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A Methodology for Carbon Footprint Estimations of Research Project Activities—A Scenarios Analysis for Reducing Carbon Footprint

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Abstract: The main objective of the present study is the development of a comprehensive methodology for the estimation of the Carbon Footprint (CF) of research project activities and the identification of the best practices that can be followed by project partners within the project implementation to reduce its carbon footprint. The CF methodology is based on the GHG Protocol Guidance and the emissions factors of the Department for Environment Food & Rural Affairs (DEFRA). The emissions sources related to project activities are the following: heating (from fuels combustion), electricity, water, work-commuting, materials, printable deliverables, IT equipment and events. An application study is performed for a research project focusing on the Mediterranean area and it is found that on-site events represent a 41% share of the total CF of the project. The use of public transport and soft mobility by employees can result in a −37% reduction in the CF of work-commuting. The most significant best practices for more sustainable organization of project events, leading to a reduction of −62% and −50% in the CF of the events, are (1) public transportation and soft mobility of the events' participants to reach the event location within the host city, and (2) the promotion of the use of buses and railway for the international/national travels of participants to/from the event's host city, respectively. The organization of hybrid events may also reduce the project event's CF by −50%. The cumulative reduction in the total CF of the project examined from all the CF mitigation scenarios studied, relevant to the energy-efficient target of the EU, the origin of materials used, work-commuting and events (materials used, transportation, hybrid events), is estimated to be −45%.

Keywords: carbon footprint; research project activities; Mediterranean; GHG emissions methodology; mitigation scenarios

1. Introduction

A carbon footprint is the amount of greenhouse gases (GHG) emitted into the atmosphere generated by activities of a person, organization or community and contributing to climate change. According to the European Environment Agency [1], in 2019, GHG emissions were 24% below 1990 levels, consistent with the 2020 target. However, by 2030, the corresponding GHG emissions reduction should reach a 55% reduction compared with 1990 levels, highlighting the urgent need of steeper GHG emissions reductions.

The Mediterranean area is one of the most susceptible areas in Europe to climate change. It has been found that the annual mean temperatures over the Mediterranean region are 1.54 °C above the 1860–1890 level for land and sea areas. This is 0.4 °C more than the global average change, while it has been estimated the future regional warming will exceed the global mean value by 20% on an annual basis and 50% in summer [2]. Thus, any effort to reduce the carbon footprint will reduce climate change impacts on the Mediterranean environment, resources and citizens.

Literature on the estimation of carbon footprint from research activities and the scientific community has increased rapidly in the few past years [3–9] and indicates the significant impact of travels and events on the CF of research activities. The current study focuses on the development of a general methodology of GHG emissions of research projects, taking into account the most common and usually prevalent emissions sources related to common office activities (e.g., materials used/disposed by employees, energy used in offices, water used/disposed of by employees and purchased IT devices within the project), work-commuting and events, and by using statistical data, enables the possibility of estimating the CF of any project implemented within the Mediterranean area.

Thus, the aim of this study is to present a comprehensive approach for estimating the CF of research project activities based on well-known and established methodologies, emissions factors and statistical data while focusing on the Mediterranean area. The presented methodology has been developed within the framework of the Interreg-MED project "ToWards thE CARbon offsEtting in MED" (WECAREMED). In the framework of WECAREMED, the CF of several research projects had been estimated using the presented methodology; therefore, in the current study an application of the methodology is performed for the Interreg-MED project "Regenerating mixed-use med urban communities congested by traffic through innovative low carbon mobility solutions" (REMEDIO) which was implemented during the 3-year period 2017–2019, i.e., before the outbreak of the COVID-19 pandemic. The impact of "smart working" or "working-at-home", introduced during the COVID-19 pandemic and maintained as a working option afterwards, on the CF can be accounted for in the methodology of the current study through the reduction in the number of trips for work commuting. Any additional change in energy consumption or the use of office material is presently under investigation. However, the major scope of this study is to identify the most important emissions sources that contribute to the total CF of a research project and apply several mitigation scenarios for identifying the best practices to reduce carbon footprint in order to achieve a sustainable research project implementation.

In the current paper, a comprehensive methodology for estimating CF of research projects taking place in the Mediterranean area is presented in Section 2. An application of the methodology for the project REMEDIO is presented in Section 3, as well as an evaluation of the methodology through comparison with other studies. In Section 4, a mitigation scenarios analysis is discussed. The major conclusions of the study, including a list of the best solutions for a sustainable research project implementation, are presented in Section 5.

2. Materials and Methods

GHG emissions included in the Carbon Footprint estimation are the following: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulphur hexafluoride (SF_6) and Nitrogen trifluoride (NF_3). However, the GHGs emissions quantification process converts all GHGs emissions into Carbon Dioxide emissions as a CO_2e (equivalent), which is the universal unit of measurement to indicate the global warming potential (GWP) of GHGs, expressed in terms of the GWP of one unit of Carbon Dioxide. In the current methodology, the unit to measure the CF is tonnes of CO_2e.

The CF methodology developed in the current study is based on the GHG Protocol Guidance [10] and the Emissions Factors (EF) of the UK Department for Environmental, Food and Rural Affairs (DEFRA) [11], which includes the 2021 Greenhouse Gases Conversion Factors. We also used EF from the GHG Emissions Calculation Tool [12] and EF derived from the Clim'Foot Project [13].

According to the GHG Protocol, three "scopes" (scope 1, scope 2, and scope 3) are defined for GHG accounting and reporting purposes. The current methodology aims to include in its CF estimations all the activities taking place in each emissions source based on the Life Cycle Assessment (LCA) procedures.

It should be mentioned that the current study focuses on the Mediterranean area while its application concerns an Interreg-MED project. For this reason, it has been decided to collect activity data for the Cooperation area of Interreg-MED projects that include 10 EU Member States (Portugal, Spain, Italy, France, Slovenia, Croatia, Cyprus, Greece, Malta and Bulgaria) and 4 countries from the Instrument for Pre-Accession Assistance (IPA) (Bosnia and Herzegovina, Montenegro, Albania and North Macedonia). In case of limited data availability, activity data referring to the EU areas are used.

2.1. Emissions Sources

The emissions sources related to project activities estimated in the current methodology of CF are the following: heating from fuels, electricity, water, materials, transportation, printable deliverables, equipment and events. A detailed description of the methodology used (activity data, statistics, emissions factors) for the CF calculations of each emission source is presented in the following subsections.

2.1.1. Fuels (Heating)

The CF from the use of fuels (i.e., Natural Gas, Oil, Biomass, Coal, District Heat) for heating purposes by employees participating in the project was estimated. It should be mentioned that the CF from the use of electricity for heating purposes is accounted for in the next section within the source "Electricity". These emissions are classified into two scopes according to the GHG protocol: scope 1 emissions include primary fuel sources combusted at a site or in an asset owned or controlled by the reporting organization, and scope 2 emissions are associated with extraction, refining and transportation of the raw fuel sources to an organization's site prior to combustion, indicating that emissions are based on the whole LCA.

The CF is estimated using the emissions factors of DEFRA (2021) by fuel type. The main activity data, which are the annual energy use per employee for heating for each fuel type (that is, in kWh/PersonYear (i.e., kWh per employee per year)), is multiplied by the appropriate conversion factor to produce the corresponding fuel-type GHGs emissions for employees (Equation (1)).

$$\begin{aligned} \text{CF (Fuels-heating) (kgCO}_2\text{e, fuel)} &= \text{Energy Use (kWh/PersonYear, country)} \\ &* \text{Percentage Distribution of energy consumption (\%, fuel)} * \text{Emission} \\ &\text{Factor (kgCO}_2\text{e/kWh, fuel)} * \text{PersonYears (dimensionless)} \end{aligned} \quad (1)$$

The input activity data required for the CF estimation for fuels—heating are:

(a) The annual energy use per employee for heating purposes (in kWh/Personyear), which has been estimated from the required average energy consumption for space heating in non-residential buildings (in kWh/m^2) per country [14], multiplied by the average space occupied by one employee in offices (about 10 m^2) (Supplementary Materials, Table S1).

(b) The percentage distribution (%) of energy use for heating by energy source. A European profile of energy consumption by energy source in the service sector for the reference year 2018 has been derived from the European project Odyssee-Mure [15]: natural gas (31.6%), oil (9%), biomass (3.3%), coal (0.6%), district heat (6.8%), electricity (48.7%).

2.1.2. Electricity

The CF from electricity used by employees participating in the project was estimated. According to the methodology, emissions from electricity were estimated based on scope 2 emissions from electricity supplied to the grid that organisations purchase, and scope 3 emissions related to the transmission and distribution of electricity. The emissions factors of GHG Protocol Tool [12] per country were used.

The activity data, the average annual electricity consumption per employee (that is, in kWh/PersonYear) (Table S2) [16], were multiplied by the appropriate conversion factor to produce the corresponding CF emissions from electricity used by employees participated in the project (Equation (2)). For the Interreg-MED countries with no available data, the average annual electricity consumption per employee of the EU was used.

$$\text{CF (Electricity) (kg } CO_2e) = \text{Electricity Consumption (kWh/PersonYear, country)} * \text{Emission Factor GHGs (kg } CO_2e/\text{kWh, country)} * \text{PersonYears (dimensionless)} \quad (2)$$

2.1.3. Water

The CF from the water supply and treatment was estimated using the EF from DEFRA (2021). Water supply conversion factors were used to account for water delivered through the mains supply network, while water treatment conversion factors were used for water returned into the sewage system through mains drains. This emission source is classified as scope 3.

For the estimation of CF from water supply and treatment, the corresponding average annual water use and disposal per employee based on statistical data of previous studies [17] is required. It is estimated that 92.6% of water used is disposed [18]. Thus, the annual quantity of water used (9.3 m^3/PersonYear) and the annual quantity of water disposed per employee (8.6 m^3/PersonYear) was multiplied by the appropriate conversion factor to produce the corresponding CF emissions from water supply and treatment, respectively (Equation (3)).

$$\text{CF (Water) (kg} CO_2e\text{, water supply/treatment)} = \text{Water used/disposed } (m^3/\text{PersonYear, partner}) * \text{EF (kg} CO_2e/m^3\text{, water supply/treatment)} * \text{PersonYears (dimensionless)} \quad (3)$$

2.1.4. Transportation—Work-Commuting

The CF from employees commuting to/from work was estimated using the EF of DEFRA (2021) for the scope 3 emissions related to travel for business purposes in cars owned by employees or public transport, as well as upstream scope 3 emissions associated with extraction, refining and transportation of the raw fuels before they are used to power the transport mode.

According to the methodology, the total distance travelled in km for each mode of transportation is multiplied by the appropriate conversion factors to produce emissions for land/sea-based modes of transport (Equation (4)). The modes of transportation included in the CF estimations for work commuting are the following: cars, motorbikes, buses, taxis, national rail, light rail and tram/underground, ferries and other (for which CF is not estimated e.g., cycling, walking).

The main input data required were:

1. Total Number of two-way travels (to/from work).
2. Percentage distribution of travel distance by main travel mode (car, motorbike, bus, taxi, national rail, light rail and tram/underground, ferries, cycling, walking and other) per person per day for urban mobility.
3. Distance per daily two-way travel (in km) per person. These data were estimated using the average distance travelled per person per day of urban trips per country multiplied by the percentage of distance travelled per person per day for work commuting for urban mobility [19].
4. Percentage distribution of car fleet by technology (fuel) for EU countries (personal comm. with Emisia S.A), with 2019 being a reference year.

$$\text{CF (Work commuting) (kgCO}_2\text{e, mode transport)} = \text{Number of two-way travels (dimensionless)} * \text{Distance (km, country)} * \text{Percentage Distribution of urban travel distance per person per day (\%, mode transport, country)} * \text{EF (kg CO}_2\text{e/km, mode transport)} \quad (4)$$

2.1.5. Materials

CF calculations are made for the materials used or disposed of by employees in offices during the project's implementation. The methodology used is based on DEFRA (2021), in which emissions factors take into account processes based on the LCA. According to DEFRA (2021), for material use, materials are categorized based on their origin, either primary material or recycled materials. Emissions from primary materials cover the extraction, primary processing, manufacturing, and transportation of materials to the point of sale, and emissions from recycled materials cover sorting, processing, manufacturing and transporting to the point of sale. On the other hand, for waste disposal, emissions from end-of-life disposal of different materials come from a variety of different disposal methods. For landfill, emissions include collection, transportation, and landfill site emissions ('gate to grave') while for recycling, the factors consider any materials reclamation facility.

For material use, different EF are given for each type of material (glass, food and drink, aluminum cans, plastics, and paper) based on their origin (primary, recycled or reused). For material waste, different EF are given for each type of material (glass, food and drink, aluminum cans, plastics and paper) and each type of disposal.

The main input data required were:

1. The annual amount of material used or wasted (glass, food and drink, aluminum cans, plastics and paper) (in tn/PersonYear) per employee in offices (Table S3) based on previous studies [20,21], while it is assumed that all the materials used (except for food and drink) are wasted. Concerning food and drink, it was found that around 20% of food produced is wasted [22,23].
2. The percentage distribution of materials used by origin as primary, recycled and reused per type of material. It should be noted that reused materials have zero CF.
3. The percentage distribution of materials wasted by type of disposal per country (Table S4). This profile was based on the recycling rates (i.e., the share of recycled material waste in all generated material waste, expressed in percent (%)) by type of material per European country as derived from Eurostat for the year 2018 [24]. It should be mentioned that landfilling and recycling represent the main types of disposal for the majority of the Mediterranean countries according to Eurostat data [25]. Thus, it was assumed that the wastes that are not recycled are put in landfills. The percentage distribution (%) of food and drink wasted by type of disposal (i.e., composting, anaerobic digestion, landfill) per country (Table S5) was derived from the EEA (2020) [22]. In particular, the percentage distribution of bio waste (food and garden waste) collected separately (i.e., considered as composting or anaerobic digestion treatment) as a share of bio waste generated at a national level as well as the shares of treatment capacities of bio waste (i.e., % of composting and anaerobic digestion to bio

waste) were used. Moreover, it was taken into account that according to EEA (2020) the percentage contribution of garden waste in MED countries is lower than those of food waste and therefore these profiles could be considered as representative for food waste.

Equations (5) and (6) are used for CF estimations for materials used and wasted, respectively.

$$\text{CF (Materials use) (kgCO}_2\text{e, material, origin (primary/recycled))} = \text{Material used (tn/PersonYear, material)} * \text{Percentage distribution of materials used by origin (\%, material, origin)} * \text{Emission Factor (kgCO}_2\text{e/tn, material, origin)} * \text{PersonYears (dimensionless)} \quad (5)$$

$$\text{CF (Materials wasted) (kgCO}_2\text{e, material)} = \text{Material wasted (tn/PersonYear, material)} * \text{Percentage distribution of materials wasted by type of disposal (\%, material, type of disposal)} * \text{Emission Factor (kgCO}_2\text{e/tn, material, type of disposal)} * \text{PersonYears (dimensionless)} \quad (6)$$

The emission source "Materials" also includes the amount of paper used and wasted by employees for the printing of the deliverables required within the framework of a project. For this reason, activity data such as the number of copies, pages per copy and size of paper per deliverable are used for the CF estimation.

2.1.6. Equipment

The CF from the primary production of IT equipment purchased during the projects was calculated based on the EF derived from the Clim'foot Project [13]. The activity data (that is the number of items of individual IT devices) are multiplied by the appropriate EF (given $kgCO_2e$ per device) to produce the corresponding CF. The IT devices for which CF can be estimated in the current work are the following: laptops, PCs, PCs with flat screens, flat screens, printers and copy machines.

$$\text{CF (Equipment) (kgCO}_2\text{e, IT equipment)} = \text{Number of IT devices (devices, IT equipment)} * \text{EF (kgCO}_2\text{e/device, IT equipment)} \quad (7)$$

2.1.7. Events

The CF from events (e.g., meetings, public events and conferences) organized by the project or participated in by the project was generated from the following sources, according to the current methodological approach.

For on-site events organized by the project, CF from the following emissions sources was estimated: fuels (heating), electricity, water, materials used, materials disposal, transportation and hotel stays.

The transportation section in events includes two emissions sources:

- arriving at or departing from the host city (including national or international travels by car, bus, national/international rail, ferries and airplane)
- moving to/from the hosting place (e.g., the moving of participants from the hotel to the hosting place) by car, motorbike, taxi, public transportation, cycling, foot.

The methodology implemented is based on that described in the previous subsection with the following considerations:

- The main input data for the CF estimation were the average daily energy use for heating per participant (kWh/participant/day) in on-site events associated with the physical presence of participants. Thus, the average total daily energy use per participant in events was considered to be 0.2 kWh/participant/day [26].
- The average daily water use/disposal per participant in events was based on the average annual water use/disposal per employee, assuming that an employee works for 220 days per year.

- The average wasted material per event per day per participant was considered to be 0.5 kg distributed as follows: 55% paper, 19% food and drink, 0.4% aluminum cans, 16% plastics and 5.6% other material [26,27].
- The percentage distribution of travels by type of destination (72% national and 28% international) as well as the percentage distribution of international/national travels in Europe by transport mode (Table S6) was derived from Eurostat [28], using the number of outbound (i.e., international) and domestic (i.e., national) trips in Europe for professional/business purposes by mode of transport for the year 2019.
- The average distance per two-way international and national travel (in km) was assumed to be 3600 km (considering that the half the length of the Mediterranean area is 1800 km) and 1000 km, respectively.
- The number of two-way travels for moving to/from the hosting place was assumed to be equal to that of the number of participants, while the two-way distance travelled is relevant to the country hosting the event (similar to that presented in Section 2.1.4).
- The length of stay (in number of nights) was assumed to be equal to the duration of the event (in days).
- The number of hotel rooms per night was assumed to be equal to the total number of non-local participants.

For the participation of project partners in on-site events, only the arrival at or departure from the hosting city and the hotel stay emissions were considered. A detailed CF estimation was made based on the means of transportation (e.g., car, airplane, railway), distance travelled, hosting country and duration of the event.

For the on-line events (internal meetings or hybrid events with the option of virtual participation) the electricity consumption of PCs, wi-fi routers, lighting (desk lamp usage) and data transfer by the on-line participants was taken into account for the estimation of the corresponding CF [29,30].

It should be mentioned that the CF from the hotel stay of participants was estimated based on the EF and methodology of DEFRA (2021) according to Equation (8). Thus, the number of hotel rooms was multiplied by the length of stay (in number of nights) and by the conversion factor for the hosting country to give the associated emissions.

$$\begin{gathered}\text{CF (Hotel Stay) (kgCO}_2\text{e, event)} = \text{Number of hotel rooms per night} \\ \text{(dimensionless, event)} * \text{(Duration of event in days) (nights, event)} * \text{EF} \\ \text{(kgCO}_2\text{e/room per night, hosting country)}\end{gathered} \quad (8)$$

2.2. Application

In the current study, the methodology described in the previous section was implemented for the Interreg-MED project REMEDIO. REMEDIO had a duration of 3 years (2017–2019) and focused on innovative low carbon mobility solutions. Four cities from the Mediterranean area were chosen as pilot cities to implement REMEDIO actions (Loures, Treviso, Split and Thessaloniki) while eight partners participated in the project from five Mediterranean areas.

The basic data used for the implementation of the CF methodology for the project REMEDIO are listed below (for both base case and mitigation scenarios):

1. Duration: 36 months
2. Number of project partners: 8
3. Country of partners: Greece, Italy, Spain, Portugal and Croatia
4. Number of full-time employees participating in the project: 34 (13 for Italy, 7 for Portugal, 7 for Spain, 5 for Greece and 2 for Croatia)
5. Number of part-time employees participating in the project: 8 (4 for Spain, 3 for Greece and 1 for Croatia)
6. IT equipment purchased during the project by all partners: 10 PCs.

For the number of two-way travels for work-commuting, it was assumed that a full-time employee commutes from/to work 220 times per year.

In the following subsection the description of the application study for the base case scenario, as well as for the mitigation scenarios, is presented.

2.2.1. Base Case Scenario

In the base case scenario, the following activity data were used:

- Three copies (of 50 pages) of deliverable reports, 420 brochures and 20 posters/rollups were printed.
- All of the materials (100%) used by employees for office activities, printable deliverables and materials used in events had primary origin.
- Twenty-nine on-site events were organized by the project partners in the Mediterranean area (Croatia, Spain, Italy, Portugal and Greece); 24 events with 30 participants (10 of them were non-local participants who travelled only for the event participation) with a duration of 1 day and 5 events with 30 participants (20 of them were non-local) with an average duration of 1.5 day.
- Fourteen participations in on-site events that took place in the Mediterranean area (France, Spain, Italy, Portugal, Greece and Cyprus) by project partners (two participants in each event) with an average duration of 1.5 day.

Regarding the commuting of employees to/from work as well as the movement to/from the hosting place of events by participants, a standard profile for the percentage distribution of travel by main travel mode (car, motorbike, bus, taxi, national rail, light rail and tram/underground, ferries, cycling, walking and other) was used as derived from Eurostat (Table S7).

2.2.2. Mitigation Scenarios

In the current section, the mitigation scenarios implemented for the REMEDIO project are described and explained in detail. The mitigation scenarios implemented for reducing the CF of the project were related to:

- the promotion of recycled or reused materials by employees and participants of events
- the limitation of the number of printed deliverables
- the promotion of public transportation and soft mobility (e.g., cycling, walking) for the commuting of employees to/from work or for moving to/from the hosting place of events
- the promotion of environmentally-friendly means of transportation for the arriving at or departing from the hosting city of events (e.g., public transportation, railway instead the use of private cars)
- the organization of hybrid or on-line events instead of on-site events.

Mitigation scenarios related to office activities were selected to change in the origin of materials used by employees (i.e., paper and plastics) while the use of public transportation and cycling or walking for the work-commuting was also implemented. The scenarios implemented are presented in detail in Table 1.

In particular, according to the European Strategy for plastics [31], all plastic packaging will be reusable or recyclable in a cost-effective manner by 2030 while it is stated that by 2030, 55% of the plastics waste generated in Europe will be recycled and re-used. Thus, a moderate scenario (SCN1) for plastics was chosen in addition with a more ambitious one (SCN2) where employees used only recycled and re-used materials. Similarly, a moderate scenario where the 50% of paper used by employees was recycled (SCN1) was used in addition with a more optimistic one where employees used only recycled paper (SCN2).

Table 1. Description of the mitigation scenarios related to office activities and employees for reducing the CF of the research project.

Relevance	SCN1	SCN2
Origin of paper used for office activities	50% primary 50% recycled 0% re-used	0% primary 100% recycled 0% re-used
Origin of plastic used for office activities	45% primary 30% recycled 25% re-used	0% primary 50% recycled 50% re-used
Limitation in printed materials	-	Replace all printable deliverables (reports, brochures) with digital ones
Promotion of public transportation and soft mobility in work commuting	decrease by −20% the use of cars and increase the % of public transport, cycling, walking	decrease by −55% the use of cars and increase the % of public transport, cycling, walking

For printed deliverables, SCN2 was implemented, taking into account that all deliverables (reports, brochures) were disseminated electronically as it was proposed in the Greening and Social Inclusion of the Interreg-MED programme, being in line with the Sustainable Development Strategy [32].

For the work-commuting of employees, the percentage distribution of travels by main travel mode (car, motorbike, bus, taxi, national rail, light rail and tram/underground, ferries, cycling, walking and other), as given in Table S7, was modified in order to implement a moderate (SCN1) and an optimistic (SCN2) mitigation scenario related to the promotion of public transport and soft mobility. According to the European Green Deal, the European Commission proposes a −55% reduction in emissions from cars by 2030 [33] while focusing on promoting public transportation, cycling and walking. Moreover, in the framework of the REMEDIO project, a low carbon mobility solution was implemented based on the redesign of a main road axis of Thessaloniki, which would result in an increase in the use of buses and bicycles through the construction of a modern 2nd generation separated bus lane and bicycle lane. In that case, a −20% reduction in the use of cars and motorbikes was foreseen for Thessaloniki along with an increase in the public transport by a factor of 2 [34]. Furthermore, according to a previous study related to urban passenger transport toward sustainability through modal shift in Germany [35], a proposed target for 2035 is given where motorized private transport will be reduced by around −55% compared with 2017 modal shift while public transport and soft mobility (i.e., cycling and walking) will increase by a factor of 2.5 and 1.5, respectively. Based on the above, the scenarios presented in Table 1 were implemented for work-commuting.

Regarding the mitigation scenarios implemented for events organized by the project (Table 2), those were chosen by taking into account the Guidelines for Sustainable Events provided by the Interreg-MED programme [26].

According to the guidelines, a plastic-free event is recommended, along with the use of recycled materials (paper, glass, metal) and therefore only the use of 100% re-used plastics and recycled paper, glass and aluminum cans were used.

Furthermore, regarding the moving of participants to/from the hosting place, it is recommended to select hosting places and suggest accommodation options with easy access on public transportation (walking distance). Thus, for moving to/from the hosting place, only the use of buses and soft mobility options was selected. For the travels of participants to/from the hosting city, it is recommended to select a location based on its accessibility (direct flights, rail connections) and encourage participants to use only air transport and railways. For this reason, an ambitious scenario where participants used only railways, buses and air transport for their travel instead of cars was implemented.

Table 2. Description of the mitigation scenarios related to events organized by the project for reducing the CF of the research project.

Name	Relevance	Scenarios
A1	Origin of materials (i.e., paper, glass, aluminum cans) used in on-site events	0% primary 100% recycled 0% re-used
A2	Origin of plastic used in on-site events	0% primary 0% recycled 100% re-used
B	Promotion of public transportation and soft mobility in moving from/to the hosting place	Use only buses, cycling, walking
C	Promotion of environmentally friendly means of transportation for the travel of participants from/to the hosting city	Use buses and railway instead of cars
D1	On-line events	Reduce on-site events by 25% and replace them with on-line ones
D2	On-line events	Replace all on-site events with hybrid

The replacement of on-site events organized by the project with hybrid (both on-site and on-line) or on-line was examined since it is suggested the organizers consider whether a video conference instead of a meeting is possible. More specifically, scenario D1 (in Table 2) replaced 25% of on-site events with on-line ones, while in the case of scenario D2 (in Table 2), all on-site events were replaced with hybrid ones where it was considered that 50% of participants would attend the event virtually and 50% of them would participate in-presence.

3. Results

The results for the base case scenario of REMEDIO project are presented along with an evaluation of the methodology through comparison with other studies.

3.1. Base Case Results

For the base case scenario, the carbon footprint results of the REMEDIO project are presented in Table 3 for each emissions source. It is shown that the major contributor to the carbon footprint was the on-site events organized by the project (40.7%) followed by electricity (30.1%) and materials used (15%) by employees for office activities. It seems that material waste has a low impact on the total CF of the project (<1%). This is due to the fact that the emissions from recycling, composting and anaerobic digestion are attributed to the user of the recycled materials, not the producer of the waste, as per the GHG Protocol Guidelines (DEFRA 2021). Work-commuting represents 4.6% of the total carbon footprint of the project, while printable deliverables have a negligible impact.

Since on-site events were the major contributor to the CF of the project, it is worth further analyzing the subcategories of emissions sources that increased its CF. According to Table 4, the travel of participants to/from the host city of events contributed about 88% to the total CF of on-site events. In particular, as shown in Table 5, cars and air transport contributed by around 49% and 45%, respectively, to the total CF of the participants' travels. Hotel stay was the second contributor (by 9.3%) to the total CF of on-site events, followed by the materials used by participants (2.1%).

Table 3. Carbon Footprint (in tCO_2e/project) for the base case scenario during the whole REMEDIO project period.

Emission Source	CF (tCO_2e/Project)
Fuels (Heating)	7.3
Electricity	79.1
Water	0.15
Work-commuting	12.0
Materials use	39.4
Materials waste	2.1
Equipment	5.1
Printable deliverables	0.01
On-site events organized by the project	107.1
On-line events organized by the project	0
Events participation	11.7
Total	263.9

Table 4. Carbon Footprint (in tCO_2e/project) of on-site events organized by the project for the base case scenario.

Emission Source	CF (tCO_2e/Project)
Fuels (Heating)	0.02
Electricity	0.04
Water	0.02
Moving from/to the hosting place	0.6
Arriving at/departing from the hosting city	94.1
Materials use	2.2
Materials waste	0.08
Hotel Stay	10.0
Total	107.1

Table 5. Carbon Footprint (in tCO_2e/project) of the arriving at or departing from the hosting city of on-site events organized by the project for the base case scenario.

Emission Source	CF (tCO_2e/Project)
Cars	46.3
Buses	2.7
Rail	3.1
Ferries	0.1
Airplane	41.9
Total	94.3

3.2. Evaluation of Methodology

In this section, a comparison is made of the CF of specific emissions sources, estimated with the current developed methodology, with CF results found in the literature. In order for the comparison to be easily made, the estimated CF was converted to an average value of CF per employee per year or per participant per event in case of events.

According to the methodology presented above, the estimated CF of a project, taking into account only office activities related to fuels (heating), electricity and water use/disposal, is 2.57 tCO_2e per employee per year. According to Europeana's Carbon Footprint Hack Week Project [36], the corresponding CF was estimated as 1.87 tCO_2e per employee per year. It should be mentioned that the estimations were made for Italy.

Regarding work-commuting, it has been estimated that around 0.143 tCO_2e per employee per year was generated [37] while the corresponding emissions for Italy in the current methodology were estimated at 0.17 tCO_2e per employee per year.

As far as on-site events are concerned, it has been found that for a 1-day event with 241 non-local participants, 0.44 tCO_2e per participant was generated [38] while the corresponding emissions estimated with the current methodology were 0.30 tCO_2e per participant per event.

Finally, according to Eurostat [39], on average over the EU28 countries, the average annual carbon footprint was estimated to be about 8.3 tCO_2e per capita for 2019 while the average value of the CF for Greece, Italy, Croatia, Portugal and Spain was estimated to be 7.1 tCO_2e per capita. In the REMEDIO project application, with a duration of 3 years and around 39 full-time employees located in the aforementioned countries, the total CF was estimated at 263.9 tCO_2e/project, which corresponds to 6.7 tCO_2e per employee.

4. Discussion

In this section, the results from the mitigation scenarios are presented and discussed in order to identify the best practices that can be followed while implementing a research project to reduce its CF.

Table 6 presents the percentage differences in CF of emissions source, separately, related to office activities and employees (that is, work-commuting and materials use) between the base case and the mitigation scenarios shown in Table 1. It should be noted that the differences refer to the difference in the CF of each emissions source when implementing the corresponding scenario and not to the difference in the total CF of the project. The promotion of public transportation in combination with soft mobility results led to a reduction of up to −36.6% in the CF of the work-commuting of employees while the use of recycled papers and re-used plastics reduced the CF of this source by up to −6.2%. Regarding printable deliverables, the change in the origin of the paper used in addition with the digitalization of deliverables and brochures resulted in a reduction of up to −79% in CF of printable deliverables. The cumulative impact of the scenarios related to work-commuting and office activities on the total CF of the office activities of the project (including fuels-heating, electricity, water, materials, IT equipment, printable deliverables) is a reduction of up to −4.7%.

Table 6. Percentage differences (%) in CF of each emissions source between the base case and the mitigation scenarios related to office activities and employees for reducing the CF of the research project.

Emission Source	SCN1 (%)	SCN2 (%)
Work-commuting	−10	−36.6
Materials use by employees	−3.3	−6.2
Printable deliverables	−77	−79
Total office activities	−1.7	−4.7

Regarding the mitigation scenarios for events, Table 7 presents the percentage difference in the CF of each emissions source for each individual implementation scenario. Using environmentally-friendly means of transportation (i.e., railway, buses) instead of cars for the travels of participants from/to the hosting cities resulted in a −50% reduction in the CF of this emissions source, which is the major contributor to the total CF of the project. The combination of scenarios A, B and C, which are related to the materials used and transportation, can be considered very effective since they reduced CF of the on-site events organized by the project by around −45%. The replacement of the 25% of on-site events with on-line ones led to a satisfactory reduction of about −29% in CF of events organized by the project, while the more ambitious scenario (D2) where all the on-site events were replaced with hybrid events resulted in a −48% reduction in the corresponding CF. An increase in the total CF of events organized by the project by around +2% was found due to the addition of on-line events, attributed to the electricity consumption. It should be noted that the duration of the virtual events was considered to be 5 h. The implementation of the most optimistic mitigation scenarios for events (A, B, C, D1, D2) led to a steep reduction of about −78% in the CF of events organized by the project.

Table 7. Percentage differences (%) in CF between the base case and the individual mitigation scenarios related to events organized by the project.

Name	Scenario	Emission Source	Difference in CF of Each Emissions Source between the Base Case and Mitigation Scenario (%)
A1-A2 (A)	Use of 100% recycled papers and 100% re-used plastics	Materials use by participants	−13
B	Use of buses/cycling/walking	Moving from/to the hosting place	−62.1
C	Use of railway and buses instead of cars	Arriving at/Departing from the hosting city	−50
A-B-C	Cumulative impact of scenarios A, B, C	On-site events organized by the project	−44.9
D1	Replace the 25% of on-site events organized by the project with on-line ones	Events organized by the project	−28.6
D2	Replace all on-site events organized by the project with hybrid	Events organized by the project	−48
A-B-C-D2	Cumulative impact of scenarios A, B, C, D2	Events organized by the project	−70.6
A-B-C-D1-D2	Cumulative impact of scenarios A, B, C, D1, D2	Events organized by the project	−78.4

When examining the cumulative impact of the implementation of all the optimistic scenarios studied (SCN2 for office activities and scenarios A, B, C, D1, D2 for events) on the total CF of the project, it is found that a −35% reduction in the total CF of the project is foreseen.

Even though the individual scenarios had a significant effect on the reduction in the CF of the corresponding emissions source where the scenarios related to travels being the most effective, the total CF of the project was not highly reduced due to the impact of electricity consumption by employees on the total CF, for which no mitigation scenarios were investigated through the study. This is because, scenarios for the reduction in the electricity consumption were mostly related to the use of renewable sources and therefore are not always feasible, since employees participating in research projects usually work in the premises of research institutes or universities. However, according to the energy efficiency targets of the European Union (https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-targets_en, accessed on 1 November 2022), an energy efficiency target of at least 32.5% for 2030 has been set.

Based on the EU energy efficient target, a corresponding reduction in the CF of electricity would result to a −23% reduction in the CF of office activities (including work-commuting) when implementing SCN2, and a −45% reduction in the total CF of the project when implementing the optimistic scenarios (SCN2 for office activities and scenarios A, B, C, D1, D2 for events).

Regarding energy-saving practices, several studies in the past have investigated practices followed by employees for reducing energy consumption in offices [40–42]. Thus, according to the literature, easy ways for making a workplace energy-efficient and sustainable is (a) to switch off artificial lights and use natural light, (b) use low wattage lights, (c) use laptops instead of desktops, (d) use energy-saving features for all electronical devices, (e) upgrade outdated equipment, (f) buy energy efficient devices and (g) control heating and cooling systems.

5. Conclusions

This study presented a comprehensive methodology of estimating the carbon footprint of research projects using well-known and established methodologies, emissions factors and statistical data. An application of the methodology for the Interreg-Med project REMEDIO identified the major emissions source of CF of the project as the on-site events, representing a 41% share, followed by electricity (30%), materials used (15%) and work-commuting (4.6%). Regarding events, it was shown that the travel of participants to/from the hosting city was the most significant contributor to CF and cars and air transport contributed the highest share.

Considering the sensitivity analysis performed by implementing several mitigation scenarios, it is concluded that the best practices to be followed for a more sustainable project implementation, which could result in a −45% reduction in the CF of the project examined, are the following:

- energy-saving practices in offices following the EU target of −32.5% reduction
- promoting the use of re-used and recycled plastics and papers by the employees
- promotion of the use of public transport and soft mobility for work commuting (up to −37% reduction in the CF of work-commuting)
- improved organisation of events as described below (resulting to a reduction of up to −78% in the CF of events):
    - use of re-used and recycled materials (−13% reduction in the CF of events)
    - use of public transportation and walking/cycling for the transportation of the participants to/from the host location (−62% reduction in the CF of events)
    - use of environmentally friendly means of transportation (i.e., buses, railway) for national/international travelling to participate in events (−50% reduction in the CF of travels)
    - organization of hybrid events (−48% reduction in CF of events).

Finally, it should be noted that our methodology focused on projects implemented within the Mediterranean area, taking into account research activities related to office activities, work-commuting and events. Additional research activities such as experiments or small-scale investments are outside of the scope of the study, which focused on the most common research activities and usually the major emissions sources. Moreover, the application study concerned an Interreg-MED project including a relatively large number of organized events leading to an increased carbon footprint from this source. Applying the methodology for different types of research projects and its extension into other European geographic areas, in order to investigate further the variability of the contribution of each emissions source in the different project types, will be a future work.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/atmos14010006/s1, Table S1: Average annual energy use per employee (in kWh/Personyear) for heating purposes. Table S2: Average annual electricity consumption per employee (in kWh/Personyear) for heating purposes. Table S3: Average annual amount of material used or wasted (glass, food and drink, aluminum cans, plastics, paper) (in tn/PersonYear) per employee in offices. Table S4: Percentage distribution (%) of materials wasted by type of disposal per country. Table S5: Percentage distribution (%) of food and drink wasted by type of disposal. Table S6: Percentage distribution (%) of international/national travels in Europe by transport mode. Table S7. Percentage distribution of travels by main travel mode (car, motorbike, bus, taxi, national rail, light rail and tram/underground, cycling, walking and other).

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