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# Doing conferences differently: decentralising for ecological and social sustainability

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## **Abstract**

Conferences are invaluable for career progression, offering unique opportunities for networking, collaboration, and learning. However, there are challenges associated with the traditional in-person conference format. For example, there is a significant ecological impact from attendees' travel behaviour, and there are social inequities in conference attendance, with historically marginalised groups commonly facing barriers to participation. Innovative event design practices that enable academic conferences to be 'done differently' are crucial for addressing these ecological and social sustainability challenges. However, while some innovative conference practices have emerged in recent years, largely as a result of the COVID-19 pandemic, there has been little research carried out on the effectiveness of such practices. Our study addresses this gap using a mixed methods approach to analyse a real-world decentralised conference held in 2023, comparing it to traditional in-person conference and fully online conference scenarios. The decentralised format consists of local in-person hubs in different locations around the world, each with a bespoke local programme developed around a shared core global programme. We calculated the CO<sub>2</sub> emissions from transport for each scenario and found the decentralised conference had significantly lower emissions than a traditional in-person conference, but higher emissions than a fully online conference. We also interviewed 14 local hub organisers and attendees to gain their perspectives about the ecological and social sustainability benefits of the decentralised conference format. We found that the more accessible and inclusive format attracted a more diverse range of attendees, meaning that the benefits attributed to conference attendance were able to be shared more equitably. This study is the first to provide evidence of the ecological and social sustainability benefits of doing conferences differently; by doing so it can be used in the argument to help transition conferences to a more desirable state in terms of ecological and social sustainability.

## **Author summary**

Conferences are very important for career progression but at the same time they create negative ecological and social impact. For example, flying to a traditional in-person conference causes high carbon emissions which negatively impact the environment. Socially, there are many people who are unable to attend conferences because they do not have funding, are disabled, or have children/parents to care for (among other reasons) and this affects their career. We need to do things differently to both minimise the ecological impacts and be more inclusive to allow more people to gain the benefits of attending. In this study we looked at a decentralised conference format which allowed people to gather in groups in different places around the world to share the same core programme, instead of all travelling to a single place. We found the carbon emissions were much lower than a traditional in-person conference, and it was much more socially inclusive so more people could benefit from the experience.

## Introduction

Conferences are essential for academics. They facilitate a direct and effective exchange of ideas, findings, practices and methods, and create opportunities for collaborations (1-3). In addition to sharing perspectives and challenging assumptions with a diverse range of attendees in cross-cultural dialogue, there are other benefits that accrue from regular conference attendance. For example, conferences provide unique opportunities to establish and strengthen relationships that contribute to career progression; this is especially true for early career academics, who can benefit from regular conference attendance to improve their profile by presenting their work, and make their way in the highly competitive world of academia (2-5). Conferences can also lead to journal publications and other forms of productive outputs (which are widely used metrics for career promotion), increased job satisfaction, performance and motivation, and a sense of belonging within an academic community (6-10). Moreover, conferences can incorporate satellite sessions that address broader societal issues, further expanding the scope of discourse and fostering a sense of shared responsibility.

However, traditional in-person conferences raise concerns with regard to ecological and social sustainability. They often concentrate resources in privileged locations that have good transport links and established infrastructure, such as the main tourist destinations, and there is a significant ecological impact from attendees' travel behaviour as many choose to (or, especially for those from long-haul destinations, need to) fly (11, 12). Furthermore, these traditional conference practices often perpetuate the structural and systemic social injustices that are deeply embedded within academia (13). For example, many studies have identified

inequities in conference attendance, with historically marginalised groups commonly facing barriers to participation (14-16).

New event design practices are therefore important for delivering academic conferences while addressing both social and ecological sustainability concerns (17), and in so doing provide benefit for our disciplines and society at large. However, to date, little research has been carried out on the effectiveness of conference design practices that could help us transition to this desirable state (18). There are some analyses of *potential* CO<sub>2</sub> emission savings and ‘think pieces’ about the inclusivity benefits of moving from traditional in-person to virtual or other alternative format conferencing (11, 14, 18). Yet as these are hypothetical in nature it remains unclear whether these savings or aspirations of inclusion are realised *in practice*.

This paper seeks to address this gap in our knowledge. We adopt a mixed methods approach to compare the ecological and social sustainability of the decentralised conference format with two other common conference formats: a traditional in-person conference, and a fully online conference. First, using a real-world decentralised neuroscience conference delivered in 2023 as a case study, we calculate the real CO<sub>2</sub> emissions saved as a result of reduction in long-haul air travel. Second, we interview conference organisers and attendees of that decentralised conference to understand their experiences and perceptions of its ecological and social sustainability. The results provide evidence of the sustainability benefits that can be achieved by doing conferences differently through the decentralised conference format. We hope this will act as a catalyst for further conversations and actions as we work towards better practices in academia.

The remainder of the paper is structured as follows. We begin by situating the paper within the relevant academic literature. We then introduce the research context and present details of

the real-world decentralised conference that we will use as the case study. This model can be adapted for use in a wide range of disciplines from the physical and social sciences to business, arts and humanities. Next, we describe the study methodology before presenting the results of our analyses. We emphasise the carbon emission savings compared to traditional in-person and fully online conference format, and discuss the accessibility, inclusion and equity aspects of social sustainability. We conclude that decentralised conferences offer a viable alternative to traditional in-person and fully online conferences: they offer a means of reducing negative ecological impacts and providing more equitable access to the benefits of conference attendance, while at the same time still offering the face-to-face social element that attendees desire.

## **Literature review**

### **Conferences and sustainability**

The practices of traditional centralised in-person conferences have traditionally been incompatible with both ecological and social sustainability. Ecologically, in-person business events such as conferences are a considerable driver of air travel, and there is a perception that this professional travel (as opposed to leisure travel) is essential for career success (5, 19, 20). While there is conflicting evidence of whether this is the case within academia (see for example Berné, Agier (21) and Wynes, Donner (22)), air travel nevertheless remains the largest cause of researchers' carbon emissions (12, 23). For conferences, air travel contributes the most to the CO<sub>2</sub>-equivalent (18). Conferences also have other negative ecological impacts: for example, consider air conditioning, meat consumption, non-locally sourced food, beverages and other products, the use of plastic, the ubiquitous 'conference bag' with its disposable contents, and the printing and transport of posters in plastic tubing (18, 24, 25).

In terms of social sustainability, conference attendance certainly has long-term benefits for career progression, job satisfaction and sense of belonging. Regarding events more generally, Smith (26, p. 111, emphasis added) stated that “sustainable development requires long-term benefits that are distributed *equitably*”. However numerous studies have found that the benefits of academic conferences are not distributed equitably, as barriers to attendance exist for many historically under-represented groups within academia (27). This includes women, BIPOC (Black, Indigenous and people of colour), migrant scholars, those from the Global South, early career, precarious, first-in-family, members of the disability and LGBTQIA+ communities, and/or low or no-income academics (28). Indeed, Hanser (29) notes that conferences are often a silent struggle for belonging for academics from these groups. Conference organisers, hosts, and other attendees who engage in exclusionary practices and microaggressions emphasise the ‘outsiderness’ of historically marginalised academics (15, 16, 30, 31). Where conferences are not inclusive (i.e. where they are exclusionary), they are not equitable, and thus not socially sustainable.

Exclusionary practices include, but are not limited to, the selection of keynote and other high-profile roles (where these academics are under-represented), the structuring of registration fees (costs may be prohibitive for students, low/no income academics or those on precarious contracts, especially where catering and social events are not included in the registration fee), inaccessible venues (for people with disabilities), host destination politics (particularly for LGBTQIA+ and Muslim academics, but also for those that require visas to enter the destination country) and lack of consideration given to those with caring responsibilities, and other needs such as dietary or religious requirements (27, 31-33).

## **Alternative models of conference delivery**



The advent of virtual conferencing, which became more prevalent during COVID-19, is one practice that has opened the possibility for academic conferences to address social and ecological sustainability concerns. It has the potential to revolutionise inclusivity and equity by making these events more widely accessible to academics worldwide, facilitating a sense of belonging and community for historically marginalised groups (12, 25, 34, 35). In addition, virtual conferencing offers an opportunity for those attendees who do not wish to attend in-person for moral issues (such as concern for the environment) to be able to still present their work and engage in meaningful discussion with colleagues (12, 36).

That said, virtual conferences cannot fully replicate the richness of in-person interactions, which play an important role in ‘breaking the ice’ and fostering serendipitous collaborations, and which are vital for those from collectivist cultures (33). In collectivist cultures (most Asian/Pacific countries), the interests of the group are more important than those of the individual and it is important to conform to social norms (37); in a virtual conference setting this can manifest in not feeling comfortable asking a question in front of other attendees. Virtual conferences may also leave people feeling isolated and disconnected from the broader academic community through ‘Zoom fatigue’ and multitasking during virtual conferences which leads to disengagement (12, 18). Another challenge faced by many is the speed and reliability of internet connectivity required to engage fully (33).

To overcome some of these limitations, recent years have witnessed the rise of hybrid conferences which offer both in-person and virtual participation options – with virtual participants usually attending individually from their home location. The format of hybrid conferences is highly diverse, using a wide range of governance schemas. For instance, some organisations maintain a centralised governance structure with a single presidency, centrally determined programme and a tightly coordinated schedule across locations. Examples of

hybrid conferences include that of the [Organisation for Human Brain Mapping](#), [Tourism and Leisure Studies Research Network](#), European Group for Organisational Studies (17), [South Pacific Educators in Vision Impairment](#), the [International Conference on Music Perception and Cognition](#), and the [2024 American Geophysical Union](#) conference which is the largest earth and space scientist event in the world, attracting over 25,000 attendees (11). Others adopt a distributed decision-making model (38, 39). One example is [Brainhack Global](#), held regularly since 2017. It opens up a two-week global window for any type of local research organisation around the world to participate and run their own ‘hackathon’, a creative project-oriented type of event.

An alternative ‘hub’ model of conferencing has now emerged, with participants convening in person to a number of deliberately selected locations (hubs) spread around the world at a given time to attend an online live broadcast (12, 18). Conferences delivered in this format include the 2024 iteration of the [Royal Geographic Society \(with the Institute of British Geographers\)](#) conference, the [Neuromatch](#) computational neuroscience conference which evolved from virtual to hub format over the course of the COVID-19 pandemic (40), and the 2023 [CuttingGardens](#) conference which is the focus of this paper (41). The hub approach to conference delivery helps maintain the in-person social interaction, thereby addressing the most frequently mentioned limitations of virtual meetings – and it has the additional benefit of minimising long-haul air travel which in turn reduces the ecological impact.

Among the various models of multi-hub conferences though, it is important to note that there is a high variability in the ability for each hub to determine content or make it locally relevant – many still run centrally which means hubs have little autonomy. It is also important to note that a number of the conferences that implemented the hub format during the height of COVID-19 have now reverted back to traditional in-person iterations or have downscaled to a

simpler hybrid offering (as predicted by Kinakh (24), perhaps reflecting the additional amount of work the hub format required from the organisers (18).

## **Research context**

### **Introducing the case study conference**

As an international network of over 2,000 members, the [CuttingEEG](#) association has been organising scientific events in the field of neuroscience for over 10 years. They operate under the guiding principles of sharing knowledge globally and building competence locally: their mission is to promote best scientific practice, and to connect scientists worldwide by hosting events that showcase cutting-edge methods applied to neurophysiology. As part of this mission, and as a way to address the aforementioned ecological and social sustainability concerns generated by traditional in-person conferences, the CuttingEEG collective implemented a decentralised conference format, a hybrid approach with multiple hubs located around the world. They called it ‘CuttingGardens’, a play on their name, and the first edition was held in late 2023. They believed this approach could reduce the carbon footprint, increase inclusivity, and develop new rules to open up the field to perspectives less centred on WEIRD (Western, Educated, Industrialised, Rich, and Democratic) countries. The conference was created with a threefold objective, namely, to:

1. Reduce long-haul travel – organisers sought to highlight the importance of minimising attendees’ and speakers’ need to fly, to lower the ecological impact of the conference.
2. Empower local groups – hubs could strengthen bonds with their local disciplinary communities while simultaneously engaging with the global community, attending the same lectures and asking live questions to the same international speakers at no cost.

3. Give autonomy – organisers took advantage of the autonomy in local organising committees to advertise cultural diversity, supporting them all to operate differently.

Over four days, 21 local hubs with 730 in-person and 300 online attendees were involved in CuttingGardens 2023 (129 lectures with 42% women speakers, 53 tutorials, 137 posters, see detailed report in [associated online resources](#)). The hubs were located in: Los Angeles (USA), Havana (Cuba), Montréal (Canada), Santiago and Talca (Chile), Oro Verde (Argentina), Donostia/San Sebastian (Spain), Bournemouth and London (England), Dundee (Scotland), Caen and Lyon (France), Gent (Belgium), Nijmegen (the Netherlands), Frankfurt, Regensburg and Münster (Germany), Genova (Italy), Belgrade (Serbia), Haifa (Israel), Tehran (Iran). Each local hub was called a “Garden”, and the people responsible for organising them were called “Gardeners”. 122 "Gardeners" participated, 52% of whom were women.

## **The decentralised conference format**

We now provide an overview of the format for decentralised conferencing adopted for the delivery of the CuttingGardens 2023 conference. We acknowledge that this hub format is not unique and the logistics and organisational details have already been covered by Parncutt, Lindborg (18). Thus, here, we focus on the conference design elements (specifically the governance and programme structure) that contributed to its success that may be of value to others considering adopting the decentralised format for their conference.

### **1. Governance structure**

This decentralised conference framework was based on a two-tiered governance structure, with separate financial accounting:

*Central governance:* There was a central team (working together but from different locations) responsible for developing a shared core programme (33% women speakers), unified communication and website platforms, some practical ‘à la carte’ tutorials, and information about how to establish a local hub. The resources prepared by the central governance team ensured high-quality programming was made accessible to any internet-connected location, providing a strong foundation for a successful conference and simplifying/encouraging participation (see as an example the “Gardener’s starter's guide” in [associated online resources](#)).

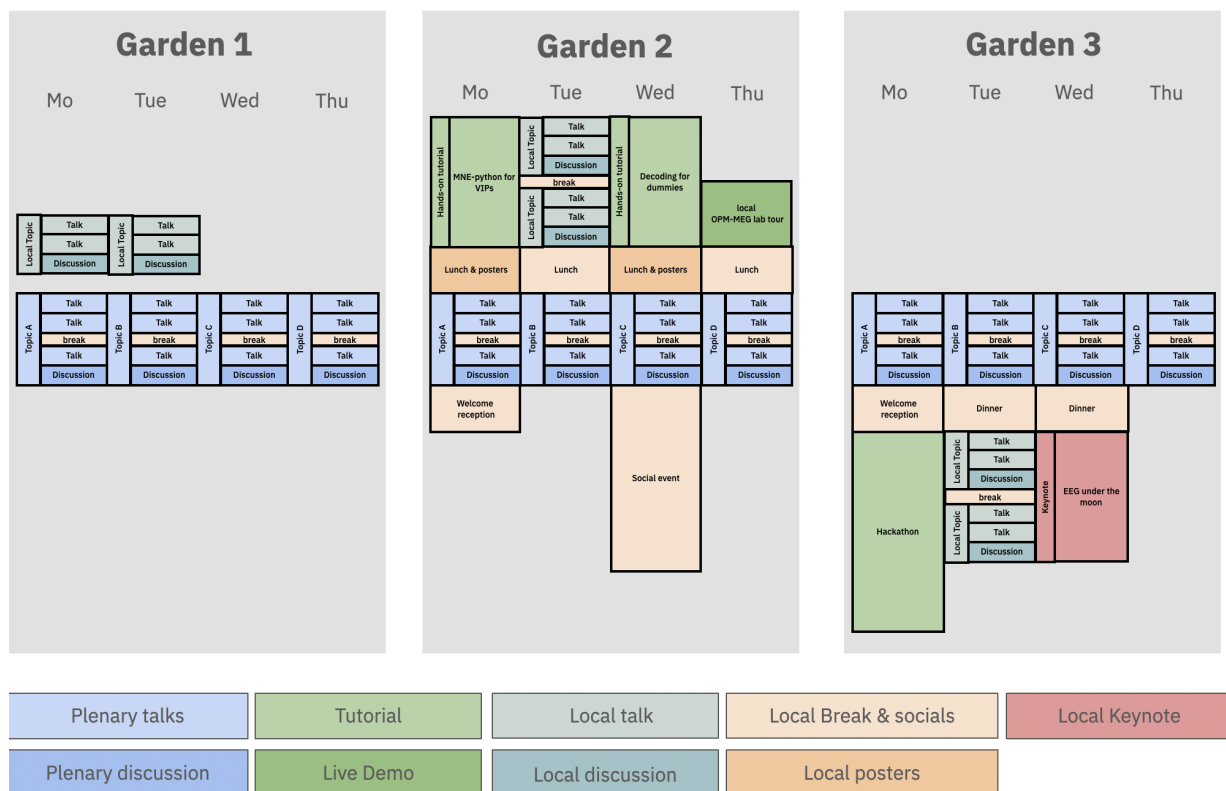
*Local governance:* Local hub organisers had the autonomy to devise their own bespoke conference programme while staying within the overarching framework of the conference. They could choose to complement the main programme with locally relevant activities like poster sessions, talks, workshops, or social gatherings.

*Financial governance:* Finances were separated transparently into global and local expense categories. All costs related to global aspects (such as hiring a professional organiser, arranging plenary talks, acquiring licenses for technical tools) were borne by the central governance body. Attendees paid a nominal membership fee to join the CuttingEEG association – this income was used towards the global costs (the fee was waived on demand for low/no income participants). Hubs were responsible for their own local expenses and were able to charge their own registration fee separate from, and in addition to, the CuttingEEG membership fee.

## 2. Programme structure

In the decentralised conference format, a two-tiered approach was also taken to organising the programme: a centrally organised core global programme and local programmes.





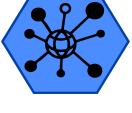
*Synchronous global programme:* To foster a sense of global community among attendees and set the tone for the conference, it was important to develop a common synchronous programme of activity broadcast live to all locations. The central governance team chose how many of these synchronous sessions to include in the programme, and what the content should be. Developing in this way ensured it featured the most cutting-edge topics in the field. Broadcasting each presentation live from the speaker’s closest local hub reduced travel emissions and provided an opportunity for smaller local hubs to host a featured speaker. This in turn fostered a more inclusive and geographically diverse event. Other studies have noted that different time zones can cause challenges with scheduling synchronous global programmes in an online conference (14, 18). However, while noting these difficulties, CuttingGardens 2023 was timetabled such that conference attendees at *most* local hubs could participate in *most* of the synchronous global programme sessions, creating a shared experience for attendees worldwide (Fig 1).



**Fig 1. Three examples of how local hub programmes of different extent can be integrated with the synchronous global programme (in blue). See real programs on the [CuttingGardens 2023 website](#). (Source: Authors)**

To consolidate this shared experience and enhance the community-building aspect, a key element of the global programme was to elicit local discussions among attendees while also enabling them to engage with the global speakers. After each presentation, a short ‘camera-off’ break allowed local hubs to hold discussions amongst their attendees to identify their most relevant questions for the speaker, and/or vote for the most relevant questions posed by other hubs. A small subgroup of the central governance team was responsible for selecting which questions to address in a live online Q&A session following the break; the remainder were forwarded to the speaker to provide answers in a live document which was shared with all attendees after the conference.

*Autonomous local programme:* The decentralised conference framework enabled each local hub to develop its own autonomous programme around the global programme to foster local initiatives and enhance global connections (Fig 1). They could choose to broadcast their own content live to their community, and could also share this via the global video feed of the conference. The central governance team called for proposals to host a local hub, which enabled local hub programming to be incorporated into the global programme (as discussed above, speakers in the global programme were able to present from their closest local hub). It also meant they could benefit from the global communications and visibility. Standardised activity definitions and associated icons were developed so that a common understanding and language could be used – each local hub could choose which activities they wished to offer, and the related icons were displayed next to their listing on the global conference website (Table 1).

<p><b>Attendee hub</b> A local hub with a gathering of people who attend the live global programme together are called Attendee hubs. To qualify as an Attendee hub, a location only needs a streaming device (e.g. computer), a good internet connection, and a space to gather and follow the talks.</p>	
<p><b>Speaker hub</b> Local hubs that host one or more in-person lecture(s) are called Speaker hubs. These locations need to provide a physical space to host the talk(s), as well as the ability to stream it to all the other local hubs.</p>	
<p><b>Tutorials hub</b> Local hubs that host local training sessions are called Tutorial hubs. This can be:</p> <ol style="list-style-type: none"> <li>1) A hands-on session. This requires local Teaching Assistants and a dedicated space for the attendees to work on their own laptops.</li> <li>2) A demo session. This is a shorter session with a live demo from the main tutor. It only requires a broadcasting system.</li> </ol>	
<p><b>Posters hub</b> Local hubs can also organise poster sessions. These need an appropriate infrastructure (e.g., room, poster stands, etc.), as well as a submission platform for attendees. Local hubs have autonomy to decide the format and content of posters.</p>	
<p><b>Satellite</b> Local hubs may also organise any type of satellite event, such as additional workshops, talks/presentations, hackathons, social events, visits to local lab(s).</p>	

**Table 1. Standardised activity definitions and associated icons.** (Source: [CuttingEEG](#), 2023)

As a result, the CuttingGardens 2023 local programmes were diverse. For instance, one local hub was held at a venue where attendees mixed with employees in their communal spaces. The local organisers used this opportunity to create a conference that challenged attendees and employees about the climate emergency and systemic oppression, collaborating with a national art company to develop an installation in the garden. This additional temporary setup took the form of a kitchen with cooks on site (short supply food, vegetarian), a coffee bar, a cafeteria under the awning, a communal dishwashing area and an exhibition on climate



change questioning the role of scientists in and outside the lab, open to both attendees and employees.

Another local hub organised a very well-attended public lecture with two goals - to promote electroencephalography and science to the public and to give back to the local community that finances their public university. Other local activities included field trips to laboratories and research centres, tutorials, symposia, presentations, workshops, posters, a roundtable on Women Leading Neurosciences, a 'getting to know you' session where researchers presented their labs (their research teams, equipment and topics) rather than their research, special sessions for postgraduate students and postdocs, plus social events such as welcome drinks, guided city tours, beach walks and conference dinners.

## **Methods**

We used a mixed methods approach to compare the ecological and social sustainability of the decentralised conference format with two other common conference formats: a traditional in-person conference, and a fully online conference. To provide evidence for ecological sustainability we used quantitative methods to calculate comparative CO<sub>2</sub> emissions for each of these three scenarios. This was supplemented with qualitative data gained from semi-structured interviews with local hub organisers and conference attendees, where their views of both ecological and social sustainability were sought. We detail our methods below.

## **Data collection**

### **Quantitative data collection**

To estimate the CO<sub>2</sub> emissions of passenger transportation for CuttingGardens 2023 attendees, a post-conference online survey was conducted. Attendees were asked which hub

they attended, where they travelled from, and how; a free-text box allowed them to add comments. Participation in the survey was voluntary.

From 727 attendees who attended via a hub, a total of 247 responses were collected, out of which 228 were considered valid, resulting in an overall response rate of 31% (Table 2). A total of 18 responses were excluded from further analysis. This included 14 who reported attending online, 3 who reported using “other” transport modes such as a mixture of local transportation and online attendance, and one who provided a comment that their travel would have occurred anyway for family reasons, and believed it should not be taken into account for the carbon footprint of the conference.

As only the city of respondent origin was collected, rather than suburb, the distance to the respective local hub yielded zero for six local hubs (Los Angeles, Havana, London, Münster, Talca, and Tehran) as all respondents lived within the city. These hubs were therefore excluded from the analysis.

<b>Local hub</b>	<b>Attendees</b>	<b>Responses</b>	<b>Proportion (%)</b>
Belgrade; Serbia	19	8	42
Bournemouth; UK	20	6	30
Caen; France	50	4	8
Dundee; Scotland	30	3	10
Frankfurt Am Main; Germany	90	32	36
Genova; Italy	45	32	71
Gent; Belgium	30	14	47
Havana; Cuba	15	2	13
London; UK	10	6	60
Los Angeles; USA	50	4	8
Lyon; France	100	38	38
Montreal; Canada	50	6	12
Muenster; Germany	10	2	20
Nijmegen; The Netherlands	25	6	24
Oro Verde; Argentina	16	16	100
Regensburg; Germany	7	7	100
Donostia/San Sebastian; Spain	40	14	35
Santiago; Chile	95	20	21
Talca; Chile	10	3	30
Tehran; Iran	15	5	33
<b>Total</b>	<b>727</b>	<b>228</b>	<b>31</b>

**Table 2. Distribution of responses by local hub.** (Source: Authors)

## **Qualitative data collection**

Semi-structured interviews were chosen for their ability to generate rich, nuanced data about the topic while allowing some flexibility for deeper questioning and exploring other related areas as necessary (42). After gaining ethics approval from the second author's university, recruitment emails were sent to the central governance team's database of local hub organisers and attendees. As a diverse range of perspectives was sought, interviewees were subsequently selected based on role, local hub size, range of offerings and location. A total of 14 interviews were held: seven with local hub organisers and seven with attendees, from a total of 12 local hubs. Interviews were conducted online and recorded for note-taking purposes. They ranged in length from 21 to 45 minutes, averaging 34 minutes. One was conducted asynchronously via email. In addition to general questions about their experience of the decentralised format, more specific questions were asked about what ecological sustainability measures they took (local hub organisers) or observed (attendees), and their perceptions of social sustainability (using terms such as accessibility, equity and inclusion) at the conference compared with both traditional in-person and fully online conferences.

## **Data analysis**

### **Quantitative data analysis**

We used the arc distance between cities to calculate travel distances as extracted from the post-conference survey responses, and R version 4.4.2 (43) to perform all computations presented here. The scripts are available on the [associated online resources](#). To estimate transportation-related CO<sub>2</sub> emissions, the emission factors as reported in Table 3 were used.

<b>Transportation means</b>	<b>Corresponding nomenclature from source</b>	<b>Emission factor (kg CO<sub>2</sub>eq / km)</b>
Feet		0.0000
Bike		0.0000
Train	International Train	0.0370
Metro or Regional train	Metro	0.0040
Intercity Coach or City Bus	Bus.Intercity	0.0306
Plane	Medium Haul	0.1875
Car	Unknown Engine Car	0.2156

**Table 3. Emission factors extracted from original detailed data, specific to French transportation devices.** See <https://apps.labos1point5.org/documentation>. (Source: Mariette, Blanchard (44))

In all cases, the estimated equivalent CO<sub>2</sub> emissions (CO<sub>2</sub>eq) of transporting a given attendee was obtained by multiplying the distance from the city they reported travelling to the local hub from by the respective emission factor for the reported means of transport. We created three scenarios in order to compare the attendee transportation footprint of CuttingGardens 2023 as it took place with two alternative formats: a traditional in-person conference and a fully online conference.

#### Scenario 1: CuttingGardens

The *CuttingGardens scenario* corresponds to the actual conference as it took place in 2023, with attendees travelling to a local hub where the core global programme was broadcast and a bespoke local programme offered. In this scenario, we estimated CO<sub>2</sub> emissions based on the results of the attendee survey. We used a random resampling method (bootstrap with 1000 resampling iterations) to estimate the transportation emissions of all attendees. Computations were based on the subsample of participants who responded to the survey in each local hub (no responses from Havana, Los Angeles, London, Münster, Talca and Teheran). For each local hub, we randomly resampled the actual number of attendees (Attendees column of Table 2), with replacement from the survey responses (Responses column of Table 2). The

CO<sub>2</sub> emissions from live streaming for the 21 different hub locations were computed following Equation 1 described below in Scenario 3.

#### Scenario 2: Traditional In-Person

The *Traditional In-Person scenario* estimated CO<sub>2</sub> emissions that would have occurred if exactly the same CuttingGardens 2023 attendees had instead travelled to a single location to attend a traditional in-person conference instead of their local hub. Each of the local hubs in turn was used as the single conference location in a series of simulations (i.e. we carried out a simulation whereby all attendees travelled to Caen, France, another simulation whereby all attendees travelled to Santiago, Chile, and so on for each of the 21 local hubs). The same resampling procedure as above was used. To keep geographical consistency with the original conference, resampling was still performed per local hub.

We used the distance to that single location to determine a likely transportation means. All travel below a certain distance  $D$  was assumed to be done by train, and all travel above that distance was assumed to be done by plane. We computed the total CO<sub>2</sub>eq emissions for this scenario with  $D$  ranging from 300 km (all attendees living closer than 300 km from the location travel by train, others by plane) to 1500 km (all attendees living closer than 1500 km from the location travel by train, others by plane).

#### Scenario 3: Fully Online

Finally, in the *Fully Online scenario*, we estimated the emissions of live streaming the full online content of the conference (48 hours of content available after the event) to all attendees using methods provided by the [Carbonalyser tool](#) made by [the Shift Project](#). We estimated the amount of data transferred during one hour of video from the platform used during the conference (Crowdcast.io) and found that 2.7 GB data was transferred during this hour. In addition, we also made the following assumptions for this simulation: one participant

per terminal using a laptop computer on a Wi-Fi network located in Europe. Following the same methodology as the Carbonalyser tool documented in the [full report of the Shift Project](#), we used the following formula to compute the total impact of streaming:

$$TI = IF * NU * (UD * DEI + DS * (DCEI + NEI))$$

where:

		Unit	Value	Comment	Source
TI	Total Impact	kg CO <sub>2</sub> eq			
IF	Intensity Factor	kg CO <sub>2</sub> eq/kWh	0.519	Average world Intensity Factor	
NU	Number of Users	person	727		
UD	Usage Duration	min	48 * 60	Total duration of streamed content	48 hrs of video watched on Crowdcast
DEI	Device Energy Impact	kWh/min	3.19E-04	For a standard laptop computer (2018)	Lean ICT Materials Forecast model by The Shift Project
DS	Data Size	Bytes	129.6E09	Total size of streamed data	At 2.7 E09 B /hour
DCEI	Data Centre Energy Impact	kWh/Byte	7.20E-11	1 PB ~ 72 MWh	Lean ICT Materials Forecast model by The Shift Project
NEI	Network Energy Impact	kWh/Byte	1.52E-10	Local Wi-Fi network	Lean ICT Materials Forecast model by The Shift Project

## Qualitative data analysis

The interviews were subjected to reflexive thematic analysis, an iterative process of reading and re-reading the interview transcripts and notes to identify recurring themes (45). An inductive approach was taken to the analysis, with words or phrases related to any aspect of ecological and social sustainability initially being highlighted as of interest. These were then coded, and similar codes grouped together into themes. These themes were subsequently

consolidated into higher order, more abstract themes with shared meaning, and the codes cross-checked for internal consistency and theme coherence (45).

## Results

### Ecological sustainability at CuttingGardens 2023

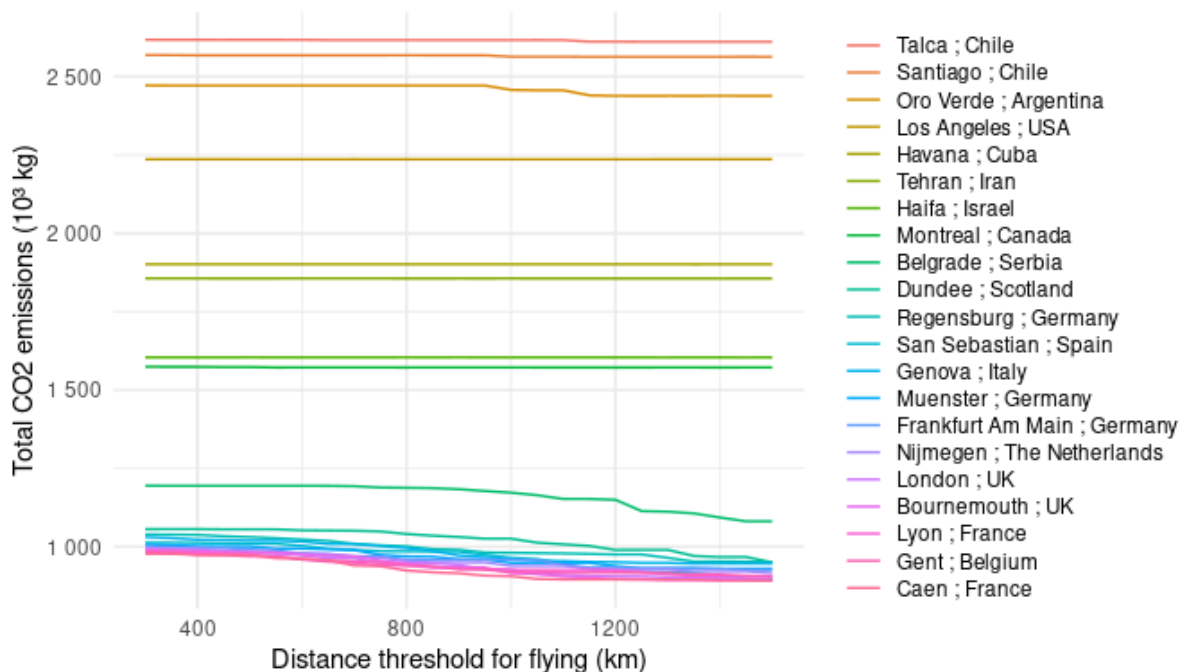
In this section we firstly discuss the individual components that comprise the CO<sub>2</sub> emissions calculations (transport and live streaming). We then provide an overall assessment of the three scenarios and supplement this with the interview findings. Of note, the computed emissions due to live streaming are only a fraction of those due to transport.

The average estimated CO<sub>2</sub> emissions from transport for each local hub in the *CuttingGardens scenario* are shown in Table 4; there are no transport emissions to present from the *Fully Online scenario* as it was assumed all attendees participated online.

<b>Local hub</b>	<b>Avg CO<sub>2</sub> emissions (10<sup>3</sup> kg)</b>	<b>Std dev (10<sup>3</sup> kg)</b>	<b>No. participants</b>
Belgrade; Serbia	2.481	1.101	19
Bournemouth; UK	1.755	0.789	20
Caen; France	1.818	0.164	50
Dundee; Scotland	0.304	0.029	30
Frankfurt Am Main; Germany	1.115	0.151	90
Genova; Italy	1.093	0.155	45
Gent; Belgium	2.451	1.010	30
Lyon; France	1.715	0.230	100
Montreal; Canada	3.269	0.657	50
Nijmegen; The Netherlands	0.232	0.051	25
Oro Verde; Argentina	0.079	0.061	16
Regensburg; Germany	0.095	0.031	7
Donostia/San Sebastian; Spain	2.382	0.598	40
Santiago; Chile	3.184	0.374	95
<b>Total</b>	<b>21.973</b>	<b>1.980</b>	<b>617</b>

**Table 4. Average CO<sub>2</sub> emissions (kg) for each local hub in the CuttingGardens scenario.** Only cities for which we have survey data are listed. Std dev column corresponds to the standard deviation of the resampled data. (Source: Authors)

For the *Traditional In-Person scenario*, the estimated CO<sub>2</sub>eq emissions in simulations where each local hub acted as the single conference location for all attendees are shown in Fig 3. In this scenario the total CO<sub>2</sub> emissions range from a minimum of 892 tons CO<sub>2</sub>eq (equivalent to almost 900 return trans-Atlantic flights) if all participants travel to Caen (France) and take the train for any distance below 1500 km, and a maximum of 2617 tons if all participants travel to Talca (Chile) and take the plane for any distance above 300 km. These two values reveal the wide range of possible emissions depending on the choice of location for a traditional in-person conference. Noteworthy, the simulation reveals minimal differences between all western European local hubs. This highlights both the considerable contribution of long-haul air travel to emissions, and the availability of low carbon transportation options for travel across Europe where the majority of CuttingGardens 2023 attendees were from.



**Fig 3. Conference CO<sub>2</sub> equivalent emission simulations for the *Traditional In-Person scenario*.** The locations are sorted by average emissions across distance thresholds for flying. (Source: Authors)

The total CO<sub>2</sub> emissions from live streaming content on a single screen at all 21 local hubs in the *CuttingGardens scenario* was calculated as follows:



$$TI = 0.519 * 21 * (48 * 60 * 3.19e - 4 + 129.6e9 * (7.2e - 11 + 1.52e - 10))$$

$$TI = 0.326 \times 10^3 \text{ kg CO}_2\text{eq}$$

This emission value is ignored in Tables 4 and 5 because it represents only a small fraction of the estimated emissions due to travel.

For the *Fully Online scenario*, the emission was computed using 727 as the number of users:

$$TI = 0.519 * 727 * (48 * 60 * 3.19e - 4 + 129.6e9 * (7.2e - 11 + 1.52e - 10))$$

$$TI = 11.300 \times 10^3 \text{ kg CO}_2\text{eq}$$

The *Traditional In-Person* scenario was assumed to have no live streaming content. Under the best conditions then (in which all attendees at the same local hub use a single stream), we can see that emissions in the *CuttingGardens scenario* are 34 times lower than those of the *Fully Online scenario*.

Overall, the total simulated CO<sub>2</sub> emissions across each of the three scenarios are provided in Table 5. Perhaps unsurprisingly, the *Fully Online scenario* performed best in terms of ecological sustainability using CO<sub>2</sub> emissions as a proxy, while the *Traditional In-person scenario* was the worst. The *CuttingGardens scenario* created approximately twice the emissions of the *Fully Online scenario*, but created just around 2 percent of the emissions of the *Traditional In-Person scenario* (with the least estimated emissions hub in Caen).

Scenario	CO <sub>2</sub> emissions (10 <sup>3</sup> kg)	Standard deviation (10 <sup>3</sup> kg)
1. CuttingGardens	21.973	1.980
2. Traditional In-Person (maximum: Talca, Chile)	2,617.748	1.737
2. Traditional In-Person (minimum: Caen, France)	924.356	2.604
3. Fully Online	11.300	NA

**Table 5. Comparison of CO<sub>2</sub> emissions for each scenario.** (Source: Authors)

Lastly, while we focused on transport and live streaming, the findings from the interviews highlighted ecologically friendly initiatives such as vegetarian catering, recycling, bringing their own name badges, reduced/no printed material, and reusable crockery/cutlery. Interviewees believe these actions helped to reduce the ecological footprint of their local hub. One local hub implemented a food waste strategy whereby they confirmed people's attendance a few days before. This meant they were able to "order the amount of food as close as possible as what was needed", and they also encouraged attendees to bring their own container to take any leftover food home. However, all interviewees believed these were generally less impactful and that the decentralised conference format had one highly significant benefit for ecological sustainability: flying had been reduced significantly or, in the case of long-haul flying, ceased altogether – this supports the results of the carbon emissions calculations presented above.

## **Social sustainability at CuttingGardens 2023**

In this section, we present evidence from the interviews of how the decentralised format contributed to social sustainability. Two main themes were identified in the analysis: accessibility and inclusion; and equity.

### **Accessibility and inclusion**

Interviewees reported that the decentralised format of CuttingGardens allowed a more accessible and inclusive conference than a traditional in-person conference. Arguably the groups that benefited most were students, researchers from the Global South and others on low incomes, as registration fees and travel costs were reduced. These verbatim quotes are illustrative of what was said:

*First, I like the inclusivity like because I think there was a there was a [local hub] in Havana. As far as I know, and in South America, and usually these are places where rarely researchers come from [to an in-person conference] (Interviewee #9)*

*I like for different reasons, since for example, sometime in the in the conference, not all people can travel. People sometimes doesn't have a fund money to go. So I think that this kind of the conference is very democratic and the gives the possibility to all people to join. (Interviewee #3)*

While a number of interviewees agreed that a fully online conference may be even more accessible and inclusive, they pointed out that meeting in-person added something intangible to the conference experience that could not be replicated online. As one interviewee reflected, the decentralised conference format offered a good compromise, helping reduce CO<sub>2</sub> emissions and barriers to attendance, but still providing important in-person contact and experience:

*I still think that the benefit of lowering the barrier of attendance really outweighs the potential con of not meeting [all together in a single location]... Especially because we had this small group of very engaged people and the discussions were actually super interesting and very engaged. And some days I would just leave at six, really tired from the day, and they were still drawing on the board and discussing things. So I think that you would not get that from a fully online conference. And I think it was still good at like giving the feeling that you shared something or you shared the experience with some other people, which in terms of memory, I think is quite important and that I don't think you would get with the fully online. (Interviewee #2)*

Funding is a significant barrier to conference attendance for researchers globally: numerous interviewees commented that, had the conference been somewhere held in Europe (the most

likely destination for an in-person CuttingEEG conference), many attendees would not have been able to participate. Indeed, when prompted, interviewees estimated that between 50 and 85 percent of those who attended their local hub would have been excluded.

Several interviewees also noted that even where conference funding was available, researchers were encouraged to prioritise attendance at conferences that were tightly aligned to their work or area of expertise – there was little opportunity to attend conferences that were of interest but in less strongly relevant or allied fields. Therefore some interviewees felt that the lower cost of participation allowed a more diverse range of attendees:

*There were people from EEG side, but on [a different topic]. So that might have been for us was a special point in our program, but is not usually the case. So usually people from these topics they tend to go to cluster in other conferences. (Interviewee #1)*

*Due to company funding I could maybe have gone [if CuttingGardens 2023 had been held in Paris and therefore cost more], but unlikely, as there were other more relevant conferences that I would have been supported to go to as a priority. (Interviewee #10)*

Relatedly, one local organiser deliberately hosted their hub in a “neutral” venue on campus rather than in a disciplinary space. They believed this attention to reducing power dynamics created a more accessible environment that promoted diversity, contributing to a broader mix of attendees that in turn facilitated cross-disciplinary communication:

*So it was kind of good to have, you know, people gather somewhere, which is where it is neutral otherwise maybe some engineering students would not be that, you know, maybe reluctant to go to the Faculty of [XYZ] for conference because they would maybe think this is not for us. (Interviewee #12)*

Another traditionally under-represented group that benefited from the decentralised CuttingGardens format was the disabled community, with a number of interviewees noting the local hubs' smaller size enabled them to better manage challenges such as neurodiversity or social anxiety:

*On a very personal level, I have some issues with processing too much sound in the crowd and I just get overwhelmed very easily. And then my brain just shuts off. And on that level, it's just nicer to have for example, a poster conference in a room with well 20 to 50 posters instead of I don't know, 100. And even then, it's a bit much, but... (Interviewee #9)*

*I'm not like the person that goes the most, the social events in general, I feel too exhausted with like the conference... And especially because like as I say, I didn't attend the online part, so it was more half a day, so it's like really less for the brain to process in term of information. (Interviewee #11)*

As discussed earlier in the paper, people with caring responsibilities often find conference attendance challenging. One of the local hubs recognised this and provided childcare, but as this interviewee with a baby says, even being able to attend partially online was valuable:

*I have a baby now, and then... I have the feeling that I'm less productive and then I miss some conference because we cannot afford to go for one week. We cannot afford to spend 2-3 days [outside of home] and then just to leave the baby for the [other parent] or vice versa. So knowing it online it's easier and also for the jet lagging. (Interviewee #7)*

Three of the interviewees acknowledged that needing to apply for a visa can be a problem for people from some countries – and that the processing can take a long time and be expensive.

Some of them had personally experienced this with traditional in-person conferences themselves in the past, but having local hubs effectively alleviated this issue.

## **Equity**

Being able to attend a global conference at a local hub conferred significant benefits, particularly for those who presented their research, whether in poster form, panel discussion, workshop, demonstration or oral presentation. There was very much a sense of community created at both local and global levels, and the visibility it facilitated was valued:

*Well, this this was interesting for us because if it were fully online, we still wouldn't have that kind of sense of a community gathering... in having it in person had some additional charms to it on the local level, but still at the same time feeling that you're part of a global community and also enabling participants who presented their work at the local [hub] to be visible by the global [audience]. (Interviewee #12)*

Likewise, Interviewee #8 said a benefit was “offering the opportunity of people here to broadcast their own talks much more broadly” noting that a decentralised model allowed “international content and richness.”

The connections made at the local hubs were also beneficial, as this Principal Investigator observed with one of the students in their lab:

*I think [my student] benefited a lot from a workshop that we had, organised by the local community doing EEG there with certain software that after that she started using that to analyse data and actually this started to kind of I wouldn't say a very fruitful collaboration, but she could rely on people in [city] for some advices about data analysis and stuff like that (Interviewee #6)*

For some interviewees, the benefits of the conference lasted well beyond the conference itself, with a number of new relationships and collaborations forming:

*A small 'reading' group has been formed, meeting monthly to discuss our work – thus creating lasting networking legacy, creating a community in [country]...we are not in a big group with a lot of money so for us is very important to create a network. (Interviewee #3)*

*We kept in touch with colleagues from all participating institutions - they exchanged information on upcoming events and attended each other's events, they exchanged training materials, gave lectures and workshops. (Email from local hub organiser)*

*Also I've been invited to other conferences after this. This so from thanks to people that I knew during the [local hub]. (Interviewee #1)*

Thus in terms of social sustainability, the benefits were more equitably distributed with a wider range of attendees. This was due to the fact that the decentralised CuttingGardens format was more accessible and inclusive than a traditional in-person conference, but still with the advantages of a sense of community that is difficult to replicate in a fully online conference environment.

## **Discussion and conclusion**

This study used quantitative and qualitative methods to analyse how a real-world decentralised conference could address the ecological and social sustainability concerns surrounding traditional in-person conference formats. In so doing, it has provided evidence of a viable alternative to both the traditional in-person and fully online conference formats which is not only more ecologically sustainable but also more accessible, inclusive and

equitable - thus enabling the benefits of conference attendance to be recognised by a wider range of attendees.

To explore the ecological implications, we used post-conference survey responses to gather attendees' actual travel data. We developed two alternative scenarios to compare the decentralised conference attendees' CO<sub>2</sub> emissions: a traditional in-person conference and a fully online conference. Our analysis showed that CO<sub>2</sub> emissions from transport were considerably lower for the decentralised conference than for a traditional in-person conference. This was largely due to the reduction in long-haul travel engaged in by attendees, as the majority were able to utilise low carbon transportation (i.e. not plane or private car) to travel to their local hub. However, and unsurprisingly, CO<sub>2</sub> emissions were still twice as high as if the conference had been held fully online. The results from the traditional in-person scenario reveal that gathering the whole attendance at any single European local hub would have generated lower CO<sub>2</sub> emissions than at any non-European local hubs (Fig 3). This is perhaps unsurprising as it mirrors the location of the CuttingGardens 2023 attendees. This suggests that, if a narrow carbon-centered focus was taken to ecological sustainability, selecting a single European location to host a traditional in-person conference would most effectively lower CO<sub>2</sub> emissions. As discussed below however, this solution would have excluded many attendees and thus reduced the social sustainability. In contrast, in this paper, we argue that the decentralised conference is a viable solution to go beyond such a narrow carbon-centered perspective addressing sustainability more comprehensively.

The analysis of interview data found that, in addition to reducing CO<sub>2</sub> emissions via reduced travel, local hubs took a number of other measures to improve ecological sustainability (such as vegetarian and local catering, not using plastics, recycling). Our evaluation of the ecological sustainability of the conference is restricted solely to calculations of CO<sub>2</sub>



emissions due to travel, as this is the largest contributor to conference carbon emissions (18), and the estimated video streaming emissions. A more comprehensive analysis could take into account the amount and type of waste, meal composition, and local commuting and we acknowledge that this is a limitation of the study. This may be a valuable avenue for future research.

Social sustainability was evaluated using semi-structured interviews with conference organisers and attendees. For those that we spoke to, the social sustainability benefits of local hubs centred on the ability to meet with people in-person. They perceived this as being vital in creating a sense of community and something that would not have been possible with a fully online scenario (12, 18, 33). The evidence suggests that the local hubs were invaluable in facilitating a feeling of belonging for attendees, and the ability to participate in a global programme with opportunities for live discussions contributed to feeling part of a much larger, global community (12, 25, 34, 35).

The more accessible and inclusive format allowed a diverse range of attendees to participate, meaning that the benefits attributed to conference attendance were able to be shared more equitably. Short-term benefits have already been seen, such as early career researchers expanding their professional networks, research groups being formed for future collaboration, and people being invited to speak at other conferences and events by someone they met at the conference – these are all activities that build one's curriculum vitae and assist career progression (1-3, 5). For the 50-85 percent of people who would not have been able to attend an in-person conference in a central hub, for a range of reasons including socio-economic status, disability, neurodiversity, visas, and/or other disciplinary priorities, this is important. This finding thus supports the work of Wynes, Donner (22) who argued that frequent and/or long-haul travel is not necessary for career success.

These findings show CuttingGardens 2023 to be a successful instance of a decentralised format, demonstrating feasibility of organising events with this type of structure. That said, further refinements could be made to the model, such as optimising the hub sizes and locations, and involving non-WEIRD communities. In addition, the central governance team could incorporate specific social sustainability best practices into the resources they create to help people organise their local hub. This could include (but is not limited to) making sure conference communications and websites are designed for screen-readers, providing guidelines for developing presentations for visually impaired attendees, having synchronous transcription and/or translation for presentations, and including pronouns (27, 32, 47, 48). These enhancements should be harmonised with the engaged community, to nurture the richness of its diversity and its open, ethical and sustainable evolution.

We therefore conclude that even though a decentralised conference format requires more consideration than the traditional in-person model (18), it nevertheless meets the essential function of academic conferences while addressing both ecological and social sustainability concerns (17, 46). This experience is one humble attempt to address the legacy of complex and intersecting systems of oppression, working towards ecological and social justice. While much remains to be done, we believe that these issues can be effectively addressed together through creative approaches and a commitment to ongoing improvement.

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