on low carbon travel and the tourism sector has been published (World Economic Forum, 2009). The measures proposed in the report for decreasing carbon intensity in tourism include: a) Increase of energy efficiency and use of low carbon fuels in aviation and in marine transport, b) Increase in using renewable energies in the accommodation sector, c) Promotion of low carbon transportation in tourist destinations, and d) Integration of international aviation and marine transport in the post-Kyoto climate change agreement. The implications of travelling on sustainable tourism have been investigated (Boley, 2014). The author mentioned that tourism has positive and negative impacts regarding ecological, socio-cultural and economic sustainability. In order to increase tourism benefits, marketing efforts should be targeted towards travelers who are able to maximize benefits within destinations, attracting “responsible tourists” like eco-tourists and environmentally friendly tourists. He also stated that measures should be taken for reducing GHG emissions including: a) Voluntary purchase of carbon credits by tourists offsetting their travelling footprint, b) Assisting tourists to know their carbon footprint before choosing their destination, and c) Promoting slow travel options such as rail travel, bus travel, or bike travel. Aviation’s impacts on atmosphere and climate have been studied (Lee et al., 2010).

The authors stated that climate impacts of aviation are due to its CO<sub>2</sub> emissions, emissions of water vapor, particles and nitrogen oxides (NO<sub>x</sub>). They also mentioned that mitigation of these impacts requires technological breakthroughs and innovation which might delay them. Use of liquid hydrogen produced in a carbon-neutral way is unlikely until the arrival of the “hydrogen economy”. A model for developing low carbon tourism has been presented (Huang et al., 2011). The model was based on the promotion of low carbon attractions for tourists, creation of low carbon tourist facilities and promotion of low carbon tourists’ consumption style. The authors mentioned that promotion of low carbon technologies in tourism include low carbon accommodation buildings, low carbon transport, low carbon equipment, low carbon attractions, low carbon catering, etc. The future of tourism regarding reconciliation of tourism growth and climate change mitigation has been examined (Gössling et al., 2010). The authors mentioned that carbon emissions are anticipated to grow while technology and management improvements will not be sufficient to achieve even moderate emissions reduction. They have pointed out the key role of social and behavioral change for achieving climatically sustainable tourism. The future of tourism mobility regarding emissions growth versus climate policy has been investigated (Dubois et al., 2011). The authors stated that in approaching climate policy targets in tourism, and particularly in tourism transportation, emissions should be reduced by a high percentage, even using carbon trading schemes and carbon offsetting mechanisms. Avoiding dangerous climate change requires shift in the use of current transport modes, reduction in the distances traveled during vacations and the development of new low carbon transport fuels and technologies. Development of tourism towards a low carbon economy has been studied (Yang, 2010). The author mentioned that various measures should be taken in the tourism industry for reducing its impacts on climate change, including: a) Scientific management of tourism destinations following ecological principles, b) Reduction of direct carbon emissions caused by transport, c) Promotion of the development of green hotels, d) Reduction of carbon emissions in tourist activities at the destination, and e) Changing travelers’ behavior to become more climate-friendly. A report on tourism and climate change has been released by the UN World Tourism Organization (2007). In this report, various solutions have been proposed for reducing carbon emissions of the global tourism industry. These measures include: a) Development of more fuel-efficient airplanes, ships and vehicles, b) Promotion of more energy-efficient tourist accommodation, c) Encouragement and sensitization of tourists to reduce their carbon footprint, d) Promotion of alternative fuels in all sectors of the tourism industry, and e) Offsetting carbon emissions with various trading schemes.

## *2.2 Tourism Industry in Crete*

The barriers perceived for investing in the Cretan hotel industry have been studied (Sardianou et al., 2019). The author’s findings indicated that hoteliers perceive economic, institutional and human-related barriers in investing in RES. These barriers include organizational issues, lack of funds and the high initial cost of renewable energy investments. Additionally, hotel owners have limited access to appropriate information regarding the benefits and drawbacks of these benign energy technologies. A

study on the tourism industry in Crete has been reported (Angelakis, 2018). The author mentioned that over 5 mil tourists arrive annually in Crete while approximately 2 mil. of them arrive in Western Crete. He also stated that the share of the tourism sector in the Gross Domestic Product (GDP) of the island was very high at 47%. A report regarding regional policies for the development of tourism in the Region of Crete has been published (BRANDTOUR project, Region of Crete, 2017). The report stated that in 2016, 3,938,580 passengers arrived by air with international flights in Crete while 963,614 passengers arrived by sea. Data regarding the tourism industry in Greece during 2018 have been published, (Greek Statistics Organization, 2018). The report mentioned that in the island of Crete, during this year, 23,609,000 overnight stays of foreign tourists and 907,000 of domestic tourists had been recorded. Estimation of carbon emissions due to the tourism industry in the island of Crete, Greece has been reported (Vourdoubas, 2019). The author estimated the carbon emissions at 428.77 KgCO<sub>2</sub> per trip while the share of transportation in the total carbon emissions was at 80.69%, slightly higher than the value reported by UNWDO at 75%. Mitigation and compensation options of carbon emissions due to international tourism in Crete, Greece have been studied (Vourdoubas, 2019). The author estimated that annual compensation with carbon credits of all tourism-related emissions in Crete, including aviation emissions, will cost €20.53 mil., corresponding to 0.51% of the total annual income of the tourism industry in the island. He also estimated the carbon intensity of the tourism industry in Crete at 0.562 KgCO<sub>2</sub>/€, and excluding transport emissions at 0.108 KgCO<sub>2</sub>/€.

### *2.3 Carbon Offsetting and Impacts of Carbon Taxes on Tourism*

The impacts of a carbon tax on international tourism have been investigated (Tol, 2007). The author stated that the effect of the tax on travel behavior is small. A global tax of \$1,000/tC would change travel behavior and reduce carbon emissions from international aviation by 0.8%. He mentioned that a carbon tax on aviation fuel would particularly affect long-haul and short-haul flights while medium distance flights would be affected least. A study on the impacts of a carbon tax in the tourism industry in Australia has been presented (Tourism and Transport Forum, 2011). The report mentioned that a carbon tax will have severe impacts on the travel and tourism industry, resulting also in significant job losses. For a carbon tax at 25\$ per tCO<sub>2</sub>, the study calculated a loss in total revenues in tourism-related enterprises at 0.7-1.2% while the reduction in net profits would be up to 10%. The attitude of Swedish air travelers to voluntarily offset their carbon emissions due to their flights has been investigated (Gössling et al., 2009). Various tourist agencies and traveling companies are offering various offsetting schemes. However, the authors mentioned that only a small percentage of tourists are willing to offset their carbon footprint of their vacations. A study on the attitudes of air travelers in Australia and in the UK to voluntarily offset their carbon emissions has been reported (Mair, 2011). The author reported that only air travelers who are environmentally sensitized and conscious about climate change purchase voluntary carbon-offsetting credits.

#### 2.4 Carbon Intensity of Tourism Industry

The GHG intensity of the tourism sector in Switzerland has been investigated (Perch-Nielsen et al., 2010). The authors stated that the tourism sector in the country is more than four times more GHG-intensive than the Swiss economy, while air transport has a share of approximately 80% on the total tourism-based GHG emissions. They also estimated the GHG intensity of the Swiss tourism industry at 0.530 KgCO<sub>2</sub>/€. Additionally, they presented the carbon intensity of tourism in other countries as well as for their whole economies. Estimation of the carbon footprint of global tourism between 2009 and 2013 has been made (Lenzen et al., 2018). The authors mentioned that the GHG intensity of global tourism was 1.8 KgCO<sub>2</sub>/\$ in 2009, and 0.96 KgCO<sub>2</sub>/\$ in 2013, which is four times higher than previously estimated. The authors concluded that tourism does not result in low GHG emissions compared to other activities. They proposed various mitigation strategies including encouragement of travelers to avoid aviation transport and to choose public transportation together with improvements in energy and carbon efficiency in various sectors of the tourism industry, which however have limited success so far. A report on the eco-efficiency of tourism has been published (Gössling et al., 2005). The authors mentioned that the carbon intensity of the tourism industry varies greatly between 0.04 KgCO<sub>2</sub>/€ and 16.01 KgCO<sub>2</sub>/€ while the carbon intensity of the global economy has been calculated at 1.18 KgCO<sub>2</sub>/€. They also stated that on average the tourism industry has higher carbon intensity than the global economy. Considering current studies focusing on moving towards a global low carbon economy, the authors estimated a benchmarking value of the eco-efficient tourism industry at 0.24 KgCO<sub>2</sub>/€. Direct and indirect carbon dioxide emissions in the Chinese tourism industry have been calculated and quantified (Meng et al., 2015). The authors mentioned that indirect tourism carbon emissions by other sectors, except the transport sector, were 3 to 4 times higher than their direct carbon emissions. They also estimated the carbon intensity of the tourism sector at 0.881 KgCO<sub>2</sub>/€ compared to 1.130 KgCO<sub>2</sub>/€ in all sectors of the Chinese economy. They have concluded that the high carbon intensity in China is due to its rapid industrialization and the resulting high energy consumption. Carbon intensity in various tourist destinations as well as in the economy of various countries according to published literature is presented in Table 1.

**Table 1. Carbon Intensity of the Tourism Industry and the Economy in Various Countries**

Country	Carbon intensity of tourism industry (KgCO <sub>2</sub> /€)	Carbon intensity of the economy (KgCO <sub>2</sub> /€)
Switzerland <sup>1</sup>	0.530	0.120
Austria <sup>1</sup>	0.120	0.340
Spain <sup>1</sup>	0.440	0.540
Sweden <sup>1</sup>	0.680	0.310
U.K. <sup>1</sup>	0.850	0.440

China <sup>2</sup>	0.881	1.130
Various countries and world economy <sup>3</sup>	0.04-16.01	1.18 (global economy)
Globally <sup>4</sup>	1.066 (in 2013)	--

<sup>1</sup> Perch-Nielsen et al., 2010, <sup>2</sup> Meng et al., 2015, <sup>3</sup> Gossling et al., 2005, <sup>4</sup> Lenzen et al., 2018.

The objectives of the current work include:

- a) Estimation of carbon intensity in various sectors of the tourism industry in Crete,
- b) Comparison of the carbon intensity of the tourism industry in Crete with the carbon intensity in other tourist destinations and countries, and
- c) Proposal of various measures and policies which would improve the sustainability of the tourism industry in the island.

The methodology used includes:

Estimation of carbon intensity in different sectors of the tourism industry in Crete; Comparison of the available data according to published research regarding the carbon intensity of tourism in other countries; and, Proposals of various realistic measures for improving carbon intensity in each sector of the tourism industry in the island, either by lowering its carbon emissions or by increasing the tourism-generated income.

### 3. Methodological Difficulties

There are various methodological difficulties in calculating the carbon intensity of the tourism industry in Crete and comparing it with the corresponding values in other countries. During estimations of carbon intensity in various studies, it is not clarified if all GHGs or only carbon emissions have been taken into account. Data regarding the tourism industry in Crete are available for different years. This results in inconsistent data use. In estimating tourism-related carbon intensity in Crete, only CO<sub>2</sub> emissions have been taken into account but not other GHGs emitted due to fossil fuels use which have been included in some other studies. Most tourists traveling in Crete are arriving from other countries with international air flights. Emissions due to their air transportation have a high share in the total carbon emissions of the Cretan tourism industry. During international air flights in Crete, a lot of carbon dioxide is emitted in foreign territories while many international airlines do not buy bunker fuels in Crete. Bunker fuels also are not included in the national inventories according to the existing international regulations. Therefore, there is a dispute concerning whether bunker fuels used in tourist arrivals and departures in the island should be included in the estimation of carbon intensity of the Cretan tourism industry. Published data regarding tourism-related carbon intensity in other countries and globally have been calculated for different years, and their comparison is also inconsistent. Therefore, there are various difficulties in obtaining comparable results with high accuracy in the

current study.

#### 4. The Tourism Industry in the Island of Crete

Crete is the second largest island in the Eastern Mediterranean sea and the fifth in size in the Mediterranean basin. Its area is 8,332 Km<sup>2</sup> and its population 621,340 inhabitants. The island has three international airports and six sea ports which are used for tourist arrivals and departures. Crete has beautiful landscapes, gorges, high mountains, long coastlines and unique sandy beaches, while its history and culture are very rich. It is very popular and well known globally among travelers as an attractive tourist destination. Annual visitors in the island, during the last years, exceeded 5 mil., while most of them are coming during the period from April to October each year. Tourists choosing Crete for their vacations use air transportation while the British, Germans and Scandinavians dominate among its annual visitors. The tourism industry is very important for the Cretan economy and its share in the regional GDP is estimated at 47%. Employment in this industry is increasing and counterbalances the decrease of employment in agriculture which was traditionally the main driver in the regional employment. Since the majority of tourists arrive in Crete by international air flights, traveling from long distances, carbon emissions due to aviation are important in determining the carbon footprint of the tourism industry in the island. Tourist arrivals in Crete through different transport modes are presented in Table 2.

**Table 2. Tourist Arrivals in Crete with International Flights, Domestic Flights and Ships (2016)** <sup>1,2</sup>

Mode of transport	Number of tourists	% of total
Number of tourists arriving with international flights	3,938,580	74.04
Number of tourists arriving with domestic flights	416,790	7.84
Number of tourists arriving with airplanes	4,355,370	81.88
Number of tourists arriving by ships	963,614	18.12
Total number of tourists arriving in Crete	5,318,984	100

<sup>1</sup> Source: Region of Crete, Regional survey, BRANDTOUR, 2017, <sup>2</sup> Vourdoubas, 2019.

#### 5. Carbon Intensity in Different Tourism Sectors in Crete

The majority of tourism-related carbon emissions in Crete are produced during the air travel of visitors to the island, followed by emissions due to accommodation and various activities at their destination (Vourdoubas, 2019). The carbon intensity in various tourism sectors in Crete is presented in Table 3.

**Table 3. Carbon Intensity in Various Tourism Sectors in Crete**

Tourism sector	CO <sub>2</sub> emissions Tn/year <sup>1</sup>	Carbon intensity KgCO <sub>2</sub> /€ <sup>2</sup>	% of total
Arrival and departure of tourists	1,840,368	0.4533	80.70
Accommodation	296,640	0.0731	13.00
Various activities in Crete	143,613	0.0354	6.30
Carbon emissions excluding arrival and departure of tourists	440,253	0.1085	19.30
Total	2,280,621	0.5618	100

<sup>1</sup> Vourdoubas, 2019,

<sup>2</sup> Estimations based on tourism-related regional GDP of Crete in 2015 at €4.06 bil (Vourdoubas, 2019).

A decrease in the carbon intensity in various tourism sectors has different impacts on the total tourism-related carbon intensity in Crete. The impacts of a 20% reduction in each tourism sector on the total carbon intensity, when intensities in other sectors remain unchanged, are presented in Table 4.

**Table 4. Effect of Change in Carbon Intensity in Various Sectors of the Tourism Industry in Crete on the Total Carbon Intensity**

Tourism sector	Carbon intensity KgCO <sub>2</sub> /€	Carbon intensity decreased by 20% KgCO <sub>2</sub> /€	% change in total carbon intensity if carbon intensities in other sectors remain unchanged
Arrival/departure of tourists	0.4533	0.363	16.69
Accommodation	0.0731	0.058	2.69
Various activities in Crete	0.0354	0.028	1.32
Total	0.5618	0.449	20

Source: Own estimations.

It is noticed in Table 4 that since tourist transportation-related emissions have the highest contribution in the total carbon intensity, their reduction by 20%, when intensities in other sectors remain unchanged, has a high impact on the overall carbon intensity reduction at 16.69%, while a decrease of carbon intensity in the accommodation sector by 20% results in a small decrease in its overall value at 2.69%. Table 4 indicates that improvement of carbon intensity in the accommodation sector or in various activities realized by the tourists in the island has a small impact on the overall tourism-related carbon

intensity in Crete. On the contrary, a decrease in the carbon intensity related with air flights of tourists has a higher impact on its overall value. A decrease in the carbon intensity of the tourism industry in Crete could be achieved either by decreasing its carbon emissions or by increasing the tourism-generated income in the island. Emissions due to aviation, particularly from long-haul airports, are generated outside the Greek and Cretan territory. Bunker fuels used in aviation and in ships, causing transport-related emissions, are not included in national inventories according to the Kyoto protocol. The carbon intensity of the whole Greek economy has been estimated, in 2014, at 0.312 KgCO<sub>2</sub>/€. Calculations have been made taking into account the Greek GDP per capita which was 19,783 € (2014), while the national annual CO<sub>2</sub> emissions per capita were 6.18 tnCO<sub>2</sub> (2014) (World Bank).

## **6. Measures for Lowering Carbon Emissions and Offsetting Them in Various Sectors of the Tourism Industry in Crete**

### *6.1 Decrease of Carbon Emissions*

A decrease in carbon emissions in the tourism and travel industry in Crete could be achieved with various measures, including:

- a) Use of more energy-efficient airplanes and ships for tourist arrivals and departures,
- b) Use of innovative fuels with less carbon emissions during transportation at the destination,
- c) Improvement of energy performance in accommodation buildings and replacement of conventional fuels and grid electricity used in them with renewable energies and green solar photovoltaic electricity,
- d) Promotion of public transportation for tourists in Crete,
- e) Promotion of car sharing among tourists during their activities in the island,
- f) Promotion of the electrification of the transport sector in Crete,
- g) Use of local food products instead of food imported from long distances and less use of meat products in tourist-related catering, and
- h) Sensitization of visitors for behavioral change towards more sustainable methods during their vacations.

Some of the abovementioned measures can be implemented easily and soon while others can only be implemented in the long run since they require innovations and development of new technologies. Some of them could be implemented by enterprises and actors related with the local tourism industry while others depend on policy development by regional and national authorities.

### *6.2 Offsetting of Carbon Emissions*

Reduction of tourism-related carbon emissions in Crete could be achieved through emissions compensation. Travelers could voluntarily buy carbon credits corresponding to air flight emissions which dominate their vacation's carbon footprint. However, voluntary compensation of aviation emissions is not very popular and acceptable so far among tourists. Additionally, tourism-related enterprises, including hotels, restaurants and tour operators in Crete, could compensate their emissions

by purchasing carbon credits from certified international organizations. In that case, their enterprises could be declared carbon neutral, attracting environmentally conscious visitors and obtaining economic benefits. Improvement of tourism-related carbon intensity in Crete is achievable with various measures related with the actors of the tourism industry including public authorities, tourism enterprises and visitors. Measures reducing carbon emissions in the Cretan tourism industry are presented in Table 5.

**Table 5. Measures Reducing Tourism-Related Carbon Emissions in Crete, Time Horizon for Their Implementation and Tourism-Related Actors Involved in Their Promotion**

Measures reducing carbon emissions	Public Authorities	Tourism-related enterprises	private	Tourists
Use of more energy-efficient airplanes and ships for tourist arrivals		Medium-long term		
Use of innovative fuels with less carbon emissions during transportation to the destination		Medium-long term		
Improvement of energy performance in accommodation buildings and replacement of conventional fuels and grid electricity used in them with renewable energies and green solar photovoltaic electricity	Short-medium term	Short-medium term		
Promotion of public transportation for tourists in Crete	Short term	Short term		Short term
Promotion of car sharing among tourists during their activities in the island				Short term
Promotion of the electrification of the transport sector in Crete	Medium-long term	Medium-long term		
Use of local food products instead of food imported from		Short-medium term		Short-medium term

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long distances; less use of meat products in tourist-related catering		
Sensitization of visitors for behavioral change towards more sustainable methods during their vacations	Short term	Short term
Voluntarily offsetting of air flight related emissions by the visitors		Short-medium term
Carbon emissions offsetting by tourism enterprises	Short-medium term	

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According to Table 5, the majority of the required measures should be taken by tourism-related private organizations in Crete while the role of regional authorities regarding new policies development is less important.

**7. Measures for Increasing the Income of the Tourism Industry in Crete**

A decrease in the carbon intensity of the tourism industry in Crete can be obtained with an increase in the tourism-related income in the island. This can be achieved with various measures, including:

- a) Attraction of tourists with higher income—they are usually more environmentally conscious,
- b) Improvement of the infrastructure in the island including the solid and liquid waste management, combined with better environmental management of the local natural resources,
- c) Increasing the quality of the accommodation used by the visitors, offering them more amenities,
- d) Promoting tourism all year round instead of the current seasonal tourism,
- e) Enriching the possibilities for different experiences acquired by visitors during their vacations, increasing the various activities offered to them,
- f) Differentiation of the touristic product in Crete, which today is based mainly on the sea and sun model, promoting thematic tourism and attracting tourists with different priorities and interests, and
- g) Increasing the nexus between agriculture and tourism in Crete, promoting the local gastronomy and the famous health-linked Cretan diet, in order to support local agriculture and increase the indirect economic benefits of the tourism industry.

**8. Discussion and Conclusions**

*8.1 Estimation of Carbon Intensity in Various Sectors of the Tourism Industry in Crete*

Carbon intensity due to transportation of tourists in Crete, at 0.4533 KgCO<sub>2</sub>/€, has the highest share in the tourism-related carbon intensity in Crete. Existing studies in various tourist destinations have also

indicated that air transportation has a high impact on tourism-related carbon intensity.

### *8.2 Comparison of the Carbon Intensity of the Tourism Industry in Crete with the Carbon Intensity in Other Tourist Destinations and Countries*

The carbon intensity of the tourism industry in Crete at 0.5618 KgCO<sub>2</sub>/€ (Vourdoubas, 2019) is in the same range of values reported for other EU countries except for Austria. It is lower than the value reported for China and almost half the value reported for global tourism. However, it is almost two and a half times higher than the benchmarking value reported at 0.24 KgCO<sub>2</sub>/€, for achieving global sustainability and an eco-efficient tourism industry. The estimated value of the carbon intensity in the whole Greek economy at 0.312 KgCO<sub>2</sub>/€ (2014) is approximately 55% of the corresponding value of the tourism industry in Crete. The carbon intensity of the tourism industry in Crete is significantly lower, at 0.1085 KgCO<sub>2</sub>/€ (Vourdoubas, 2019), if emissions due to international tourist transportation in Crete are excluded. This value, at 0.1085 KgCO<sub>2</sub>/€, is less than half the proposed benchmarking value, at 0.24 KgCO<sub>2</sub>/€, for achieving global sustainability and an eco-efficient tourism industry. It is also significantly lower than the carbon intensity reported in other tourist territories and almost one third of the carbon intensity of the Greek economy.

### *8.3 Measures which Could Decrease Carbon Emissions in Cretan Tourism*

Measures which could be used for reducing tourism-related carbon emissions in Crete, in the short and medium term, include: use of more energy-efficient airplanes and ships, use of bunker fuels with less or zero carbon emissions like bio-fuels or hydrogen, improvement of energy performance in accommodation buildings and promotion of renewable energies in them, promotion of electrification of the transport sector in Crete, promotion of public transportation and car sharing for tourists in Crete, use of local food products instead of food imported from long distances and less use of meat products in tourist-related catering, sensitization of visitors for behavioral change towards more sustainable methods during their vacations, and voluntary offset of air flight-related emissions by the visitors, as well as carbon emissions offset by tourism enterprises in the island.

### *8.4 Measures which Could Increase the Income Generated by the Local Tourism Industry*

An increase in the income generated by the Cretan tourism industry can be achieved with various measures including: attraction of tourists with higher incomes, improvement in the infrastructure of the island, an increase in the quality of the accommodation offered to visitors, promotion of tourism all year round, enriching the activities offered to tourists, differentiating the tourism product currently offered and increasing the nexus between agriculture and tourism in Crete. Future work should be focused on investigating the impacts of a carbon tax on the tourism industry in Crete, quantifying its impacts on tourism revenues and on tourism-related carbon intensity. More studies are also required regarding the estimation of tourism-related carbon intensity in Crete in the previous ten years, in order to draw conclusions regarding its change over time.

## References

- Angelakis, G. (2018). *Tourism observatory: A joint effort for an innovative Entrepreneurship in Western Crete*. Retrieved July, 8, 2019, from <http://chania-cci.gr/wp-content/uploads/2017/10/angelakis.pdf>
- Boley, B. B. (2015). To Travel or Not to Travel? Both Have Implications for Sustainable Tourism. *Tourism Planning & Development*, 12(2), 208-224. <https://doi.org/10.1080/21568316.2014.925489>
- Building regional actions for new development in Tourism, Region of Crete. (2017). *Regional survey, BRANDTOUR, INTERREG Europe*. Retrieved July, 7, 2019, from [https://www.interregeurope.eu/fileadmin/user\\_upload/tx\\_tevprojects/library/file\\_1508251948.pdf](https://www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1508251948.pdf)
- Bunker fuels and the Kyoto Protocol: How ICAO and IMO failed the climate change test. (2009). *European Federation for Transport and Environment*. Retrieved November, 4, 2019, from [https://www.cleanshipping.org/download/2009\\_06\\_aviation\\_shipping\\_icao\\_imo\\_history\(2\).pdf](https://www.cleanshipping.org/download/2009_06_aviation_shipping_icao_imo_history(2).pdf)
- Carbon tax and tourism and travel—Trade and global warming exposed*. (2011). Retrieved November, 6, 2019, from <https://www.ttf.org.au/wp-content/uploads/2016/06/TTF-Carbon-Tax-and-Tourism-2011.pdf>
- Dubois, G., Peeters, P., Ceron, J. P., & Gossling, S. (2011). The future tourism mobility of a world population: Emission growth versus climate policy. *Transportation Research Part A*, 45, 1031-1042. <https://doi.org/10.1016/j.tra.2009.11.004>
- Gössling, S., Hall, M. C., Peeters, P., & Scott, D. (2010). The future of tourism: Can tourist growth and climate policy be reconciled? A mitigation perspective. *Tourism Recreation Research*, 35(2), 119-130. <https://doi.org/10.1080/02508281.2010.11081628>
- Gössling, S., Hultman, J., Haglund, L., Källgren, H., & Revahl, M. (2009). Voluntary carbon offsetting by Swedish Air Travellers: Towards the Co-creation of Environmental Value?. *Current Issues in Tourism*, 12(1), 1-19. <https://doi.org/10.1080/13683500802220687>
- Gössling, S., Peeters, P., Ceron, J-P, Dubois, G., Patterson, T., & Rishardson, R. B. (2005). The eco-efficiency of tourism. *Ecological Economics*, 54, 417-434. <https://doi.org/10.1016/j.ecolecon.2004.10.006>
- Hall, C. M., Scott, D., & Gossling, S. (2013). The primacy of climate change for sustainable international tourism. *Sustainable Development*, 21, 112-121. <https://doi.org/10.1002/sd.1562>
- Huang, C., & Deng, H. (2011). The model of developing low carbon tourism in the context of leisure economy. *Energy Procedia*, 5, 1974-1978. <https://doi.org/10.1016/j.egypro.2011.03.339>
- Lee, D. S., Pitari, G., Grewe, V., Gierens, K., Penner, J. E., Petzold, A., ... Sausen, R. (2010). *Transport impacts on atmosphere and climate: Aviation, Atmospheric Environment*, 44, 4678-4734. <https://doi.org/10.1016/j.atmosenv.2009.06.005>
- 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, 522-528. <https://doi.org/10.1038/s41558-018-0141-x>
- Mair, J. (2011). Exploring air traveler's voluntary carbon-offsetting behavior. *Journal of Sustainable*

- Tourism*, 19(2), 215-230. <https://doi.org/10.1080/09669582.2010.517317>
- Meng, W., Xu, L., Hu, B., Zhou, J., & Wang, Z. (2016). Quantifying direct and indirect carbon dioxide emissions of the Chinese tourism industry. *Journal of Cleaner Production*. <https://doi.org/10.1016/j.jclepro.2016.03.067>
- Perch-Nielsen, S., Sesartic, A., & Stucki, M. (2010). The greenhouse gas intensity of the tourism sector: The case of Switzerland. *Environmental Science and Policy*, 13, 131-140. <https://doi.org/10.1016/j.envsci.2009.12.002>
- Sardianou, E., & Kostakis, I. E. (2019). Perceived barriers to invest in renewable energy sources in the Cretan hotel industry. *International Journal of Sustainable Energy*. <https://doi.org/10.1080/14786451.2019.1673393>
- Tol, R. S. J. (2007). The impact of a carbon tax on international tourism. *Transportation Research Part D: Transport and Environment*, 12(2), 129-142. <https://doi.org/10.1016/j.trd.2007.01.004>
- Tourism and Climate Change. (2019). *Confronting the common challenges*. UNWTO Preliminary Considerations, October, 2007. Retrieved July, 8, 2019, from <http://sdt.unwto.org/sites/all/files/docpdf/docuconfrontinge.pdf>
- Tourism in Greece. (2018). *Greek Statistics Organization* (In Greek). Retrieved July 8, 2019, from [http://www.statistics.gr/documents/20181/12044283/elstat\\_tourism\\_2018.pdf/e10383fe-053e-4f5c-aa4b-ae35b257fa9b](http://www.statistics.gr/documents/20181/12044283/elstat_tourism_2018.pdf/e10383fe-053e-4f5c-aa4b-ae35b257fa9b)
- Towards a low carbon travel and Tourism sector*; *World Economic Forum*. (2009). Retrieved July, 8, 2019, from <http://www.greeningtheblue.org/sites/default/files/Towards%20a%20low%20carbon%20travel%200&%20tourism%20sector.pdf>
- Vourdoubas, J. (2019). Estimation of carbon emissions due to tourism in the island of Crete, Greece. *Journal of Tourism and Hospitality Management*, 7(2), 24-32. <https://doi.org/10.5539/eer.v9n2p61>
- Vourdoubas, J. (2019). Mitigation and compensation of CO<sub>2</sub> emissions due to international tourism in the island of Crete, Greece. *Energy and Environment Research*, 9(2), 61-69.
- Yang, W. (2010). The development of tourism in the low carbon economy. *International Business Research*, 3(4), 212-215. <https://doi.org/10.5539/ibr.v3n4p212>