



Carbon emissions of a public engagement event: The case of Sharper European researchers' night

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ABSTRACT

Aiming to set sustainability benchmarks for scientific dissemination, educational and networking, and societal engagement events, this research assesses the carbon footprint of an annual academic initiative in Italy within a European Framework, quantifying the impact of connecting science and society through a Life Cycle Assessment. Primary data were collected on organization management, participant travel, and waste from the "European Researchers' Night - Sharper" in Perugia. Transportation accounted for 85% of total greenhouse gas emissions, primarily due to individual displacement, while energy and materials contributed minimally. The Sharper night has a low-carbon-emissions profile compared to events explored in literature. Findings highlight the importance of travel management in a context where infrastructure and cultural habits impacts on local mobility, possible benefits of centralized or hybrid formats, although energy use for large-scale digital participation remains a consideration. Recommendations include integrating better policies for public transportation and sharing mobility to reduce impacts and using energy-efficient digital tools. This work contributes to sustainable event management and encourages academic institutions to adopt green practices in their public engagement activities, advancing beyond sustainable campus initiatives, supporting a transition towards low-carbon events.

1. Introduction

Advancements in science have enabled society to understand and address environmental and social issues arising from human activities (Fischer et al., 2012; Boggia et al., 2018). At a higher level of education, universities play a crucial role in guiding society toward sustainable development. They are aware of the pressing climate crisis and boast robust connections with communities, businesses, and public administrations, empowering them to actively involve society (Purcell et al., 2019; Ferrer-Balas et al., 2008).

Life Cycle Assessment (LCA), defined by Rebitzer et al. (2004) as "methodological framework for estimating and assessing the environmental impacts attributable to the life cycle of a product (...)", has been proven to be effective for understanding the trade-offs in various production methods. This approach supports sustainable development and societal well-being (Caratù et al., 2023) by providing essential methods and tools for quantifying and comparing the environmental impacts of

goods and services (Rebitzer et al., 2004). While LCA for products and systems has been widely adopted and already plays a key role in guiding the design and use of greener materials and goods (Fabiani et al., 2022; Frota de Albuquerque Landi et al., 2022a,b; Frota de Albuquerque Landi et al., 2022), carbon footprint analysis for events and other 'soft' activities has only recently been supported by significant policy frameworks, such as Italy's CAM for Events (MiTE, 2022).

Many studies have already conducted comprehensive LCAs of several types of events (Borggren et al., 2013; Cavallin Toscani et al., 2022; Kitamura et al., 2020; Notaro and Paletto, 2021; Toniolo et al., 2017) including academic conferences (Astudillo and AzariJafari, 2018; Cavallin Toscani et al., 2023; Edwards et al., 2016; Roland and Lorenz, 2002; Neugebauer et al., 2020; Tao et al., 2021), cultural events (Domingues et al., 2023) and the university campus (Clabeaux et al., 2020). However, no studies have specifically assessed the potential impact of the University's public engagement events, i.e., those focused on societal engagement and sustainability and aimed at non-academic

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audiences.

The present analysis focuses on the 2021 "Sharper Night" event in Perugia, part of the European Researchers' Night, and held simultaneously across 16 Italian cities. Perugia's event was chosen for its notable pioneering and practices in promoting science to the public, embodying the university's "third mission" of community engagement. By assessing this case, the study considers the broader implications of such large, multi-city events on environmental sustainability directly related to at least four of the Sustainable Development Goals, i.e., quality education, sustainable cities and communities, peace, justice and strong institutions, and partnerships for the goals. This study addresses a gap in existing literature by estimating the carbon footprint of an academic outreach event. Previous research has primarily focused on university infrastructures and academic conferences, while local initiatives connected to the university–society engagement dimension remain largely underexplored.

The paper is structured as follows: sections 1.1 and 1.2 introduce the background and present the case study supporting the analysis, section 2 describes the research and LCA methodologies. Subsection 2.1 defines the goal and scope, followed by the functional unit (Subsection 2.2), the system boundaries (Subsection 2.3). In Section 2.4, the life cycle inventory is organized into five subcategories: office organization, event implementation, promotional materials, visitors, and waste management. In section 2.5, the LCA method is specified. Section 3 presents the results of the impact assessment, while Section 4 discusses the interpretation of the findings, sensitivity scenarios, and their managerial implications. Finally, Section 5 concludes the paper and outlines potential avenues for future research.

1.1. Background

Traditionally, teaching and research are well-known duties of superior institutions. Higher education institutions have a share in the responsibility for social development, particularly in the instruction of future leaders and public awareness about sustainability (Amaral et al., 2015; Ruano-Borbalan, 2024). This task, or "third mission", includes community outreach, technology transfer, and social engagement (Sormani, Baaken, and van der Sijde, 2021).

Compagnucci and Spigarelli (2020) conducted a systematic literature review (2000–2018) offering a comprehensive assessment of the opportunities and limitations linked to the third mission of universities: strengthening this role has the potential to cultivate collaboration between universities and external stakeholders, enhance their societal impact and significantly contribute to economic progress by fostering entrepreneurship and innovation, while enriching the educational landscape. However, pursuing public engagement may also present challenges to the core functions of universities, since it requires considerable resources and encounters conflicting interests, being vulnerable to political pressures.

The Higher Education Sustainability Initiative (HESI) meeting (Nations), in 2019, resulted in an open commitment to achieving carbon neutrality within the timeframe of 2030–2050 (International Institute for Sustainable Development). Their agreement encompassed actions aimed at advancing climate change research and fostering skills development, all while enhancing environmental and sustainability education across academic curricula, campus facilities, and others (Amaral et al., 2015). The pursuit of higher education missions, however, introduces some paradoxes, since it necessitates the adoption of innovative approaches in the everyday operations of academic institutions: the challenge, here, lies in effectively engaging and mobilizing the public (a task that traditionally involves interactive and in-person activities, which can result in environmental impacts).

International rankings such as GreenMetric, THE Impact (Times Higher Education), and QS sustainability (QS Quacquarelli Symonds) serve as evaluative instruments comparing institutions at the highest echelons of academia, each employing specific methodologies and

objectives. A component of their scoring criteria incorporates assessments of campus cultural activities and sustainability-related events.

Ferrer-Balas et al. (2008) conducted an in-depth examination of the Sustainable Development initiatives undertaken by seven universities, using the Framework-Level-Actors method. Their study offered insights into the characteristics, motivations, and obstacles, but no predominant factor or typical pattern emerged among the cases studied; the author's conclusion emphasized that the most significant challenge resides in addressing individual-level issues, while the strengths of these institutions lie in their connections with society and their financial resources.

Purcell et al. (2019) engaged on the challenges universities face in effecting transformative sustainability, which includes the imperative for interdisciplinary collaboration and active engagement with stakeholders: the authors presented a framework designed to facilitate transformative sustainability and the achievement of Sustainable Development Goals, including leadership and governance, integration, innovation, and engagement. Three case studies illustrated the vital role of a strong institutional culture and a network of supportive peers in implementing sustainability-led transformations. The abovementioned investigations underscore the pivotal importance of fostering a transdisciplinary institutional structure.

Winkleby (2010) emphasized the potential of universities in fostering scientific interest among young individuals through participatory and inclusive approaches: in alignment with this perspective, the "European Union's Unite! Initiative" strives to catalyze innovation and advance open science by establishing a framework for its promotion within educational institutions, including schools and universities. Simultaneously, this initiative endeavors to enhance the quality of education and scientific research (University, 2022); the leaders of this project believe that improving trust in science and stimulating innovation could accelerate the achievement of the Sustainable Development Goals (SDGs).

1.2. Case study

The term "Sharper Night" is derived from "SHaring Researchers' Passion for Engaging Responsiveness," and it has been championed by the European Commission since 2013. The "Sharper Night" constitutes an integral component of a Europe-wide series of public events supported by the Marie Skłodowska-Curie program. In 2021, this series comprised a total of 56 events across 31 countries.

The event aims at entertaining and inspiring audiences by showcasing the marvels of science and its tangible influence on daily life through an interactive format. Consequently, it seeks to foster closer connections between researchers and the public, including children, young individuals, and families. Moreover, this initiative serves as a distinctive platform for researchers to raise awareness about their work and its societal significance while honing their outreach capabilities. In 2020, the European Researchers' Night attracted over 2 million visitors. (European Commission, 2023; European Union and Western Balkans, 2021).

Aiming to measure the direct carbon footprint of 'Sharper Night (2021)' and to provide recommendations applicable to future events, this study assesses the carbon footprint linked with an immersive series of on-site and online activities. These encompass exhibitions, games, conferences, environmental engagements, quizzes, competitions, digital interactions, and various other initiatives aimed at disseminating scientific knowledge to a wider audience.

2. Methodology

To gauge the net impact of each academic event, we engaged the principal organizers in a structured data collection process. This involved the completion of an online survey hosted on the Google platform. The survey encompassed a range of question types, including

multiple-choice, dichotomous, and open-ended queries. Information solicited from organizers pertained to various facets of the event, including building facilities utilized, planning and implementation duration, materials and equipment consumption, total number of participants, and waste management practices.

Event leaders were also required to provide specifics about the event location, duration of organization, involvement of personnel (both staff and visitors), means of transportation used, average commuting distances, materials deployed, and waste management procedures.

The collected primary data were systematically categorized into distinct domains, including transportation, building energy consumption, printed materials, and consumable items. In instances where pertinent information was not available in the primary data, supplementary data were sourced from relevant literature.

The LCA method was applied to track greenhouse gas emissions (GHG) associated with the Sharper's Night held in Perugia, as carbon footprint represents a major challenge to achieving the SDGs. The methodology adhered to the standardized guidelines specified in ISOs 14 040 and 14 044 (ISO, 2006a; 2006b). The calculations were executed utilizing SimaPro version 10.2.0.0, with data sourced from the ecoinvent 3.11 database for unit processes.

2.1. Goal and scope

The primary objective of this study is to conduct a comprehensive assessment of the carbon footprint arising from the Sharper Night event held in Perugia in 2021. Concurrently, the study aims to proffer viable scenarios for enhancing the event's environmental performance. Furthermore, it seeks to underscore the University's unwavering commitment to fostering sustainability within the framework of its initiatives.

2.2. Functional unit

The functional unit employed corresponds to the total carbon footprint required to carry out one academic event in a medium-sized city (160 000 inhabitants), including the typical inputs and outputs entailed in the organization, execution, and dismantling of Sharper Night (2021).

2.3. System boundaries

Based on the previous research conducted by Fabiani et al. (2024), this investigation delves into an in-depth analysis of energy and material consumption, transportation logistics, promotional item deployment, and waste management practices directly linked to the Sharper Night event in 2021. The analytical framework adopts a cradle-to-gate approach (Rostkowski et al., 2012; Boesch et al., 2009), illustrated in Fig. 1. Boundaries include activities conducted before and after directly connected to the event, while the infrastructure facilities and

construction-related activities, the production of equipment, and the manufacturing and maintenance of vehicles fall outside the purview of this analysis.

2.4. Life cycle inventory

In this section, we provide a detailed account of the life cycle inventory, which has been meticulously segregated by activity. We offer a comprehensive discussion of the underlying assumptions and considerations guiding our analysis. The input data employed originated from 40 distinct activities reported by the University's team leaders. These data sets were subjected to scrutiny, analysis, and verification. In Table 1, an overall figure of the event is presented.

2.4.1. Office organization

This section includes inputs required for preparing the activities performed in the Sharper Night. Our calculations are based on the reported number of working days, assuming that each participant dedicated 6 h per day to the Sharper Night event (allocating 2 h for other daily tasks). Table 2 provides a comprehensive overview of all inputs calculated for both the University and home offices.

The assumptions for the calculations are reported below.

- Electricity consumption: encompasses the electricity for lighting - assumptions of 66.7 W to achieve 500 lux of lighting for office spaces and 77.8 W for home office staff, considering specific lighting requirements (Perugia, 2013), operation of appliances, and equipment such as computers and internet connectivity.
- Heating requirements: Our assessment addresses the heating needs for both University offices and home offices, since Sharper Night occurred during the autumn season, leading us to assume that all individuals worked in enclosed and heated spaces. This assumption was pivotal in shaping our calculations for heating requirements.

Specifically, for University offices, we adopted a volume-based methodology, while for home offices, we referred to external data sources to derive heating demands. For University offices, we adopted an assumption of 8 square meters per person within rooms that have a height of 3.5 m (Foscari 2019). For home offices, we referenced data

Table 1

Average values obtained on the survey for each of the 40 activities.

Activity	Remote	On-site
Organization participants (average per event)	2	4
Duration of the activities (days)	4	2
Distances traveled by academics (km)	–	18.95
Distances traveled by visitors (km)	–	8.6
Total number of participants (all activities)	392	1057

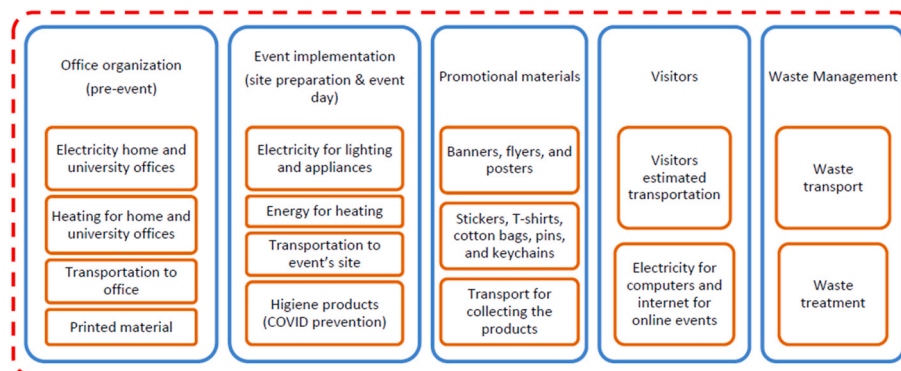


Fig. 1. Boundaries included in the analysis.

Table 2

Materials and processes inputs required for the office organization.

Materials and assemblies	Quantity	Unit	Geography
Paper, woodfree, uncoated market	2.04	kg	Europe (EU)
Graphic paper, 100% recycled market	0.73	kg	Global
Printed paper operation, printer, laser, black/white	2.77	kg	EU without Switzerland
Home-office activities			
Operation, computer, desktop, home use market	798	hr	Italy
Internet access, videoconference, 0.7 Mbit/s market	798	hr	Italy
Electricity, low-voltage market	62 084	Wh	Italy
Heat, central or small-scale, natural gas market	3.22	Wh	EU without Switzerland
University office activities			
Operation, computer, desktop, office use market	4638	hr	Italy
Internet access, work, 0.2 Mbit/s market	4638	hr	Italy
Electricity, low voltage market	309 355	Wh	Italy
Heat, central or small-scale, natural gas, market	0.32	Wh	EU without Switzerland
Umbria passenger car mix (see Table 4)	11 419	km	EU
Transport, tram market	208	Person-km	Global
Transport, regular bus market	1734	Person-km	Global

from the EPISCOPE and TABULA websites, making assumptions for a middle climatic zone (Corrado et al., 2012) and a residential area in Perugia resembling a multifamily home constructed between 1961 and 1970. The estimated heating demand was determined to be 105.2 kWh/m²y for an area of m² (Perugia, 2013).

- Printed materials: encompass the energy consumption, ink usage, and paper consumption associated with printing activities.
- Transportation: In instances where the mode of transportation was not specified, we computed an average daily travel distance of 19 km, drawing from estimations provided by team leaders. Passenger's car considers modelling the fleet according to Umbria's statistics from (ANFIA, 2021) in Table 3.

Simplifications were required due to the absence of EURO 0, 1, 2, and 6 technologies in the database. Consequently, EURO 0, 1, and 2 were grouped with EURO 3, while EURO 6 was grouped with EURO 5. The Umbria fleet mix is represented in Table 4.

2.4.2. Event implementation

The University hosted a variety of activities accommodated within distinct buildings, as illustrated in Fig. 2 (see also Table 8). These locations collectively formed the backdrop against which the Sharper Night event unfolded.

This section centers on the inputs pertinent to the event locations, as comprehensively detailed in Table 5. The duration of on-site activities was uniformly established at 8 h per day, aligning with the number of

Table 3

Data from passenger cars in use for Umbria fuel and the EURO class in 2021 (ANFIA, 2021).

Fuel type	EURO 0	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EURO 6	N.C.*	N.I.
Petrol	6.86%	1.51%	4.84%	4.30%	8.34%	3.72%	7.47%	0.00%	0.04%
Petrol-LPG	0.74%	0.19%	0.39%	0.32%	2.19%	1.35%	2.64%	0.00%	0.00%
Petrol-CNG	0.28%	0.09%	0.27%	0.24%	1.77%	1.85%	2.58%	0.00%	0.00%
Diesel	1.37%	0.40%	2.04%	5.74%	12.05%	10.16%	14.23%	0.00%	0.00%
Electric-Hybrid	0.00%	0.00%	0.00%	0.00%	0.01%	0.07%	1.77%	0.17%	0.00%
Others	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Not identified	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 4

Transport-share for the Umbria passenger car fleet (per km).

Transport mean	Distance	Geography
Transport, passenger car, electric (Italian electricity mix)	0.0202	GLO
Market for transport, passenger car, medium size, LPG, EURO 5	0.0783	GLO
Transport, passenger car, medium size, natural gas, EURO 3	0.0087	EU
Transport, passenger car, medium size, natural gas, EURO 4	0.0178	EU
Transport, passenger car, medium size, natural gas, EURO 5	0.0443	EU
Transport, passenger car, medium size, petrol, EURO 3	0.1751	EU
Transport, passenger car, medium size, petrol, EURO 4	0.0834	EU
Transport, passenger car, medium size, petrol, EURO 5	0.1119	EU
Transport, passenger car, medium size, diesel, EURO 3	0.0955	EU
Transport, passenger car, medium size, diesel, EURO 4	0.1205	EU
Transport, passenger car, medium size, diesel, EURO 5	0.2439	EU
Transport, passenger car market	0.0004	EU

days specified by the University teams. Heating and internet consumption were incorporated into our calculations when explicitly declared. Additionally, the requisite safety and signalization materials for the events were quantified based on the data provided by the teams. The transportation requirements for the teams were computed based on the reported number of days and the precise commuting distances for each day.

For enclosed spaces, the heating demands were calculated for an 8-h daily period, factoring in the area as informed or documented, the building's typology, and the reported number of days. In accordance with established literature, the energy demand reference for older buildings was considered to be 17.5 kWh/m³, whereas for reinforced concrete structures, it was assumed at 21.7 kWh/m³ (Desideri and Proietti, 2002). The electricity consumption attributed to equipment operation was determined based on a synthesis of relevant literature and data sourced from theecoinvent database, as comprehensively outlined in Table 6.

2.4.3. Promotional materials

Event organizers requested that the working teams compile a comprehensive list of promotional items utilized during the event. The teams' responses are presented in Table 7, and correspond to banners, flyers, and posters as printed paper. In addition, organizers reported the acquisition of stickers, T-shirts, cotton bags, pins, and keychains to promote the event. Since the origins of these materials were not precise, and to ensure uniform data, market inputs were considered when calculating their average transportation distances. The distribution was calculated from the Doctorate secretary's office to the event location, utilizing the mode of transportation specified by the organizers.

2.4.4. Visitors

Our investigation estimated that a total of 1906 visitors actively participated in the 40 distinct activities, supplemented by an additional 392 individuals who engaged in the events online. To ensure precision and prevent double-counting, we considered the maximum number of registered participants for each activity held in the same building. This

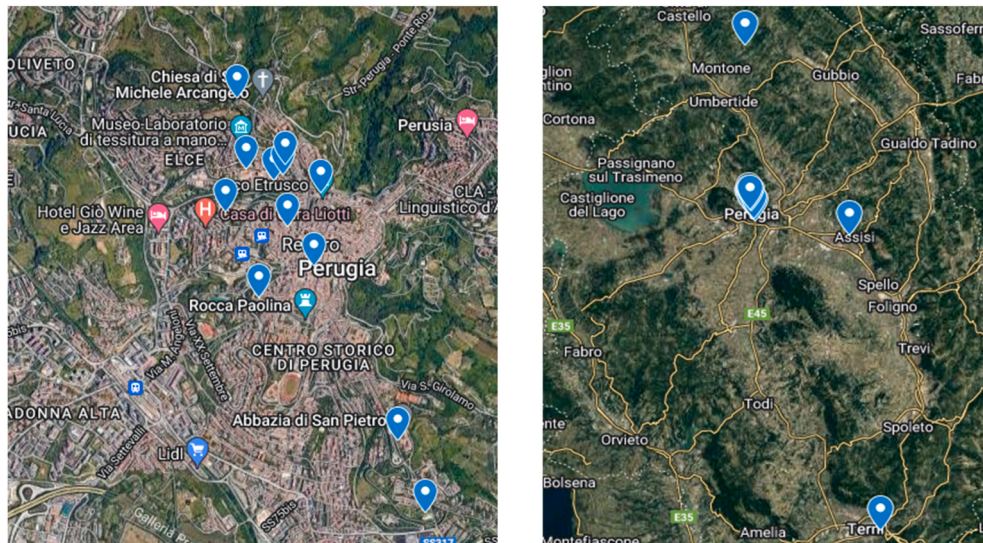


Fig. 2. On the left: activities' location (in blue) within Perugia. On the right: activities outside the Perugia Municipality (Google maps).

Table 5

Inputs for the event implementation (cut-off, unit approach).

Materials	Quantity	Unit	Geography
Polypropylene, granulate market + injection moulding	2.5	kg	Global
Magnesium oxide market	1.25	kg	Global
Tissue paper market	0.88	kg	Global
Solvent, organic market	0.93	kg	Global
Benzyl alcohol market	7.7	kg	Global
Alkylbenzene, linear market	0.45	kg	Global
Processes			
Internet access, videoconference, 0.7 Mbit/s market	488	hr	Italy
Operation, computer, laptop, 68% active work market	5.184	hr	Italy
Operation, computer, desktop, office use market	1024	hr	Italy
Electricity, low voltage market	1 538 241	Wh	Italy
Heat, central or small-scale, natural gas market	0.112	Wh	EU w/t Switzerland
Umbria passenger car mix (see Table 4) event day	5862	km	Europe
Transport, tram market event day	1734	Person-km	Global
Transport, regular bus market event day	88	Person-km	Global

approach yielded a total number of 1057 participants. It is essential to acknowledge that certain activities were strategically located within walking distance of one another, primarily in the easily accessible city center, which boasts seamless tram and bus connectivity. Consequently, determining whether a participant who attended an event at, for instance, Palazzo Murena, also visited an event at Centro Alessi, posed a

Table 6

Electric appliance power rating in Watts (W).

Equipment	Power	Source	Equipment	Power	Source
Projector	290	(Constable (2011))	Microscope	20	(Sahai)
Tv	200	(EnergyCentre for Sustainable, 2022)	Lightning	100	(Amazon)
Laptop	ecoinvent	(Wernet et al. (2016))	Sound Box	0.05	(City of Santa Clara Hall, 2023)
Tablet	10	(EnergyCentre for Sustainable, 2022)	Scale	3.9	(instruments 2022)
Telecamera	10	(Bozzoni, 2020; EnergyCentre for Sustainable, 2022)	Monitor	0.04	(City of Santa Clara Hall, 2023)
Desktop	ecoinvent	(Wernet et al., 2016; Bozzoni, 2020)	Camera	27	Nikon
Oven	2200	(EnergyCentre for Sustainable, 2022; Wernet et al., 2016)	Batteries AA	3.9	Krause (2016)
			Electric Stirrer	600	(VEVOR)

logistical challenge, as did ascertaining their mode of transportation.

To provide a conservative estimate, we made certain assumptions. First, we postulated that each visitor to the city center traveled approximately 4 km by private car, encompassing most of the city area. Additionally, we assumed that participants in Terni originated from within the city and traveled approximately 4 km by car. For the event held at the *Osservatorio Astronomico di Coloti Montone*, we considered traveling distances of 45 km from Perugia, 28 km from Perugia Palazzo Bernabei, 5 km from the city center, and 4 km from Orto *Medievale*.

The cumulative input derived from these travel scenarios corresponds to the market for transport, specifically passenger car transport (EU), encompassing a total distance of 9078 km. Furthermore, for online events, our estimations summed a total of 784 h within the market for operation, involving the use of computers and laptops. This calculation assumed 68% active work engagement and internet access at a rate of 0.2 Mbit/s.

2.4.5. Waste management

The amount of waste produced was measured in liters, and its weight was calculated based on literature that detailed the material, resulting in a total of 52.4 kg. According to the Institute for Environmental Protection and Research (ISPRA), regional data from Umbria indicates that 66.1% of the waste is collected and treated properly. This proportion, presented in Table 9, was employed to model the waste disposal (ISPRA, 2014).

2.5. Life cycle impact assessment

The selection of a single-issue method, IPCC 2021 facilitates the comparison of the results to existing activities, and, in our case, adding other environmental indicators would increase the uncertainties, to the

Table 7
Inputs for promotional materials (cut-off, unit approach).

Materials and assemblies	Quantity	Unit	Geography
Vinyl chloride, market vinyl chloride	19.48	kg	Europe
Textile, knit cotton market	11.96	kg	Global
Printed paper market	43.88	kg	Global
Polyethylene terephthalate, granulate, bottle grade market	12.24	kg	Global
Polymethyl methacrylate, beads market	2.25	kg	Global
Iron-nickel-chromium alloy market	0.44	kg	Global
Polymethyl methacrylate, sheet market	0.01	kg	Global
Aluminium Alloy, AlMg3 market	0.35	kg	Global
Packaging film, low-density polyethylene market	0.021	kg	Global
Acrylic filler market	0.02	kg	Global
Transport of promotional items			
Transport, passenger car, small size, petrol, EURO 5, market	7.50	km	Global
Transport, passenger car, small size, diesel, EURO 5, market	38.38	km	Global
Transport, passenger car, medium size, diesel, EURO 5, market	36.35	km	Global
Transport, passenger car, EURO 5 (RER), market	5.64	km	Global
Transport, passenger car, medium size, natural gas, EURO 5, market	5.21	km	Global
Transport, passenger car, medium size, petrol, EURO 5, market	56.96	km	Global
Transport, passenger car, electric market	84.4	km	Global
Transport, passenger car, large size, petrol, EURO 5 market	4.00	km	Global
Transport, passenger car, large size, diesel, EURO 5 market	40.23	km	Global
Transport, freight, light commercial vehicle market	25.00	kgkm	EU without Switzerland

Table 8
Average distance considered and number of visitors estimated.

Location	Max number of visitors	Distance in km
Dipartimento di Fisica e Geologia - Aula	100	9
Dipartimento di Scienze Farmaceutiche - Aula	60	9
Ex Borsa Merci - Centro Alessi	70	9
Palazzo Gallenga - Aula Magna	200	9
Palazzo Murena	150	9
Polo Scientifico - Didattico Terni	32	4
Osservatorio Astronomico di Coloti Montone (PG)	30	45
Biblioteca San Matteo degli Armeni - Giardino	25	4
Accademia Belle Arti - Spazi Accademia	50	4
Palazzo Bernabei	30	28
Dipartimento di Economia - Aula Di Economia	50	4
Biblioteca Umanistica - Spazi Adiacenti Ingresso	30	4
Orto Botanico	20	4
Orto Medievale	160	4
Conservatorio Francesco Morlacchi	50	4

Table 9
Waste share scenario, values in percentage (%).

Waste type	Share	Waste type	Share
Organic	41.88	Electronics	1.93
Paper	19.68	Mixed (large size)	1.28
Glass	10.82	Construction	2.48
Plastics	9.73	Road waste	5.10
Metal	1.95	Textile	1.16
Wood	3.74	Others	0.26

detriment of measuring potential trade-offs.

3. Results

According to the [IPCC, 2021](#) method the total GHG is estimated at 11 211 kg CO₂eq. Most of the emissions can be attributed to the office organization, with 41.1% (see [Fig. 3](#)). Visitors are responsible for 28.6% of the emissions, while event implementation contributes 26.7%. Promotional materials have only 3.6% of the total impact share. Waste management contribution can be considered not relevant.

GHG emissions of the office organization are predominantly attributed to individual transportation via private cars, constituting 86.6% of the total. This is followed by emissions from the use of public transportation (5.3%), energy consumption for computer usage (5.4%), and the procurement of electricity from the market, which accounts for 2.8% of the total CO₂ eq emissions. The breakdown of the event implementation showed 68.5% of the emissions due to private passenger cars, 5.4% from public transport, 18.1% of energy (electricity and heat), 6.5% computer, and 1.7% from other materials.

Promotional materials are divided as 27.8% of printed materials, cotton bags contribute with 25%, and vinyl chloride for banners with 8.4% being the main culprits for carbon emissions. Transportation accounted for 22.3% of emissions.

Transportation is the main source of emissions for visitors, with 99% of attendees contributing through travel, while the remaining 1% is attributable to electricity use for computer operation and internet access.

4. Interpretation

The ISO 20121:2012 ([British Standards Institutions, 2012](#)) provides specifications to enhance the sustainability of events. However, most literature focuses on events of touristic interest ([Attanasi et al., 2013](#); [Presbury and Edwards, 2005](#); [Negruşa et al., 2016](#)) with local academic events receiving less attention. Furthermore, academic behavior and commitment to green practices have been discussed in the literature; in particular, traveling patterns have been identified as one of the most impactful activities related to scholars' meetings and other events ([Caset et al., 2018](#); [Chirieleison and Scrucca, 2017](#)).

Private transport represented 83% of the total emissions in all Sharper Night, raising the issue of daily travel management. A questionnaire regarding mobility in Italian Universities ([RUS Rete delle Università per lo Sviluppo Sostenibile, 2017](#)), within a sample of 37 universities and approximately 70 000 respondents, reported that in Central Italy the average modal share is 24.1% for private cars, 38.5% for public transport, and 20.6% for trains, consistent with trends observed by university size.

In Perugia, characterized by a mountainous morphology, the modal profile differs, with only 31% of trips made by public transport, a high reliance on private motorized modes (40%), and 29% attributed to slow mobility. Another relevant finding is that professors, researchers, and administrative staff are the primary users of private motorized transport, while the home-to-university distance in Central Italy is about 30 km, aligned with the national average. Therefore, mode choice, rather than distance, is determinant of mobility sustainability. Perugia ranks in the upper third of Italian university cities for 'fully unsustainable trips', i.e., made exclusively using private motorized transport. At the national level, average daily transport-related emissions amount to 4.8 kg CO₂-eq per person, lower than our estimation of 6.65 kg CO₂-eq per person commuting to the University, considering the Umbria mix modelled and the 19 km distance.

[Crotti et al. \(2022\)](#) stated that car dependency remains structurally embedded in university commuting systems, particularly at medium and small campuses characterized by long travel distances and inadequate public transport. According to the authors, commuting-related emissions constitute a major share of institutional GHG emissions, reinforced

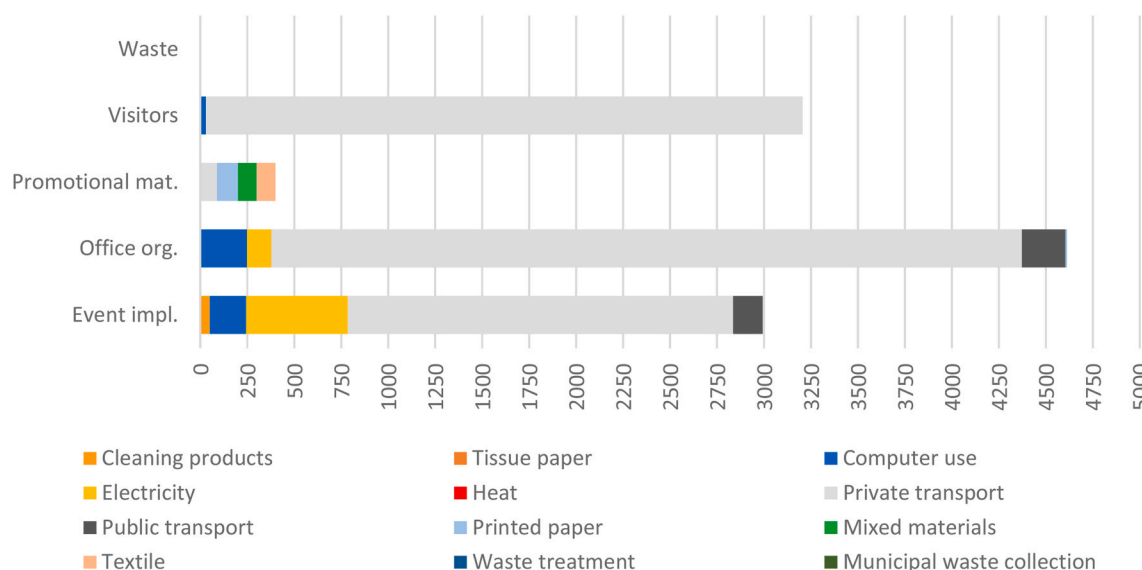


Fig. 3. GHG emissions per activity groups: waste management, visitors, promotional materials, event implementation, and office organization.

by generous parking options. Car commuters themselves recognized parking management policies as an effective tool for reducing solo driving. The study further highlights that attitudes toward reducing car use are defined by regional transport infrastructure rather than campus policies alone.

Boggia et al. (2018) proposed a novel assessment method to evaluate the ecological sustainability of events. This method covers critical issues and event steps, making it a reference evaluation method for future certification. Fischer et al. argue that sustainability requires a shift in human behavior, which can only be achieved through institutions (Fischer et al., 2012).

Amaral et al. (2015) pointed out the relevance of building energy consumption in anthropogenic emissions, which is a minor contribution in our results, but not negligible. The event organization impact highlights the importance of building renovation initiatives for a greener University campus (Magatti et al., 2013; Fischer et al., 2012) that could benefit the existing building stock owned by the University of Perugia.

4.1. Sensitivity scenarios

Due to the impact of transportation on the Sharper Night's emissions and the high level of uncertainty surrounding this input, particularly regarding visitors for whom many assumptions were made, two scenarios were designed to account for different transportation distances and the variation of the number of visitors. First, the base scenario distances that summed from 9078 km were varied between $\pm 10\%$ and $\pm 20\%$, and the number of visitors was also varied by $\pm 10\%$ and $\pm 20\%$ (see Table 10). A second scenario considers that the visitors used their cars for 4 km and complemented the route by foot, representing a reduction of 32% of the total car travel (6178 km). In Table 11 the same $\pm 10\%$ and $\pm 20\%$ scenarios were simulated.

Total emissions varied from -12.8% to $+12.6\%$ when visitors corresponded respectively to a range of 18–37% for total emissions, see

Table 10
Total distances in km for scenario 1.

Visitors	−10%	10%	−20%	20%
100%	8170	9986	7262	10 894
−10%	7353	8987	6536	9804
+10%	8987	10 984	7989	11 983
−20%	6536	7989	5810	8715
20%	9804	11 983	8715	13 072

Fig. 4.

According to literature, emissions attributed to international congresses can range from 500 kg CO₂ eq to 2.5–3 tons per attendee (Desiere, 2016; Stroud and Feeley, 2015). Caset et al. (2018) reported that an academic event in Lisbon produced over 16 tons of CO₂ eq emissions for 18 people, including the radiative forcing effects.

In a study conducted by Chirieleison and Scrucca (2017), sustainable transportation policies were examined, with a focus on the role of events in strengthening social bonds. The study analyzed Italian events that attract tourists and highlighted the impact of mobility on local administration, society, and pollution caused by transportation means. The article suggests that organizers could use the model-based cluster analysis for a pre- and post-event self-assessment, in terms of effectiveness, and as an instrument for improving the sustainability of hallmark events.

The high impacts of transportation could lead to the conclusion that migrating to virtual platforms could be the solution. However, those do not impact free activities and their effectiveness could be questioned. The Sustainable Web Manifesto (2019) claims that if the internet were a country, it would be the 4th largest polluter compared with fossil CO₂ emissions by country, using data from 2020 from the European Union's Emissions Database for Global Atmospheric Research (Digital). Awareness about internet pollution is growing, in part thanks to a breed of eco-minded companies designing websites in line with carbon minimization principles: switching to a green web host powered by renewable energy (Chan, 2021). Estimating the environmental footprint of a website can be somewhat of a challenge, but there are several tools and metrics available to help estimate it. The Website Carbon Calculator (Digital) is an example of a tool to evaluate emissions of a website. According to this calculator - based on the size of the web page, the traffic, and the location of the server - the impact of 'sharper-night.it' is comparatively higher than 85% of the tested pages with 1.51 g of CO₂ eq emissions for each visit.

Table 11
Total distances in km for scenario 2.

Visitors	−10%	10%	−20%	20%
100%	5573	6770.2	4980.8	7362.4
−10%	5004	6116	4448	6672
10%	6116	7475	5437	8155
−20%	6536	7989	5810	8715
20%	9804	11 983	8715	13 072

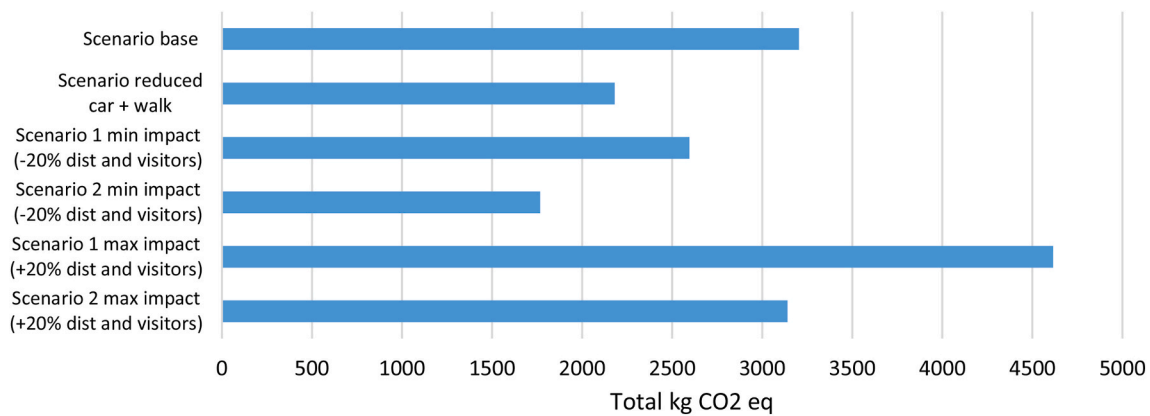


Fig. 4. GHG emissions comparison by the visitors' scenarios.

Transitioning to virtual has been shown to potentially come with reductions in socialization/networking opportunities (Goodale et al., 2026; Sarabipour et al., 2021). Emissions per participant for Sharper Night are significantly lower compared to international events, mainly due to the absence of airplane travel and hotel accommodation associated. Sharper Night, being a local event, had only 7.74 kg CO₂eq per participant, therefore not justifying the event migration to a digital platform, since mobilization and community results are not measurable.

4.2. Managerial implications

The University's third mission presents the challenge of engaging and inspiring individuals while ensuring environmental preservation (Nations, United, 2015), acknowledging thus its attention for sustainability (Trencher et al., 2014; Selvamani and Arul, 2021; Berbegal-Mirabent et al., 2022). This involves not only assessing environmental impact but also considering broader sustainability principles, as advocated by academic theories such as the Triple Bottom Line and the Triple Helix (Janjua et al., 2020; Zawdie, 2010).

From an environmental point of view, the study highlights that transportation is the major contributor to GHG emissions in the context of academic events. In this sense, this finding suggests that event organizers should prioritize sustainable transportation options: encouraging attendees to use public transportation or arranging shared transportation services could significantly reduce the event's carbon footprint, as well as building energy consumption. The latter emerges as a significant contributor to the event's overall environmental impact, so this emphasizes the importance of integrating sustainability into university building renovation initiatives. The academia can consider energy-efficient measures, renewable energy sources, and other green building practices to minimize the carbon footprint associated with event venues.

On the other side, while decentralization of events can lead to broader participation (therefore aligning with the social dimension of the triple bottom line) it may also result in increased emissions due to the need for private vehicles in areas with limited public transportation: event organizers should carefully assess the transportation infrastructure in different event locations and consider ways to mitigate emissions, such as providing shuttle services from central hubs.

The study also suggests that promotional materials like banners, flyers, and printed materials have some impact on emissions; therefore, event organizers can explore eco-friendly materials and digital alternatives (Feser, 2023) to reduce the environmental footprint associated with marketing. In this case, the organization of the event has already

tried to go "hybrid" and "phy-gital" (physical + digital) with an app of Urban Trekking called "HUSH"¹ and dedicated to exploring the event. Goodale et al. (2026) while recognizing the advantages of virtual events—such as a potential 95% reduction in carbon footprint and increased inclusivity—as well as their limitations, including social and technical requirements, reported a declining trend in fully virtual conferences in an after COVID-19 emergency. In contrast, hybrid formats combining in-person and online elements appear to be more consolidated, for larger conferences. Regional events, our case, are more sustainably feasible in an in-person format; however, the impact of car travel remains non-negligible. For the Sharper event, the in-person experience seems essential. Nevertheless, virtual promotion and the streaming of selected activities, e.g. those with limited accessibility or high demand, would require relatively less technical efforts and could promote the integration with other Italian regions, thereby expanding the audience.

In summary, while this study provides valuable insights into the environmental impact of local academic events, further research is needed to explore the broader implications, behavioral aspects, and potential optimization strategies for sustainability within the public engagement activities of higher education institutions.

5. Conclusions and future research

This study presents an LCA examining the GHG impact of the "Sharper's Night" in support of the University's broader mission to make science more accessible. The LCA methodology, adhering to ISO standards, thoroughly evaluates energy and material usage, transportation arrangements, promotional materials, and waste management procedures, bridging a notable research gap concerning the environmental effects of local academic events. Through meticulous data gathering and analysis from a local scholarly event, the University showcases its proactive stance in measuring emissions and implementing sustainable event practices.

Emissions associated with the event revealed a structural challenge case, where geography, infrastructure gaps, and behavioral patterns converge to produce an unsustainable transport pattern. The findings suggest that the decentralization of the event has both advantages and disadvantages: on one hand, it allows for shorter travel distances, but on the other hand, it may require the use of private transportation in areas that are not served by public transit or are difficult to access. However, by improving public transportation, even small-scale events can have a reduced impact on the environment.

Given that most events take place in the historical city center, which

¹ <https://www.dmi.unipg.it/ricerca/news-ricerca/425-sharper-2021-la-nott-e-dei-ricercatori-al-dipartimento-di-matematica-ed-informatica>.

is a manageable 4 km walk and already subject to limited car access, a compelling initiative could involve offering complimentary or discounted bus tickets during the event to encourage public transportation usage. Additionally, considering the circumstances, organizing a dedicated shuttle service could be beneficial. Notably, emissions arising from the transportation of organizational teams are predominant. To address this concern, implementing carpooling measures emerges as a viable strategy for emission reduction. If 30% of the working teams engaged in carpooling, it could potentially save 1225 kg CO₂ eq. Maybe the figure of a mobility facilitator could help with this transition.

The limitations presented in the study were to obtain accurate data regarding visitors in terms of number, means of transportation, and distance, covered by local statistics and organization estimation, besides data gaps for some research groups that were estimated by the organization responsible.

It is important to note that the intangible benefits of education and sustainability awareness on society were not accounted for in this study. In this sense, further research could explore the cultural, social, and economic benefits of such activities by defining metrics for cultural impact as well as the strengthening of bonds between the University and the community, therefore assessing whether the cultural and educational benefits for non-academic audiences justify the environmental costs.

Overall, this research emphasizes the importance of sustainable event management, offering optimization strategies that prioritize sustainability alongside educational and outreach objectives. By continuing to prioritize sustainability and community engagement, the University sets a compelling example for others to follow.

CRedit authorship contribution statement

Fabiana Frota de Albuquerque Landi: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Myriam Caratù:** Writing – original draft, Methodology, Investigation, Conceptualization. **Claudia Fabiani:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Anna Laura Pisello:** Writing – review & editing, Supervision, Project administration, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors do not have permission to share data.

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