



Quantifying the Carbon Footprint of Events: A Life Cycle Assessment-Based Framework for Evaluating Impact of Location and Timing

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Abstract. This research proposes a Life Cycle Assessment-based framework to quantify the carbon footprint of events, considering the event's location and timing. The framework aims to standardise environmental impact calculations through inventory analysis. To validate it, a comparative analysis on conducting an event in different locations and time periods, while maintaining similar scale and nature is conducted. The assessment includes emissions from attendee transport, accommodation, food and drink, and venue. Additionally, it considers emission reductions resulting from attendees not using their personal household resources. This accounts for the actual additional emissions released into the atmosphere as a consequence of the event. The results highlight variations in emissions across different consumption categories based on the selected location and timing. By providing this information, the LCA-based framework provides valuable guidance for event organizers and policymakers to assess event environmental impacts and promote sustainability.

Keywords: Carbon footprint · Life cycle assessment · Events · Quantitative approach

1 Introduction

Over the past few decades, the global events industry has experienced remarkable and rapid expansion, leading to significant tourism and socio-economic development advancements. However, this substantial growth has pressured global climate change mitigation goals [1]. Consequently, there has been increasing recognition of the urgent need to address the environmental impacts and carbon emissions associated with scientific and social events. This recognition has resulted in a notable surge in demand for sustainable event management practices.

The COVID-19 pandemic has profoundly impacted event planning and execution, forcing event organisers to shift to online platforms. It has been demonstrated that transitioning from in-person to virtual conferencing can substantially reduce carbon footprint

by approximately 94% and decrease energy use by around 90% [2]. However, the quick return to in-person and hybrid events following the easing of COVID-19 restrictions has highlighted the limitations and drawbacks of entirely virtual events from an efficiency and socio-economic perspective [3]. This has underscored the importance of balancing environmental considerations and participant experience in event planning and execution.

In the pursuit of sustainable event management, it is crucial to identify and accurately assess the environmental impacts of events. Several quantitative methods have been proposed to conduct environmental assessments of events to achieve this. For instance, Collins and Cooper utilised the ecological footprint method to examine the environmental impact associated with the 2012 Hay Literary Festival [4]. Their analysis focused on attendees' transport, food and drink consumption, and energy use in overnight accommodation. The scientific community has also increasingly used the life cycle assessment (LCA) method to assess event organisations' multi-dimensional impact [5]. Toniolo et al. conducted an LCA study to quantify the impact associated with an exhibition [6]. Their analysis considered the organisation, assembly, utilisation, and dismantling stages of the exhibition area for 120 exhibits over 3 days. Similarly, Edwards et al. conducted an LCA to measure the carbon footprint and other impact indicators of two Homecoming events at the University of Arizona [7]. Additionally, Toscani et al. provided a uniform life cycle model to assess the environmental impacts of any event by adapting a multi-case implementation and a multi-actor perspective [8]. These quantitative studies have provided valuable insights into the environmental impacts of various events, enabling event organizers to make informed decisions and implement sustainable practices in event planning and execution. However, a standardized approach for examining the impact of event's location and timing on the environmental impacts is missing.

This research aims to develop an LCA-based framework for quantifying the carbon footprint of events, considering the event's location and timing. The methodology of this framework involves a comparative analysis of conducting an event in different locations and time periods, while maintaining similar scale and nature. The carbon footprint is assessed by considering various consumption categories such as transportation and accommodation, which can lead to different emissions based on the selected location and timing. To validate and demonstrate the applicability of the framework, a case study is performed, focusing on the organization of a workshop in the context of TransFIRE hub (<https://transfire-hub.org/>) either in Greece or in the United Kingdom (UK). The findings of this study will offer valuable insights to event organizers, policymakers, and sustainability practitioners.

2 LCA-Based Framework for Sustainable Event Management

The LCA-based framework, as illustrated in Fig. 1, adheres to the four essential stages of LCA: goal and scope definition, life cycle inventory (LCI), life cycle impact assessment (LCIA), and interpretation. However, it incorporates two additional stages, identification, and analysis, before the LCI stage. This extended framework employs a comparative analysis methodology to determine the optimum time and location to conduct the events with minimum impacts to the environment. To conduct this comparison, the first step

is the identification of the potential event locations and timing options. The selection of options should be based on various factors, such as weather conditions, the average distances of potential attendees to the event location candidates, required organisational arrangements, availability of local suppliers, distances from possible suppliers, and the nature of the event (indoor/outdoor, event size, duration, etc.). Following the identification stage, the analysis stage aims to carefully assess the potential locations and timing for hosting the event. During this analysis, the framework defines the consumption categories that may vary depending on the selected location and timing. These consumption categories include transportation, accommodation, venue, organisational requirements, food and drink, and waste management.

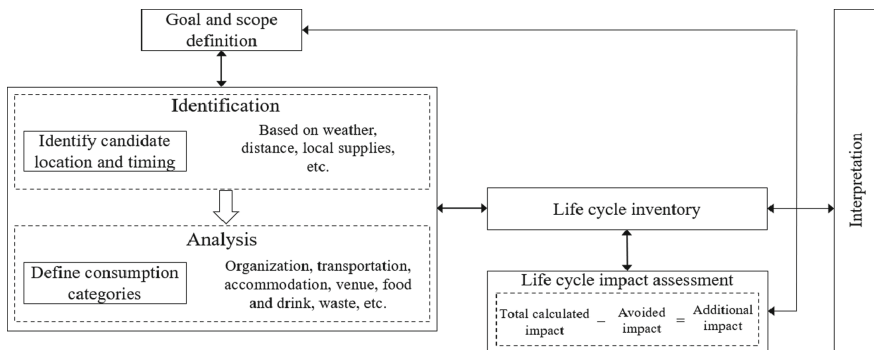


Fig. 1. The LCA-based framework for sustainable event management.

Following the identification of location and timing options, and the analysis of related consumption categories, the subsequent stages in the framework are the LCI and LCIA stages of the LCA. The LCI stage functions as a comprehensive database, encompassing all relevant information regarding resource usage and emissions associated with each selected consumption category. The data gathered during this stage forms the foundation for the subsequent LCIA stage, during which the environmental implications associated with each location and timing option are assessed and quantified. Once the environmental impact of each category is determined, the additional impact of the event is calculated by subtracting the attendees' total impact at their home location during the event from the total impact of the event. In the interpretation stage, the results are analysed to compare the selected event locations and timing in terms of their environmental impact. By conducting this comprehensive analysis, the framework empowers event organizers to make informed decisions regarding the most sustainable location and timing for the events.

3 Case Study: Organization of Workshop

This section demonstrates the applicability and usefulness of the sustainability assessment framework through a case study. For the case event, a workshop held in Chania, Greece in April 2023 was selected. This workshop lasted for four whole days with 21

attendees and took place in European Sustainability Academy (ESA), which operates wholly off-grid and is powered by a photovoltaic (PV) system. A comparison is made between the CO₂eq emission results of the workshop event held in Greece and the emissions that would be generated if this workshop were held in Lake District (UK), with the same scale and nature.

The analysis stage involves defining the consumption categories that may vary between each event location. Since the events were scheduled for the same time of the year but held in different locations, a comparison of the consumption categories; transportation, accommodation, food and drink, and venue was conducted for both event venues. Table 1 presents a summary of the scope of these consumption categories calculated for the Greece event, while estimations were used for the UK event. For the Greece event, primary data were collected from the event organizer, and government data and reports were utilized. However, for the UK event, the consumption patterns were estimated within a range, covering both low and high consumption scenarios. Details of these estimations are provided in Table 1 and further explained for each consumption category in the following paragraphs. Temperature differences between the two locations were taken into consideration as they can significantly impact energy usage for heating and cooling, thus affecting emissions from accommodation and venue operations.

The transport consumption category includes return journeys of all attendees to event accommodation and journeys made during the event. In the case of the workshop held in Greece, attendees travelled by train from their homes to the airport, flew from London to Chania, and used taxis between the airport and the accommodation. The actual flight distances between London and Chania were determined from <https://www.flightradar24.com/> using the flight numbers of attendees. In the case of the workshop held in the UK, in the low consumption scenario, all attendees used rail transport, and taxis were utilized between rail station and accommodation. No transportation was required for event days, assuming that the event venue and accommodation were at the same location. In the high consumption scenario, all attendees used their own cars, and attendees from Greece rented a car after their flight to London. As most journeys made within the UK are by rail and road, domestic air travel was not considered in the calculations. In the high consumption scenario, it was also assumed that the event venue's location differed from that of the accommodation, and for this assumption, distances and transportation types were defined same as for the Greece event. Additionally, since the common fuel type in the UK is petrol, it was used for vehicles, as opposed the diesel fuel used in the Greece event.

The accommodation consumption category encompasses the total energy consumption caused by attendees in the hotel. For the Greece event, a Four-Star hotel served as the accommodation, while a hotel of the same class was selected for the UK event. The number of room-nights was determined based on the total number of attendees and their length of stay. Energy consumption per guest-night for a four-star hotel was defined from [9], covering heating, cooling, lighting, domestic hot water (DHW) and process equipment. For the Greece event, energy consumption for lighting, DHW and process equipment was included. Electricity was used as the source for lighting and process equipment while a combination of electricity and solar power was utilized for DWH due to the presence of solar panels for water heating at the hotel in Greece. In the UK

event's low consumption scenario, energy consumptions for lighting, DHW and process equipment were included, with heating omitted because of the possible warm weather in April. However, in the high consumption scenario, heating was also considered. For the UK event, electricity was used for lighting and process equipment, while natural gas was employed for DHW and heating.

The impacts from the consumption of food and drinks were calculated based on the quantity of food and drinks consumed and the sourcing of their ingredients. For the drinks based on menu information provided by the organizer, along with portion sizes for an average person. The food and drink items served at the Greece event were prepared using locally grown ingredients within a 10 km distance to the event venue. Consequently, only the impacts associated with agriculture, processing, and use were considered, while transportation and packaging impacts were excluded from the assessment. The energy embedded in agriculture, processing, and the use of food and drink items at the Greece event was determined using data from the Joint Research Centre Science and Policy Report [10]. In the low consumption scenario of the UK event, the same type of food as in the Greece event was served, with the same quantity. However, considering the distinct nature of the food served in the UK, meals in the high consumption scenario were defined as premium buffet-style for lunch, and pub-style for dinner. Specific meals and quantities were determined based on example menus. For both scenarios of the UK event, impacts from transportation and packaging of ingredients were also taken into consideration in addition to the impacts from agriculture, processing, and use. This comprehensive approach was necessary due to the global sourcing of ingredients for the food served in the UK. The embedded CO₂eq emissions resulting from agriculture, processing, use and packaging of food and drink items for the UK event were determined using data from [11]. The transportation impact was calculated based on the countries of origin for food ingredient imported into the UK and the distances between these countries and the UK.

The venue's impact was calculated based on the total energy consumed during the event. For the event held in Greece, the venue operates entirely off-grid and is powered by a PV system, resulting in no associated emissions. The total energy used during the event was determined from PV analytics and used for the UK event, encompassing energy consumption for lighting, laptop usage, kitchen usage, router, security video camera system, and end of day cleaning. For the UK event, in the high consumption scenario, heating energy consumption was additionally considered. However, the low consumption scenario used the same amount of energy as in the Greece event.

The LCA of all consumption categories was performed utilising SimaPro 9.2 software. The background data for each category were retrieved from the ecoinvent 3 database. As for the LCIA process, the ReCiPe 2016 methodology (H) has been chosen.

The total CO₂eq emission results for both the Greece event and the low and high consumption scenarios of the UK event were determined using LCA. To calculate the additional CO₂eq emissions resulting from the attendance at the event, the total CO₂eq emissions of attendees at their home location during the event time were subtracted from the total CO₂eq emission results. The calculation of attendees' total emissions at their home locations during the event time was based on data from the Department for Environment, Food & Rural Affairs, UK Carbon Footprint results for 2019 [12]. The

Table 1. Scope of the consumption categories for Greece and UK events.

Consumption categories	<i>Chania, Greece</i>	
Transport	Return distances travelled from the home location to the event accommodation Return distances travelled from the accommodation to the event venue. Two 8-seater vans and one taxi car with diesel fuel	
Accommodation	Energy consumptions for lighting, DHW and process equipment	
Food and drink	Quantity and type of food and drink items served during the event Locally grown ingredients within 10 km distance to event venue, no transportation, no packaging	
Event venue	Total energy consumed during the event	
	<i>Lake District, United Kingdom</i>	
	Low consumption	High consumption
Transport	All attendees used public transportation. Train and taxi from train station to accommodation were utilized. No domestic flights were used No event day transportation	All attendees used their own car. No domestic flights were used Event days transportation: two 8-seater vans and one taxi car were used with petrol, as this is the common fuel type used in the UK
Accommodation	Energy consumptions for lighting, DHW and process equipment	Energy consumptions for lighting, DHW, process equipment and heating
Food and drink	Quantity and type of food and drinks were determined same as for the Greece event Transportation and packaging impact of food ingredients were also included	Quantity and type of food and drinks were determined in accordance with what is typically served in the UK Transportation and packaging impact of food ingredients were also included
Event venue	Same total energy with Greece event was used	Heating energy consumption was also considered

calculated values in kg CO₂eq were 423 for transportation, 254 for accommodation and 88 for food and drinks.

Figure 2 shows the additional CO₂eq emission results for each consumption category. Results for the Greece event are represented with a single line, as the actual consumptions data were collected from event organizer. UK event results on the other hand, are presented in a range covering both low and high consumption scenarios. Among the consumption categories, the transport category has the highest impact, measured in the scale of thousands, while the venue has the smallest impact, measured in the scale of tens. In the transport category, the Greece event resulted in higher additional emissions. The primary reason for this difference was that most of the workshop attendees travelled via international flights from the UK to Greece, whereas they used trains or cars

for transportation on the UK event scenarios. Emissions for accommodation, food and drink, and the venue were lower for the Greece event. This was because heating was unnecessary in the accommodation, food and drink items were prepared with locally grown ingredients, and the venue operated off-grid with all power generated from solar energy, resulting in no emissions.

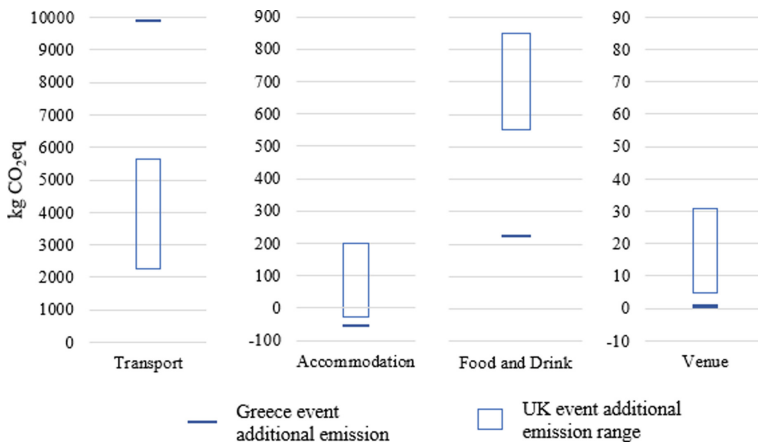


Fig. 2. Additional CO₂eq emission results for consumption categories: transport, accommodation, food and drink, and venue.

4 Conclusion

In this paper, an LCA-based framework has been presented, aimed at quantifying the environmental impact of events, taking into account the event's location and timing. The methodology involved conducting a comparative analysis of hosting an event in various locations and time periods, while ensuring a consistent scale and nature. By considering various consumption categories, such as transportation and accommodation, which can result in varying emissions based on the selected location and timing, valuable insights were provided. To validate the applicability and usefulness of the framework, a case study was conducted, focusing on a workshop that took place in Chania, Greece. The carbon emission results from this workshop were then compared to the emissions that would be generated if the same workshop were held in the Lake District, UK, with a similar scale and nature. It has been demonstrated through this research that location and timing play a significant role in determining the carbon footprint of events. By analysing factors such as weather conditions, attendees' travel distances, and organizational arrangements, the framework enables event organizers to make informed decisions to minimize the environmental impact of their events.

In conclusion, research emphasizes the importance of proactive measures in selecting event locations and implementing sustainable practices to minimize the environmental impact of events. In future work, other environmental factors, such as water usage,

waste generation, and ecosystem impacts, could be incorporated to provide a more comprehensive sustainability assessment for events. Furthermore, the framework should be applied to a wider range of event types and case studies to validate its applicability.

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