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Reflecting on the environmental impact of research activities: An exploratory study

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Abstract

Setting the sustainable transition in motion implies reflecting on all areas linked with human activities and in all types of organizations. This transition has been examined in research for many industrial activities, however a reflective positioning on the environmental impacts associated with professional activities, and notably research ones are scarce. Researchers produce knowledge that should hopefully benefit the human society in a broad sense by bringing some benefits (technological, ecological, social, economic...), but they also engage activities that have themselves an environmental impact. Although research activities vary depending on the domain, common core activities include for example professional travels (including conferences) and the use of digital resources. Moreover, there is an acknowledged potential in transferring environmental practices from home to work (or vice versa), related to waste, food, energy or mobility for instance.

The aim of this study is to conduct a first environmental diagnosis of research activities at the scale of a research department, with a specific zoom on attending conferences and other business travels. The empirical work involves 9 volunteering researchers over a period of 3 months, and is built on a declarative basis. The environmental impact (GHG emissions) of declared professional expenses (transportation, accommodation and meals) is estimated based on their nature and economic value. From the diagnosis we derive a set of recommendations and action plans to support the transition towards sustainable research practices.

Keywords: sustainable behaviour; research activities; transition; environmental impact

1. Introduction

Nowadays, the human pressure on climate change is well recognized in both technosphere and civil society. An urgent need to change behaviors is pointed out by the IPCC. Research and researchers' activities also contribute to greenhouse gases (GHG) emissions. In this context, researchers do not escape to the need of being aware of their environmental impacts and envisaging a mitigation plan towards a lowest pressure on environment, especially when they work in the field of sustainability.

At a national level, it can be mentioned the initiative of the Labos1point5 [1]. French researchers of the collective promote a positive in-depth transformation of research practices to reduce environmental impacts, in line with the objectives of the Paris climate agreement. Among the ongoing initiatives, they mention the assessment of GHG emissions for conferences, meetings or digital equipment. They also stress the support needed from the state, the financing and assessment agencies at the national and European level.

Yet in 2003, Reay already shed light on GHG emissions from research activities and especially flying to attend to scientific conferences [2]. In 1992, with 500 million tons of CO₂, air travels for such a purpose were responsible for 13% of transportation emission worldwide. Considering the increasing number of international conferences, the use, even if limited, of the virtual conferences was a promising solution.

Later the message was relayed to address the paradox of scientists acting for a better world [3,4]. Indeed, even if

involved in Nature preservation, scientists contribute to the global warming through flying activities. In 2007, thirteen scientists in the field of Nature Conservation reported that flying accounted for about 70% of their average carbon footprint [4].

At the time, Bossdorf et al. claimed the transition towards climate-neutral ecology conference was engaged [5]. The authors also pointed out that climate change was big issue to tackle. However, conferences take part of research activities. This implies several other environmental issues, such as water footprint and impact on biodiversity, which conferences are also responsible for. More recently, Holden et al. complemented this vision [6]. They evaluated the environmental impact policies of 116 international and national conferences from 18 scientific disciplines which took place in 31 countries. Only 9% engaged actions to reduce environmental impacts of the meetings. More interesting are the reasons why they did not address this issue. First, most of organizers did not think about it. Second, when they did, they felt disarmed without any kind of guidance on how preventing the environmental impacts.

Although environmental-friendly conferences do not seem to be systematic, a growing number of papers relates to environmental assessment of such meetings [7–10]. Most of them propose a breakdown structure of conference activities and their environmental impacts. Environmental benefits of specific actions, such as meat-free meals, dematerialized proceedings or limited distribution of goodies for example, are evaluated compared to traditional practices.

As flying is the most impacting contribution to the entire research activity, it is legitimate that most of papers deal with this issue. However, in a perspective of piloting research activities, such a focus does not seem to be sufficient. Moreover, since travels are organized by the conferences' participants, one may argue that the environmental impacts of a conference are mainly managed by the participants themselves.

The aim of this paper is to investigate the environmental impact and the economic cost of business trips from a researcher and research department point of view. In addition to the diagnosis, a set of recommendations is proposed to guide researchers and their organization towards the reduction of their environmental impacts in their daily activity, as individuals and members of a research community.

This paper is structured as follows. Section 2 emphasizes the scope and results of studies which assess environmental impacts of research activities, and conferences more specifically. Section 3 presents the approach and first results of the case study developed at the scale of a research department. Section 4 proposes a discussion about the usefulness of a calculator tool to assess GHG emissions in our context, and also on the implications for researchers and research teams in the individual and collective management of conference attending and business trips in general. Section 5 concludes on perspectives of evaluation of impacts associated with research activities at multiple scales (researcher, research team and organization).

2. Assessing the environmental impacts of research activities

Few studies are related to uncovering environmental impacts of research activities.

Wishing to embrace a full science making process, Achten, Almeida and Muys quantified the total life cycle carbon footprint of the scientific activities of one PhD student in environmental sciences at the university of Leuven (i.e. desktop work, fieldwork, meetings, and conferences) [11]. They showed that 74% of the emissions are attributed to the transport –including commuting–while the remaining 26% deal with office, internet, printing and food emissions. Four mitigation scenarios were developed and quantified, based on individual choices to attend remote conferences or meetings, to cycle to work; institutional choices to provide green electricity.

Among the research activities, a specific focus is made on conferences and travelling and especially the impact of flying and on scientific knowledge dissemination through international conferences.

Focusing on the carbon footprint of an annual conference in the US, Astudillo and Azarijafari [8] conducted a Life Cycle Assessment (LCA) study to estimate the transport, food and accommodation emissions per participant, based on 122 responses to an online questionnaire. They concluded that transport-related emissions are dominant and vary depending on the distance travelled, whereas food and accommodation only account for 1 and 2% of the total CO₂ emissions. They also emphasized the increase in emissions due to connecting flights.

Wynes et al. [12] explored the academic air travel emissions related to conferences and meetings for 997 travellers of a major Canadian university. In this 18 month study, the authors were specifically interested in the influence of air travel on professional success (i.e. salary, h-index and seniority). They showed that (1) air travel had no influence on academic productivity; (2) senior researchers and academics with higher salaries travelled more and caused more GHG emissions; (3) surprisingly, no difference was observed in air travel behaviour between Green (i.e. sustainability related) and Non-green academics; (4) a gender difference appeared in the sample, where men significantly air-travelled more than women.

Nursey-Bray et al. [13] qualitatively investigated the factors motivating academics to air-travel in 5 Australian faculties, and the implications on pro-environmental behaviour. They stressed multiple tensions between the perceived importance of travelling for the academic practice (work, career, face-to-face meetings etc.) and the institutional commitment to sustainability. They concluded that academic institutions indeed have the opportunity to “*Empower and reward individuals to become climate-smart travellers*”.

3. Assessment of GHG emissions of conferences and professional meetings for a research department

3.1. Method

The underpinning framework for the approach is the activity-centred design, see [14], which is based on the activities performed by daily users, in our case by researchers.

This empirical study is based on the economic and environmental diagnosis (limited in this case to GHG emissions) of activities of a research department, where three of the authors are active members. The scope of the diagnosis was set as follows.

- A trial time period of 3 months (July-Sept. 2019) was considered, during which several conferences or business trips were planned.
- An activity scope covering conferences and other professional meetings over the period, considering travel, accommodation and meals (other than provided at the conference) in line with the study by Astudillo and Azarijafari [8].

The initial call was accepted by 20 volunteering researchers. After launching in July, two reminders were sent by e-mail. The online assessment was eventually fully filled by 9 respondents. The study is built on a declarative basis, where respondents accepted to report all expenses that are eligible.

To support the assessment, the choice was directed to an online calculator tool (named Budget our Planet) currently under development and used in several organizations (both private and public) for its user friendliness and customization potential. A short manual of instructions to fill the expense sheets was provided to participants (see example of travel sheet in Fig. 1). Emission factors integrated to the calculator are drawn from ADEME. Results provided include (1) the GHG emissions (in kg CO₂ eq.) against expenses categories; (2) the costs (in euros) associated with the categories. To assess the emissions of each expense category, the online calculator proposes a simplified evaluation:

- For travels, the user chooses a transportation mode (car, plane, train...), a departure and an arrival point; if a car is used, the number of passengers, and if it is a one-way or a round trip. The emission assessment is based on the distance and the trip mode.
- For accommodation, the user indicates the length of the stay, the number of rooms and the number of people in the room; finally the users indicates if the breakfast is included in the price. The emissions are proportional to the price of the accommodation.
- For meals, the user indicates the meal type (red meat, white meat, fish, vegetarian, vegan). The emissions are estimated with the ADEME data for an average meal.

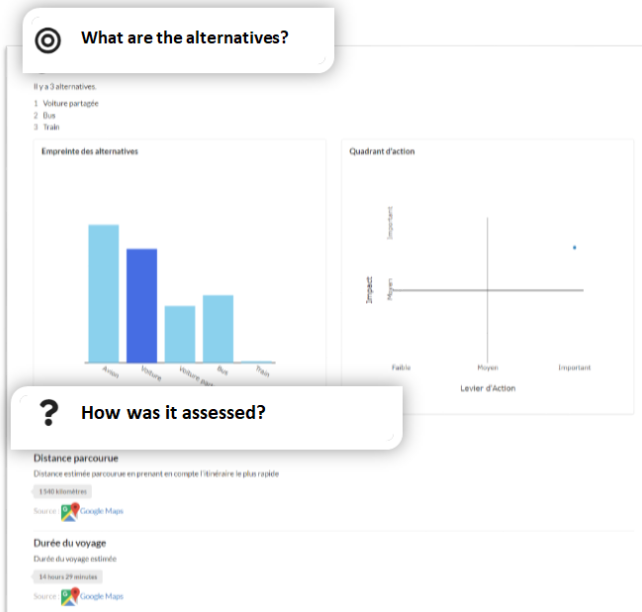
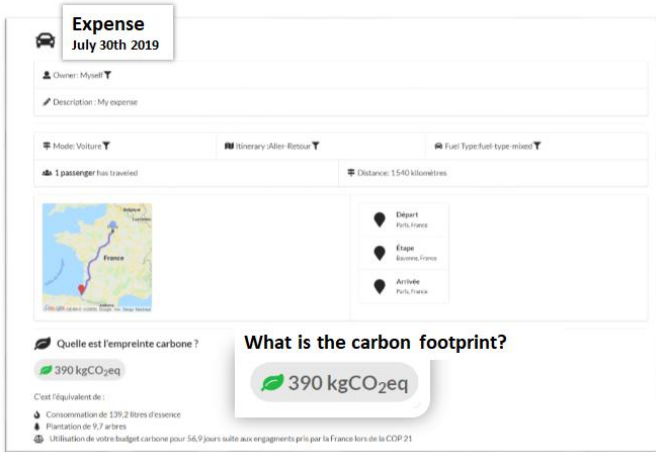


Fig. 1. Screenshot of a travel sheet

3.2. General results of the experiment

Nine participants contributed to the experiment with a total of 109 evaluations (an evaluation being one data input in one of the three observed expenses: travel, accommodation, meal) and for a total cost of 4965€, a total distance of 16.953km of distance travelled, and 2203kg of CO2 eq. Among the 109 evaluations, 6 different business travels were covered, meaning that several researchers participated to some

common events. Figure 2 shows the breakdown of the total evaluations. The contributions of the 9 participants were very variable, meaning that some participants indicated only a round train travel, while others entered the totality of their expenses during a 6 days trip (for attending a 4-days conference).

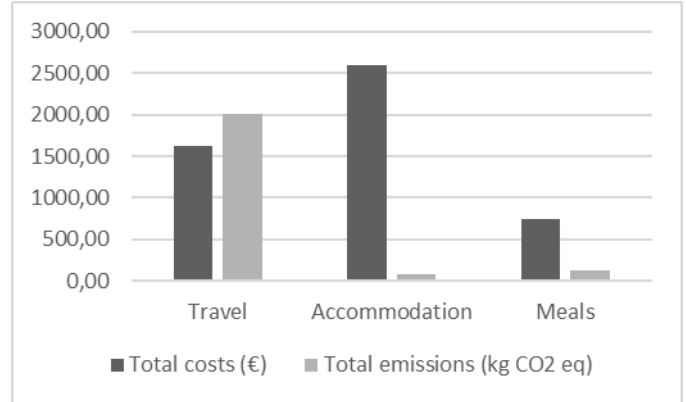


Fig. 2. Breakdown of the 109 evaluations by the 9 participants

One may notice that the economic costs and environmental impacts are not correlated. The high impacts of the travels are due to plane trips (see section 3.4), while the accommodation represents the main cost item (due to business trips in areas with high cost of living) with a minimal environmental impact. We now examine the details of the results per respondent and per conference.

3.3. Variability of the results for an identical conference

6 of the 9 participants attended to the International Conference on Engineering Design (ICED 2019) organized by the Design Society at the Delft University of Technology (TU Delft) in the Netherlands, from August 5 to 8. The completeness of the data is high, meaning that almost all the pieces of information were gathered for the travels (from Paris to Rotterdam by Thalys high speed train, and local travels from Rotterdam to Delft each day), as well as for the accommodation (5 hotel nights per person). The data were less complete for the meals because some of the participants did not entered all their meals. Figure 3 and 4 show the emissions and costs breakdown for the 6 participants.

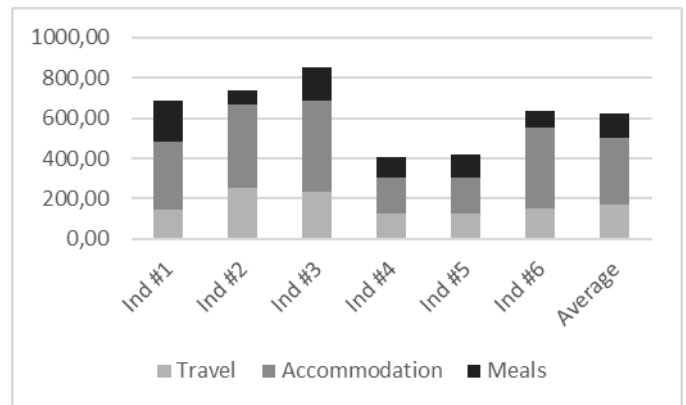


Fig. 3. Costs of the ICED 2019 participants' expenses (in €)

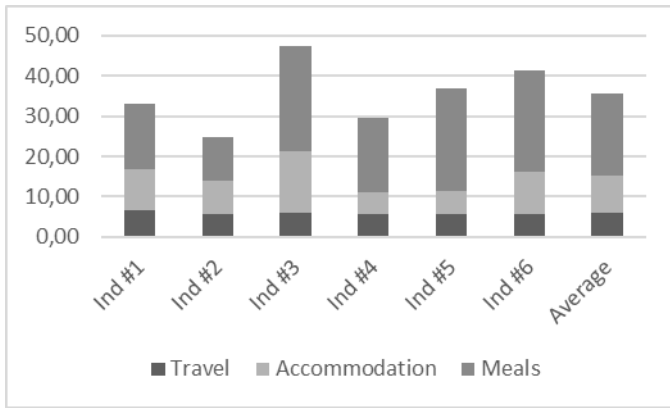


Fig. 4. CO2 eq. emissions of the ICED 2019 participants (in kg CO2 eq.)

A same order of magnitude of the costs and emissions is observed for the 6 participants. Costs of individuals 4 and 5 are lower because they shared a same hotel room with twin beds. Light differences are observed for the accommodation and travel costs because of the hotel and train prices fluctuations (the participants booked the same hotel and Thalys train at different moments; only Individual 6 was in a different hotel). The accommodation emissions (ranging from 5.61 to 15.50, Mean=9.30) are higher for Individual 3 because the breakfasts were included in the hotel price (and not for the others). The travel emissions are very low because only trains were used (ranging from 5.56kg to 6.50 CO2 eq., Mean=5.85, for a mean distance travelled of 1047km). The cost and emissions of meals are different for the 6 participants because of the completeness of the data and the personal diet choices.

3.4. Variability of the results for two different conferences

Another participant to the experiment attended the International Design Engineering Technical Conferences IDETC 2019 at Anaheim in California (USA), on August 18-21. This researcher is based at the University of Illinois at Urbana-Champaign (with a shared time with the authors' research department). He travelled by bus from Urbana-Champaign to Chicago, and from Los Angeles to Anaheim, and by plane from Chicago to Los Angeles. He also entered his accommodation date, but nothing regarding meals. The evaluation of this researcher (Individual 7) are showed on Figure 5 along with the previous ICED evaluations.

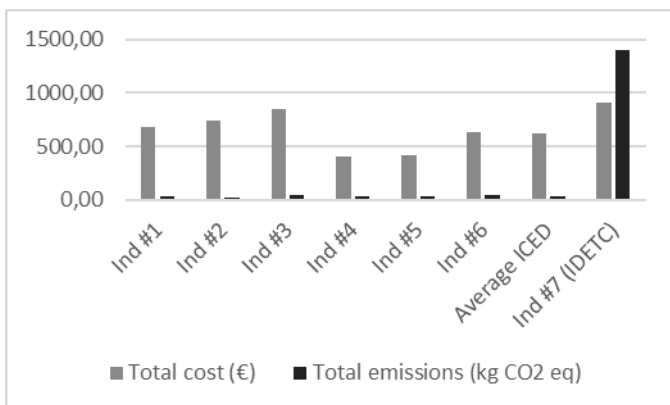


Fig. 5. Overall costs and emissions for the two conferences

While the economic costs are similar to the ICED costs, emissions related to Individual 7's trip are about 30 times higher due mainly to the plane and bus travels (1396 kg CO2 eq. for a distance travelled of 6139km).

Based on these experimental results and the inputs from the literature, recommendations are proposed in the next section.

4. Discussion

4.1. Usefulness of the diagnosis tool for monitoring research activities

The experimental results obtained show orders of magnitude and emissions breakdown in accordance with the literature. However this first experiment show multiple ways of improvement to increase the relevance of the tool. First, it was based on self-declaration by the participants. Among the 20 volunteers, only 9 effectively participated; among the 9 participants, 7 entered data with a satisfactory completeness. An automatic analysis of the expense reports (currently under development by the online platform designer) that exist on the administrative management platforms of all organization should allow gathering much more data and refine the assessments. Second, the emissions estimations are based on multiple hypotheses; some of them could be improved, for example the meal evaluations (by knowing the exact composition of a meal) or the accommodation evaluations (currently based on the price of a hotel). Third, the platform could automatically ask for more details for accommodation and meals when the travel is made without plane, as the contributions of these expenses become very important (relatively to travel).

Even if the results obtained in this experiment are not revolutionary in the sense that they follow the trends observed in the literature, revealing and displaying the emissions of business trips are extremely important as they can unlock the possibility to act at different levels of the organization (especially in public organizations like French universities, see section 4.3). The diagnosis tool could thus become a dashboard for a team or a department to monitor their business trips taking into account their revealed environmental impact instead of considering costs only.

4.2. Feedbacks on the researcher as an individual

At the individual level, highlighting the impacts of business travels may act as a trigger towards more sustainable decisions of the researcher itself. For example, taking a plane to travel in France or in the close European countries could easily be replaced by train travels under two conditions:

- The organization itself should allow this possibility, which is not always the case (see next subsection);
- The researcher him/herself should make the request.

More than considering only the transportation mode, the choices of accommodation and meals, this dashboard could stimulate reflections about the choices of business trips (for example when a researcher hesitates between two conferences at two different locations) or the utility of the trip itself (is the utility of this trip regarded as essential for the researcher's activity, as suggested in Nursey-Bray et al.[13]).

4.3. Feedbacks on the researcher's organization

The researcher is an individual part of an organization. If personal choices are essential to control the environmental impacts of his/her activities, the role of his/her organization is of the utmost importance. The authors see two levels of this organization that have strong implications. First, the research department (generally several dozens of researchers and PhD students) is seen as the appropriate level to display a dashboard of costs and emissions that could serve to mediate the utility of travels, their location, the number of attendees for each event... For that purpose the research department may provoke an internal debate to agree on and implement travel guidelines, as suggested by Nursey-Bray et al. [13]. Second, the administrative office of the University, managing the expenses, the bookings and the reimbursements of researchers. Most of public French Universities own a travel policy, which fixes the rules to select accommodations and transportations and to limit meals expenses. These policies rarely include sustainable considerations (other than simply saying that *"Travels should be limited in a sustainable development perspective"*). Sometimes the rules do not even allow a researcher to select a train instead of a plane travel because it may be judged as too expensive or too long. The hotels allowed on some universities' booking platform are most of the time off-centered to the city's downtown or the universities sites because of cheaper costs, which results in more transportations; neither consideration of the hotel's environmental performance can be found. Finally, travels' compensation (see next subsection) is rarely considered as well.

4.4. Perspectives of actions to limit impacts of conferences and professional meetings

Two levels of actions can be envisaged: the organization of the conference, where actions are managed by organizing teams; the attendance to conferences under control of researchers in their research departments. It was drawn from the literature review that transport is the main contributor to environmental impacts of conferences (regarding CO₂ emissions). Beyond the awareness of the type and magnitude of impacts of conferences, what are the possible means of intervention?

(1) Compensating travel-induced emission. An example of the pragmatic approach of compensation to a sustainability conference recently held in Berlin for 180 participants is given in [15]. The total emissions were estimated at 88 tCO₂eq, which could be compensated by a choice of labelled projects. Participants were asked to donate after being informed of their CO₂ footprint, but this only led to gather one third of the required amount of the compensation. The total amount was finally covered by the conference left budget. The organizers concluded by this relevant question "How can conference guests be motivated to travel more sustainably and to contribute more readily to climate compensation?".

(2) Choosing the conference location to minimize the environmental impacts. It is an option for recurring conferences, where statistics on previous attendees' provenance could help finding a more geographically equitable access.

(3) Avoiding the physical meeting and favoring online conferences. It has become an option to have global online conferences, see for instance CIRPe 2019 (<http://www.cirpe2019.com/>).

5. Conclusions and future work

Following the trend of transformation of research practices to reduce environmental impacts, this paper aimed at connecting research activities like conferences and professional meetings to their associated environmental impacts, examined here on a single indicator of GHG emissions. We first reported literature outcomes on the environmental impacts of research activities, and noted that studies were often dominated by discussions on academic air travel emissions. We conducted a short-term experiment with 9 volunteers of a research department, who were asked to declare the expenses of conference and professional meetings on an online calculator tool. The results for two main conferences (one in Europe, one in the US) shows that costs (in €) and emissions (in tCO₂eq.) are not correlated. As expected, results regarding emissions were very different when comparing the two conferences, because of train and air travel. We could also see the importance of accommodation and meal emissions for the European conference relatively to train emissions. This clearly differs from findings from [8]. Yet the reduced sample is clearly a limit affecting the robustness of the study. We envisage to conduct complementary experiments with a more representative fraction of the research team staff, in order to consolidate the observations and move to an action plan for the research department. This could be done by considering all of the laboratory's missions over one year, based on the database of mission orders.

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